COMING TO TERMS: AN INVESTIGATION OF FREE-CHOICE LEARNING, SCIENTIFIC LITERACY AND HEALTH LITERACY.

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Submitted in fulfilment of the requirements for the Degree of PhD in Education

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Abstract

The term free-choice learning has received relatively recent support, having been favoured by John Falk from around 2001. Free-choice learning can be described most simply as "the type of learning that occurs most frequently outside of school" (Falk, 2001, p.6). Free-choice science learning has connections with the research areas of science communication, the public understanding of science, public engagement with science and, in particular, informal learning. Additionally, Falk introduced the idea of working knowledge of science as, "knowledge generated by the learner's own interests and needs" (Falk, Storksdieck and Dierking, 2007, p.464).

This thesis explored the terms free-choice learning and working knowledge of science in order to gain a better understanding of their meaning and their importance. The work was carried out to address the following research questions:

1. Can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?
2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?
3. What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?
4. Can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

Glasgow Science Centre's BodyWorks exhibits were used as a tool to empirically investigate free-choice learning and working knowledge. Data were gathered using semi-structured interviews and staff diaries. It was found that 93% of participants referred to some type of free-choice learning experience when discussing the BodyWorks exhibits. A better understanding of free-choice learning and working knowledge was achieved.

Free-choice learning and working knowledge were used as a lens through which to revisit the concepts and definitions of scientific literacy and health literacy. This theoretical work provided an insight to key themes developing in this literature and directions for future research.

The results of both the empirical and theoretical parts of this thesis combined to produce implications for free-choice learning providers, formal education, the health sector and society. Most importantly the results presented ideas on how these groups could utilise free-choice learning and working knowledge to their benefit.

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Acknowledgement

I should like to express my appreciation to those who have, in various ways, supported the completion of this thesis. Firstly, I would like to thank my supervisor Professor Vic Lally for his advice and support through all the peaks and troughs involved in completing this work. I have thoroughly enjoyed our conversations, no matter what the subject.

Thank you to GlaxoSmithKline who provided three years of financial support for the project via Glasgow Science Centre. I would like to thank Glasgow Science Centre for setting up the project and also express my gratitude to the staff who contributed to the data collection. The participants in this research have made it worthwhile and I would like to thank them for taking part and providing such valuable information.

Thanks most of all to Sarah Watson, without her support I wouldn't have finished. Finally, thanks to my mum, for never questioning my decisions, without her I wouldn't have started.

Author's Declaration

I declare that, except where explicit reference is made to the contribution of others, this thesis is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

Signature ____________________________

Printed name ____________________________

CHAPTER 1 – STARTING POINTS AND BACKGROUND

STARTING OUT

This study developed from Falk, Storksdieck and Dierking's (2007) paper, which provided evidence for, and suggested further study into, the importance of free-choice learning and working knowledge. Falk defines free-choice learning as:

> "the type of learning that occurs most frequently outside of school; in particular, free-choice learning refers to the type of learning typically facilitated by museums, science centers, a wide range of community-based organizations, and print and electronic media including the Internet" (Falk, 2001, p.6).

So the term free-choice learning as defined by Falk, is difficult to distinguish from the more established and well known term, *informal* learning. At this point, as I began to investigate it further, free-choice learning seemed immediately more suitable to the learning I have encountered taking place outside of schools. In particular, although informal communicates the casual, everyday nature of this type of learning, and sets out how this learning is different to formal learning, free-choice underlines how people take part in this learning for their own reasons and with their own objectives. Informal relates more to how and where this learning takes place but free-choice adds in the element of why the learning is taking place and in turn what learning is taking place. How learning is taking place must be of interest to those providing the learning but the learning wouldn't be taking place without an initial reason for it. So, why learning is taking place, what has initiated the learning, or motivated an individual to learn must be of interest to those providing the learning. In my own experience, I have come across reasons including: entertainment; home education; hobbies; and, reminiscing.

A further term has been used in this thesis and was introduced alongside free-choice learning: working knowledge. Falk, Storksdieck and Dierking (2007) described working knowledge of science as "knowledge generated by the learner's own interests and needs" (p.464) and, "the public's self-defined understanding of science" (p.456). Working knowledge is gained by learning not what we "have to" but what we "choose to". Also "some of what we learn we learn rather incidentally, without consciously wanting to learn" (p.459). Working knowledge is not only skills and factual knowledge or understandings, but also consists of values, opinions, perceptions, attitudes and behaviours. Everyone's working knowledge is unique to them:

> "each individual in a community is likely to have a different science knowledge repertoire; a level of science understanding determined by his or her specific needs, abilities and socio-historical context" (Falk, Storksdieck and Dierking, 2007, p.458).

and:

> "Each individual develops an understanding of a specific area of science because of his or her unique, personal set of needs and desires to know about this area of science. Therefore, science knowledge is more likely to be patchy and context-specific, rather than broad and generalised" (Falk, Storksdieck and Dierking, 2007, pp.458-459).

So, very simply, working knowledge can be thought of as everything gained through free-choice learning. Again this term reflects what I have witnessed in that individuals know different aspects of science to different levels of detail and because of different reasons. For example, individuals with a knowledge of sound and waves because of an interest in music, and adults wanting to gain some knowledge of astronomy in order to encourage a child's interest. This also indicates the importance of free-choice learning in providing opportunities for individuals to follow interests and needs. The idea of working knowledge also suggests a positive view of individuals being part of a community with a vast range of experience and knowledge of science.

The research used Glasgow Science Centre's *BodyWorks* exhibits as a tool to examine interactions between a free-choice learning resource and working knowledge. The intention being to aid the future development of free-choice learning resources. Also, by looking at how individuals' working knowledge interacted with free-choice learning resources, this work may provide a new way of measuring the impact of such resources.

Free-choice learning and working knowledge were used in this thesis to examine research in the areas of scientific literacy and health literacy. It was hoped that this could create opportunities to share best practice between these fields and possibly prevent the two literatures from going over similar ground in isolation. Introducing the ideas of free-choice learning and working knowledge to the field of health literacy may help to tie down a clear definition of health literacy and provide ideas on how health literacy develops, how it affects health and how it can be improved. A better understanding of health literacy could help in developing more effective initiatives to improve health literacy. Improved health literacy may assist the public in making more informed decisions about their health. The aim of improving health literacy being ultimately to improve health, reduce health inequalities and result in more efficient use of health service resources.

FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

The starting point for this thesis was Falk, Storksdieck and Dierking's (2007) paper titled "Investigating public science interest and understanding: evidence for the importance of free-choice learning." It was in this paper that I first came across the terms *free-choice learning* and *working knowledge* being used in relation to the public's understanding of science. From my experiences of studying and working in informal science education, I was familiar with comparable terms and ideas, in particular, informal and nonformal education/learning but, as outlined above, the term *free-choice* seems to fit with my experiences and thoughts on this field. Similarly, I had considered how people gain knowledge outside of schools and how personal experiences can add to an individual's knowledge, but I had not come across the term *working knowledge* being used in relation to informal education. Clearly, both terms can be applied to a number of subject fields, but this study set out to focus on free-choice *science* learning and working knowledge of *science*. It also developed to include the subject of health.

Falk, Storksdieck and Dierking (2007) described free-choice learning as, "the learning that individuals engage in throughout their lives when they have the opportunity to choose what, where, when and with whom, to learn" (Falk, Storksdieck and Dierking, 2007, p.456). As such, it is a way of learning that allows an individual to follow up on interests, and to concentrate on subjects of particular importance or relevance to them. It is a way of learning that is free from the constraints of assessment and curriculums that are seen in most formal education settings.

On a personal level, when one spends some time thinking about one's own working knowledge in relation to a particular subject, how and why this working knowledge developed, and using what sources, it is soon realised that it is a complicated concept with many interactions and starting points. It is further complicated by the simple fact that for some working knowledge, it is difficult to remember where it came from and why. This goes not just for facts, but also for values, opinions, skills, attitudes and behaviours. Some key ideas from the area of psychology will be at play here too. For example, the idea of transfer, and applying knowledge gained in one situation to another. Also, motivation and how this influences learning, and the idea of flow and how this contributes to learning. Perhaps the only way to fully understand one's own working knowledge would be to keep a record of everything that happens to you, everything you interact with and what you think of it, both at that instance and in the future.

BODYWORKS

This study benefited from having access to a potential tool for investigating working knowledge and free-choice learning: Glasgow Science Centre's *BodyWorks* exhibition (a free-choice learning resource). *BodyWorks* is about "our amazing bodies" and includes science shows and interactive workshops as well as exhibits. The programme has been designed to complement the Curriculum for Excellence Science and Health & Wellbeing outcomes in Scotland (see Appendix 8 for BodyWorks development information). Although BodyWorks was developed, and is delivered by, a science centre, research involving science museums, museums, and other relevant free-choice settings were reviewed in this study. The BodyWorks exhibition is a traveling exhibition designed to visit both schools and community events. It has provided a starting point for a permanent BodyWorks exhibition, which was being developed by Glasgow Science Centre during the writing of this thesis and opened in March 2013. The current research contributed to the development of the new exhibition as the researcher liaised with science centre staff giving updates on this BodyWorks PhD project.

The first question this project needed to answer was, can BodyWorks be used to investigate working knowledge and free-choice learning? A small pilot study was used to find out if relevant data could be gained from interviewing visitors who have used some of the BodyWorks exhibits. The pilot study would show if it is possible to bring out in conversation details of individuals' working knowledge in relation to the BodyWorks exhibits. The interviews were also used to investigate if the individuals had participated in any free-choice learning activities as well as the resources they used to acquire working knowledge.

Falk, Storksdieck and Dierking (2007) found free-choice learning to be important in science learning, “The findings strongly reinforce the lifelong, predominantly free-choice nature of science learning” (Falk, Storksdieck and Dierking, 2007, p. 463). This study aimed to add to the evidence for the importance of free-choice learning and working knowledge using the BodyWorks exhibits. Additionally, the interaction between free-choice learning, working knowledge and the BodyWorks exhibits was investigated. This could provide a better understanding of working knowledge and free-choice learning.

If free-choice learning and working knowledge are important, then science centres, museums and other free-choice learning providers could benefit from a better understanding of people’s working knowledge and how it interacts with their resources. Looking at how an individual’s working knowledge interacts with free-choice learning resources, and how it is altered by these resources, may present some ideas on how to improve future exhibits and activities, in terms of visitors’ engagement, enjoyment and learning. In addition, working knowledge may also provide a new way to look at the impact of current free-choice learning resources on those who interact with them. My own background and experience of working closely with free-choice learning has led me to view it as an area having a significant impact on the education of individuals, families and groups. However, this impact (or impacts) is difficult to specify and quantify and so free-choice learning providers may not be receiving the credit, and support, they deserve. Falk’s idea of working knowledge may provide a way to look at free-choice learning that will reveal its importance and justify its role in a wider science education.

If free-choice learning is important, it should also be recognised in formal education. The individual nature of free-choice learning and working knowledge make this challenging to achieve. However, the role of formal education may be to provide the skills and motivation for successful free-choice learning throughout life.

SCIENTIFIC LITERACY

If free-choice learning and working knowledge are important, it is of interest to see if they are being recognised in the research surrounding associated ideas. From working and studying in the fields of science communication and free-choice learning I have, in the past, come across ideas that are similar to working knowledge. A literature review of these ideas showed how similar they are to working knowledge and what the relationship is between them and free-choice learning. The ideas discussed included: scientific literacy; personal awareness of science and technology; memories; strands of science learning; entrance narrative; prior knowledge; and, islands of expertise. It appeared that *scientific literacy* is the most widely used term in science communication and public understanding of science research that can be considered related to working knowledge. The link being that working knowledge makes up part of an individual's scientific literacy. Scientific literacy has many definitions and models, some of which are more closely related to working knowledge than others. It is important to try to answer the question: what is the relationship between scientific literacy, free-choice learning and working knowledge?

The literature on scientific literacy dates back to the 1950s. Since then a number of definitions and models of scientific literacy have been developed and proposed. It was of interest to this study to revisit some of these models and consider them through the lens of working knowledge and free-choice learning. This could show if, and how, models and definitions are taking free-choice learning and working knowledge into account.

HEALTH LITERACY

While researching the ideas and definitions of scientific literacy the term *health literacy* was discovered. This idea appears to overlap in places with ideas and models of scientific literacy. Both fields have separate literatures investigating and defining them, with scientific literacy having a longer history and health literacy having more recent importance. Although the two literatures span a wide range of subject areas, as diverse as museum studies and nursing, they do seem to be related suggesting that they must include ideas with the potential to benefit each other, or at least provide fresh directions for future research.

Which leads one to ask: what are the connections between scientific literacy and health literacy and what can they learn from each other?

If scientific literacy research and models include free-choice learning and working knowledge, it may be of benefit for health literacy research to move in a similar direction. As with scientific literacy, a number of health literacy definitions and models have been proposed. By looking at these from the perspective of working knowledge and free-choice learning, new insights may be gained into their relationship with health literacy.

As mentioned previously, the literature on scientific literacy and health literacy have produced models that overlap and are, in places, very similar. A comparison of these models may show what the two fields can learn from each other and provide directions for future research.

Health literacy is a new and advancing field of research. By looking at health literacy from the point of view of working knowledge and free-choice learning, new perspectives and directions for further research may be gained. Health literacy is not only important to those who are patients but to every individual as we face more choice about our health. Being able to make informed choices about one's own health is becoming more important. This importance is underlined by recent Scottish Government interest in health literacy (The Scottish Government, 2009).

Following a proposal by the Health Improvement Strategy Division, the Scottish Government carried out a scoping study into health literacy in 2009 (The Scottish Government, 2009). One of the objectives of this study was to “Identify possible options for developing programmes, policies, and/or approaches on health literacy which merit further investigation” (The Scottish Government, 2009, p.7). The input of free-choice learning on health literacy was not covered in the report. The importance of free-choice learning would suggest that activities and resources (such as Glasgow Science Centre's BodyWorks exhibition) should be considered as a relevant ongoing initiative.

The report seemed to focus on health literacy as a risk and concentrates more on health service initiatives to overcome poor health literacy, such as improving written materials, rather than ways to improve health literacy, or make use of individuals' health literacy. By considering health literacy as an asset (see Nutbeam, 2008), looking at health literacy from the perspective of working knowledge and including an input from free-choice learning, a different set of recommendations may have been proposed. For example, including utilising people's existing working knowledge to improve health literacy. Health literacy should become more prominent in governments' health policies and initiatives. This thesis may indicate that this should include recognition of the importance of the input of free-choice learning to health literacy.

In the paper used as the starting point for this study, Falk, Storksdieck and Dierking (2007) concluded from their preliminary evidence that most of the public's lifelong science learning occurs through free-choice learning. They proposed that more work be undertaken to better understand this and also to gain a better understanding of people's working knowledge. This thesis aimed to be part of this work by looking at the importance of free-choice learning and trying to gain a better understanding of working knowledge with the objective of benefiting free-choice learning providers. In addition, this study investigated the relationship between scientific literacy, working knowledge and free-choice learning and the links between scientific literacy and health literacy.

IN THE NEXT CHAPTER...

... previous research will be reviewed in order to establish how the terms free-choice learning and working knowledge fit with other ideas.

CHAPTER 2 - WHAT ARE FREE-CHOICE LEARNING AND WORKING KNOWLEDGE AND HOW DO THEY FIT WITH OTHER IDEAS?

This literature review took as its starting point the 2007 paper by Falk, Storksdieck and Dierking titled, "Investigating public science interest and understanding: evidence for the importance of free-choice learning." This paper considered the terms free-choice learning and working knowledge, and although these have been used prior to this paper, it was here that they are clearly defined and involved in empirical research. Working knowledge and free-choice learning are relatively new terms in the fields of public understanding of science and science communication. However, they are associated with other ideas that have been considered more extensively. This literature review looked at work, in particular theoretical work, in these areas and how it relates to working knowledge and free-choice learning.

The following discussion of related literature and thinking describes the emergence of the research questions to be addressed in this thesis. This project made use of Glasgow Science Centre's BodyWorks exhibition to explore the ideas of working knowledge and free-choice learning. BodyWorks is about "our amazing bodies" and includes science shows and interactive workshops as well as exhibits (see Appendix 1 for photos and descriptions of exhibits). The programme has been designed to complement the Curriculum for Excellence Science and Health & Wellbeing outcomes in Scotland (see Appendix 8 for BodyWorks development information). Although BodyWorks was developed and is delivered by a science centre, research involving science museums, museums, and other relevant free-choice settings will be reviewed in this study.

Due to the content of the BodyWorks exhibits, this study specifically looked at working knowledge of science and health. An insight into this working knowledge and the resources people use to gain this knowledge may provide valuable information for the future development of activities and exhibits in science centres and museums. It may also help in the understanding of how free-choice learning can be integrated into formal education and how formal education can provide skills for free-choice learning.

Free-choice learning is now discussed in relation to closely related ideas and a comparison of working knowledge to similar research follows.

FREE-CHOICE LEARNING

Free-choice learning of science (and working knowledge of science) can be comfortably positioned alongside a number of existing research areas including: science communication; the Public Understanding of Science (PUS); Public Engagement with Science (PES); and, in particular, informal science education/learning.

PUS has various definitions but is most simply, “the understanding of scientific matters by non-experts” (Science and Technology Committee, 2000, section 3.1). Or, similarly, “Public understanding of science, as the name suggests, focuses on understanding science: its content, processes and social factors” (Burns, O’Connor and Stocklmayer, 2003, p.190).

In some cases there has been a move away from PUS towards the related term of Public Engagement with Science (PES) where two-way communication and the public’s involvement in decision-making become important (Science and Technology Committee, 2000; Holden, 2002). In addition, there is also the term Public Awareness of Science (PAS) which has been used as an alternative for PUS:

> “Their aims are similar and their boundaries do overlap, but PAS is predominantly about attitudes toward science. PAS may be regarded as a prerequisite - in fact, a fundamental component - of PUS and scientific literacy” (Burns, O’Connor and Stocklmayer, 2003, p.187).

There are positive economic, utilitarian, democratic, cultural and social reasons that communication of science is important (Stocklmayer, Gore and Bryant, 2001, p.ix; Science and Technology Committee, 2000). These reasons are similar to those discussed in relation to the importance of scientific literacy below (see Page 46). It would not be expected to find many voices against the communication of science or its goals of increasing or improving PUS, PES or PAS. However, it has been shown that promoting the public understanding of science with the goal of increasing support for science may not produce the straightforward results that are expected. Those more knowledgeable about science may have less support for some areas of science, for example research that is “morally contentious” (Evans and Durant, 1995).

The definitions above show that there are a number of terms that are closely related to free-choice learning, and that these are not clearly defined and sometimes used interchangeably. Furthermore, when the term “science” is used it may include science, technology, engineering or maths (STEM). For the rest of this thesis, the word science is used assuming these other terms are included, unless otherwise specified.

The term “free-choice learning” first appears to have been defined and used by the researchers John Falk and Lynn Dierking (1998). Falk defined free-choice learning as:

> “the type of learning that occurs most frequently outside of school; in particular, free-choice learning refers to the type of learning typically facilitated by museums, science centers, a wide range of community-based organizations, and print and electronic media including the Internet” (Falk, 2001, p.6).

They describe their reasoning for the new term as follows:

> “We coined the term free-choice learning more than 10 years ago in order to capture the essential nature of this paradigm shift in learning – a recognition that people learn everyday throughout their lives, but also that learning is first and foremost a learner-centred, not an institution centred phenomenon” (Falk and Dierking, 2012, p.1063).

This definition corresponds with some ideas discussed in relation to informal education and learning. For example, when discussing informal education Lucas (1982) stated:

> “not all things that we are taught in the sense of learning from someone who deliberately sets out to teach us, are taught to us in institutions set aside for the purpose” (Lucas, 1982, p.89).

He added, “We are certainly not taught everything that we know”(Lucas, 1982, p.89). Also, Crane’s (1994) definition of informal science learning is similar to the idea of free-choice learning:

> “activities that occur outside of the school setting, are not developed to be part of an ongoing school curriculum, and are characterised by voluntary as opposed to mandatory participation as part of a credited school experience” (Crane, 1994, p.3).

Informal learning takes place in, and involves, a wide range of organisations and settings. Organisations including:

> "libraries, schools, think tanks, institutions of higher education, government agencies, private companies, philanthropic foundations" and settings such as "family discussions at home, visits to museums, nature centres, or other designed settings, and everyday activities like gardening, as well as recreational activities like hiking and fishing, and participation in clubs" (Bell et al., 2009, p.1).

In fact, it is difficult to think of any situation or setting where learning cannot take place. Lucas (1982, p.90) further divided out of school learning sources into two groups: "those that intentionally set out to educate" (such as science based TV programmes, documentaries, museums, zoos); and "those that are accidentally educative" (for example, science in other literature, images in books). Again it is difficult to think of a setting that would not fall into one of these groups.

The definitions above could suggest that free-choice learning and informal learning are interchangeable terms. However, this is not the case and some researchers have a preference for one term over the other:

> "The terms informal science education and free-choice learning are both popular amongst different factions, and neither fully describes the breadth of the larger field" (Phipps, 2010, p.4).

Falk (2001) preferred the term free-choice learning to informal learning as it takes into account the social context and the underlying motivation of the learner as well as the physical setting. Also, the term free-choice learning recognises the "unique characteristics of such learning: free-choice, non-sequential, self-paced, and voluntary" (Falk, 2001, p.7). Also:

> "free-choice learning tends to be nonlinear, is personally motivated, and involves considerable choice on the part of the learner as to what to learn, as well as where and when to participate in learning" (Falk and Dierking, 2000, p.13).

In building this definition, Falk (1982, p.83) quoted Laetsch's (1979) distinctions between formal and informal learning:

> "informal education is characterised by free choice, lack of prerequisites and credentials, heterogeneity of learner groups in background and interests, and importance of social interaction as part of the visit" (Falk, 1982, p.83).

Perhaps Laetsch's suggestion that informal is characterised by free choice is where Falk's idea for using the term free-choice learning came from.

Hein (1998, p.7) importantly pointed out that although the terms "formal" and "informal" are useful in describing the "administrative attributes of educational settings" they are not ideal for describing teaching. He gave the example that "classrooms in progressive schools, committed to a developmental - active learning philosophy, may look very much like a discovery gallery in a science museum" (Hein, 1998, p.7). Conversely, some activities in museums may be very similar to traditional school learning. Falk and Dierking (1998, p.2) agreed with this: "what makes learning different is partially the setting, but equally, if not more importantly, the underlying motivation of the learner." They recommended the use of the term informal in reference to the setting and free-choice when talking about the type of learning that happens in these settings. Martin (2004, S76) added:

> "the problem of defining "informal' in a new way remains but, at this point, it is fair to say that most researchers are uncomfortable with a distinction between activities based solely on their location" (Martin, 2004, S76).

In other words, formal refers to in school and informal out of school. This current study looked specifically at free-choice learning as defined and described above. However, some research that uses the idea of informal learning was useful in shaping the background and methodology of this thesis. Especially as free-choice learning is a relatively new term and so less research currently exists that uses the specific term. The differences between the terms, and perhaps the most appropriate term, could become clearer during the course of the literature review and the empirical and theoretical research that follow. For the purposes of this thesis, the terms free-choice and informal were applied according to how they were initially used by the researchers referred to. However, the general approach is that informal is describing the setting and free-choice is describing the learning.

Another point on the use of terms to be noted is that some research referred to has been carried out specifically in science centres and some has been carried out in museums. In some cases the term museum has been used generically when referring to all museum-like organisations, including science centres and also places such as zoos, botanical gardens and aquariums. General literature on museums mentioned here includes, for example: Falk and Dierking (1992; 1995; 2000; 2002); Hein (1998); Jeffery-Clay (1998); Leinhardt, Crowley and Knutson (2004); McManus (1993); Roberts (1993); and, Roschelle (1995).

THE IMPORTANCE OF FREE-CHOICE LEARNING

Falk and Dierking (2002) stated that free-choice learning is the “single most dominant form of learning” (p.6) the “most common type of learning in which people engage”(p.9).

One of the more obvious arguments for the importance of free-choice learning is the fact that we spend so little of our lifetimes in school. Falk, Storksdieck and Dierking raised this point:

> “given that the average adult spends only a fraction of their life participating in some kind of formal schooling (estimates range from 1 to 3 percent), we suggest that the contribution of school-based science learning to the long-term public understanding of science is quite limited” (Falk, Storksdieck and Dierking, 2007, p.455).

Further support for the importance of free-choice learning was obtained by Falk and Needham:

> “Adult free-choice learning experiences such as reading books and magazines about science and technology, using the Internet, and watching science related documentaries and videos were collectively the strongest predictors of self-reported knowledge of science and technology” (Falk and Needham 2013, p.446).

Falk (1982) pointed out the importance of non-school learning to schoolchildren:

> “Probably the most important things to realise about non-school learning are that: a) it exists; and b) it is probably dominant over school learning. Consider school-aged children: they spend more time out of school than in school. Despite the many hours children spend in a typical school this time amounts to only about 18% of their waking time in any given year. Something must be going on in their heads that other 82% of the time” (Falk, 1982, p. 82).

Of course, free-choice learning is not only important to schoolchildren, and Falk and Dierking think free-choice learning is becoming increasingly important to all of us, “In the 21st century, the learning strategy of choice for most people, most of the time, will be free-choice learning” (Falk and Dierking, 2000, p.213).

Despite these indications at the importance of free-choice learning, most still consider it “a nicety rather than a necessity, an adjunct to the serious business of learning that takes place in classrooms” (Falk and Dierking, 2010, p.490).

Crane (1994, p.4) also valued informal science learning and believed it should occur “not only during the limited years we are in school but throughout our lifespan.” In addition, Lucas (1983, p.1) believed schools need to prepare students for future free-choice learning and “school courses could be judged on how well they provide a framework for future informal learning.” Also, “school science decisions need to take into account how what is taught interacts with informal sources” (Lucas, 1983, p.28). Glasgow Science Centre’s BodyWorks project straddles the locations of formal education and informal education as its programme takes it into schools but also community groups and general public settings. It is perhaps a useful example of how formal and free-choice learning interact. For example, a student could interact with the exhibition outside of school but meet topics and ideas that have, or will, be covered in the classroom. Lucas (1982) believed that it is the interactions between formal schooling and out of school sources of learning that are likely to be important. He questioned what could be done in school science courses “to maximise the transfer of skills in learning to out of school sources?” (p.93). Falk, Storksdieck and Dierking (2007, p.464) suggested that better integration of school, work and leisure time learning experiences could be a “more robust approach to long-term gains in public understanding of science.” In addition, Lucas (1983, p.3) suggested that those teaching in formal education could benefit from understanding the interaction between informal and formal learning.

Crane (1994b, p.182) suggested “Informal learning is a conduit to other layers of learning” and went as far as to suggest that schools may have been claiming gains in learning that have occurred as a result of more than classroom learning. She asked, how informal and formal learning can complement each other and suggested that the interconnections between the two could be “planned systematically” (p.188). This planning seems to contradict definitions of informal learning and Falk’s description of free-choice learning. In particular the idea that free-choice learning is “free-choice, non-sequential, self-paced, voluntary”

(Falk, 2001, p.7). Also, "it is exactly because free-choice learning is not like school that it has such value" (Falk and Dierking, 2010, p.492).

It could be argued that, in simple terms, free-choice science learning, informal science education and formal science education all have very similar goals, related to increasing the public's understanding of science (or public's engagement with science). Yet, there are different opinions on what the goals of informal education are, which include: inform/educate; knowledge gains; conceptual understanding; changing perceptions and attitudes; and, behaviour change (Crane, 1994, p.8). All these goals are covered by the idea of free-choice learning, yet even this may contradict the very idea of being free-choice, which would suggest the goals of the learning are dictated by the individual.

Falk, Storksdieck and Dierking (2007) discussed the contribution of free-choice learning to the public understanding of science, suggesting that its importance is often overlooked and that this importance can only increase. Their evidence suggested that "a majority of all lifelong science learning occurs outside of school, and in particular occurs through the process of free-choice learning" (Falk, Storksdieck and Dierking, 2007, p.465). In 2010, Falk and Dierking again stressed the significance of free-choice learning:

> "Our research shows that free-choice learning experiences represent the single greatest contributors to adult science knowledge; childhood free-choice learning experiences also significantly contributed to adult science knowledge" (Falk and Dierking, 2010, p.489).

Falk (2002, p.64) underlined the importance of free-choice learning stating: "a vibrant and active free-choice learning sector is fundamental to a scientifically and technologically literate society." The need for a scientifically literate society and the importance of a public understanding of science were well described in the "Bodmer report" (Royal Society, 1985, pp.9-11). The report stated economic, political, social and cultural benefits of a public understanding of science. These reasons were described again by those examining scientific literacy (see Page 46).

Free-choice learning is a relatively new term and, although related to informal learning, very little research has been carried out to investigate it specifically; the most notable being the study by Falk, Storksdieck and Dierking in 2007. The

BodyWorks exhibits provide an opportunity to explore free-choice learning. The exhibits may be used as a tool to: find evidence of free-choice learning and to gain a better understanding of free-choice learning.

The main strength of Falk's work on free-choice learning is that over the years he has developed his thinking and adapted models according to empirical evidence. In the 1982 publication "Science education for the citizen: Perspectives on informal education" he set out his ideas with regards to informal being more important than formal education. Since then he has worked to find evidence and to produce models to better understand these ideas. For example, models of how people interact with museums (The Interactive Experience Model, Falk and Dierking, 1992; Contextual Model of Learning, Falk and Dierking, 2000; The Museum Experience Revisited, Falk and Dierking, 2013). He has also tested his ideas and models and worked to find evidence to support or adapt them (e.g. Falk and Storksdieck, 2005; 2010). Most importantly, for this study, he has worked to provide evidence for the importance of free-choice learning, specifically through the LASER (Los Angeles Science Education Research) project at the California Science Center (e.g. Falk, Storksdieck and Dierking, 2007; Falk and Storksdieck, 2010; Falk and Needham, 2011; 2013).

However, this well planned and executed body of research has its limitations. Many of the main researchers that we come across in the field of informal, out-of-school learning have worked with Falk at some point (including Storksdieck, Dierking, Rennie). As a result it is impossible to find a complete contrast in opinion or a challenge to Falk's ideas.

With regards to the introduction of the term free-choice learning, Falk has clearly explained the difference between this new term and the more widely used informal learning, i.e. it concentrates on the how and why of learning rather than the where. However, he hasn't given many distinct benefits for using the newer term. The main advantage seems to be that it provides a way of bringing together research in informal learning (mainly based in museums and organisations) lifelong learning (adult/community learning) public understanding of science and public engagement with science (including attitudes, and scientific literacy research). Also, for health literacy it brings together health education, promotion, health sector, culture and community. The lack of advantages may be part of the reason that despite being introduced around 1998 (Falk and Dierking, 1998), the term free-choice learning still hasn't been taken up by those working or researching in the area.

It is also surprising that although he has discussed the role of free-choice learning alongside scientific literacy (for example Falk, Storksdieck and Dierking, 2007, p.457) Falk hasn't revisited any of that great body of work on scientific literacy. This contributed to the development of this thesis' research questions.

A final problem with Falk's work for this thesis is that it is American based whereas the current study is UK based. Many of the ideas will work in both places but the history of science centres (where much of Falk's research is carried out) is much longer in the US. People know what a science centre is and these places have been in their culture since around the 1960s whereas in the UK most science centres only appeared in early 2000s. Also, the California Science Centre, where a great deal of Falk's work is carried out is free to visit, whereas science centres in the UK charge entry fees. This is likely to mean that different types of people attend and with different reasons for visiting.

WORKING KNOWLEDGE

Falk, Storksdieck and Dierking (2007) described working knowledge of science as "knowledge generated by the learner's own interests and needs" (p.464), "the public's self-defined understanding of science" (p.456). Working knowledge is not "some generalised body of knowledge and skills that every citizen should have" (p.458) but is "a series of specific sets of only moderately overlapping knowledge and abilities that individuals construct over their lifetimes" (p.458).

Everyone's working knowledge is unique to them:

> "each individual in a community is likely to have a different science knowledge repertoire; a level of science understanding determined by his or her specific needs, abilities and socio-historical context" (Falk, Storksdieck and Dierking, 2007, p.458).

and:

> "Each individual develops an understanding of a specific area of science because of his or her unique, personal set of needs and desires to know about this area of science. Therefore, science knowledge is more likely to be patchy and context-specific, rather than broad and generalised" (Falk, Storksdieck and Dierking, 2007, pp.458-459).

This idea of personalised, individual science knowledge was described clearly by Layton, Davey and Jenkins (1986) as they discussed their concept of Science for Specific Social Purposes (SSSP):

> "For adults, the learning of science tends to serve functional ends as diverse as the overcoming of previously implanted fears and inhibitions about scientific knowledge, the fostering of active concerns about the equality of the natural environment, and the coping with personal tragedy such as the birth of a handicapped child" (Layton, Davey and Jenkins, 1986, p.40).

This is related to how Miller (2010) describes adult learning in the age of the Internet as people gaining information in a "just-in-time" mode:

> "In the just-in-time world, most individuals will engage with science and technology when they feel a need to do so, and this need may often be associated with a more immediate need to solve a problem or understand a contested issue" (Miller, 2010, p.201).

Working knowledge, then, is gained by learning not what we have to but what we choose to. Also "some of what we learn we learn rather incidentally, without consciously wanting to learn" (Falk, Storksdieck and Dierking, 2007, p.459). Importantly, working knowledge is not just made up of facts and understandings, but also values, perceptions, attitudes, and beliefs. Perhaps working knowledge could simply be seen as the outcome of free-choice learning.

WORKING KNOWLEDGE AND CONSTRUCTIVISM

The ideas of working knowledge (and the processes of free-choice learning) are clearly rooted in the constructivism area of educational theory. Hein (1998) discussed learning in museums in terms of constructivism. His description of constructivism as "learning that requires active participation of the learner" (p.34) was similar to Falk's description of free-choice learning as "self-paced and voluntary" and of working knowledge as "generated by the learner's own interests and needs." Also, the way in which Leinhardt and Knutson (2004, p.4) described constructivist learning as emphasising "the role of the learner as actively seeking and building knowledge upon his or her prior knowledge and beliefs" was similar to Falk's idea of working knowledge being generated by a learner's personal "interests and needs" and constructed over a lifetime. Similarly, Shapiro (1994) described the role of the learner in the constructivist perspective as, "not to passively receive information, but to actively participate in the construction of new meaning" (p.8) and "approaches to teaching and learning should begin by understanding what it is that learners bring to learning" (p.xiv).

Hein (1998) pointed out that "All of us interpret nature and society differently, depending on our own background and experience" (pp.34-35). Dierking et al. (2003, p.109) had a similar view in relation to the construction of science knowledge, and stated that the experiences children and adults have "dynamically interact to influence the ways individuals construct scientific knowledge, attitudes, behaviours, and understanding." It could be said that working knowledge is the "scientific knowledge, attitudes, behaviours, and understanding" described by Dierking et al. (2003, p.109) and it is constructed from the "background and experience" mentioned by Hein (1998, pp.34-35). Dierking et al. (2003, p.109) summarised this saying, "Learning in general, and science learning in particular, is cumulative, emerging over time through myriad human experiences."

Falk (2001) described a simple example of how science knowledge might be constructed:

> "an individual's understanding of the physics of flight might represent the cumulative experience of completing a classroom assignment on Bernoulli's principle, reading a book on the Wright brothers, manipulating a science centre exhibition on lift and drag, and watching a television programme on birds. All of these experiences are combined, often seamlessly, by the person to construct a personal understanding of flight; no one source of information was sufficient to create this understanding, nor was one single institution solely responsible" (Falk, 2001, p.14).

It is the contribution of free-choice learning to this understanding that forms working knowledge. This is an example of how "All of our learning happens continuously, from many different sources and in many different ways" Falk and Dierking (2002, p.10).

When discussing theories of learning Hein described constructivism in a way that related it closely to working knowledge:

> "If people construct knowledge, then we have to ask: what knowledge resides in their minds, regardless of the formal structure of the subject? It becomes much more important to look at the learner, and to ask: what ideas does this learner have, regardless of formal education?; what are visitors' previous experiences?" (Hein, 1998, pp.36-37).

If individuals are forming their working knowledge of science from different sources, in different ways according to their interests and needs, combining this with their own personal experiences, their attitudes and beliefs, then, there is of course the chance that this working knowledge will be flawed. It may be based on misconceptions and misunderstandings. Free-choice learning providers must consider whether their position is to correct these misunderstandings or to take a more constructivist approach and to use them to build on.

Davis, Horn and Sherin (2013) discussed a constructivist approach of science learning in museums. They considered prior knowledge, even if incorrect, flawed or based on misconceptions, as something to work with and build on. They looked at theories of learning "that reconceive misconceptions not as faulty notions that need to be replaced, but as the building blocks from which expertise is ultimately constructed" (p.34). This fits with the idea of working knowledge being related to constructivist theories, and that new knowledge is built from existing knowledge (Davis, Horn and Sherin, 2013, p.35).

By being involved in the present study, and being interested in how visitors make meaning from the BodyWorks exhibition, Glasgow Science Centre is placing itself as a constructivist institution, "a learning institution that constantly improves its ability to serve as an interpreter of culture by critical examination of exhibitions and programs" (Hein, 1998, p.178).

IDEAS SIMILAR TO WORKING KNOWLEDGE

Despite there being limited research (theoretical and empirical) specifically on working knowledge, other work is closely related. There are many other ideas that are comparable to Falk's working knowledge and most of these are based on a constructivist perspective:

> ”There is an interdisciplinary community of scholars and educators who share an interest in developing coherent theory and practice of learning science in informal environments. However, more widely shared language, values, assumptions, learning theories, and standards of evidence are needed to build a more cohesive and instructive body of knowledge and practice” (Bell et al., 2009, p.305).

Those most similar to working knowledge are outlined below.

Personal Awareness of Science and Technology

Stocklmayer and Gilbert (2002) proposed the idea of PAST - Personal Awareness of Science and Technology. PAST appears to be comparable to working knowledge in that it is thought to be enhanced through “personal experience and exploration, rather than by didactic transmission teaching of the traditional kind” (Stocklmayer and Gilbert, 2002, p.836).

Like working knowledge PAST is accumulated and added to by an “iterative process”. However, the descriptions of PAST were perhaps more similar to ideas of scientific literacy (discussed later, Page 43) rather than working knowledge. For example, the definition of PAST from Gilbert, Stocklmayer and Garnett (1999, p.18) mentioned “an evaluation of the status of technological knowledge and its significance for personal, social, and economic life” and this seems to fit closely with Shen’s (1975) practical and civic scientific literacy (described later, Page 45).

In their study, Stocklmayer and Gilbert (2002, p.837) concentrated on the impact of the exhibit on PAST (changes in PAST), “we have sought to describe the impact on visitors’ mental models produced, both in the short and long term, by interaction with an exhibit.” The impact of an exhibit may include an impact on an individual’s working knowledge. It is important to note that PAST is specifically concerned with Science and Technology - working knowledge could be applied to any subject.

Memories

Afonso and Gilbert (2006) looked at the types of memories retrieved and used to understand science exhibits: episodic; semantic; and, procedural. Working knowledge is more general and could include all three types of memories. If memories retrieved during interaction with BodyWorks exhibits were analysed, a similar result to Afonso and Gilbert (2006, p.1534) might be expected, “the majority of the visitors’ accessed memories are episodic or semantic.” In other words, most memories are about personal experiences (episodic) and facts, ideas, concepts (semantic). However, different types of exhibits may retrieve different types of memories. It was anticipated that the majority of BodyWorks exhibits might be less likely to retrieve procedural memories.

Strands of Science Learning

Similar to some models of scientific literacy (see Page 43) are Bell et al.’s (2009) strands of science learning. They introduced a framework of six strands for use as a tool “for organising and assessing science learning” (Bell et al., 2009, p.4) in informal environments. Many of the ideas discussed by Bell et al. relate closely to working knowledge, and their description of learning in everyday settings is similar to how Falk describes working knowledge. For example, “Moments for science learning and teaching surface in people’s everyday lives in unpredictable and opportunistic ways” (Bell et al., 2009 p.93), “Virtually all people develop skills, interests, and knowledge relevant to science in everyday and family settings” (Bell et al., 2009, p.97).

In particular, Bell et al.’s (2009, p.28) notions of “lifelong learning”, “life-wide-learning” and “life-deep learning” could all be considered part of working knowledge. Life-wide learning emphasising that learning takes place across a range of settings and activities. Life-deep learning recognising that beliefs and values involved in the culture of communities and society is important in learning. Bell et al. (2009, p.34) also suggested the outcomes of informal learning include “the development of interests and motives, knowledge, affective responses and identity” and this was similar to Falk and Dierking’s (1992) personal context.

Personal Context

Falk and Dierking (1992) discussed a visitor’s museum experience in terms of the Interactive Experience Model. This model covers the visit from when a decision is made to go to a museum to "the remembrance of the museum visit, days, weeks, and years later" (Falk and Dierking, 1992, p.1). Of the three contexts described in the model: personal; social; and, physical, the description of the personal context is closest to the idea of working knowledge. In particular, the description of the personal context as a "personal reservoir of knowledge, attitudes, and experience" (Falk and Dierking, 1992, p.25) and that it includes "the visitor's interests, motivations and concerns" (Falk and Dierking, 1992, p.2) is very similar to the idea of working knowledge. Falk and Dierking (1992, p.136) suggested that the personal context means that "each visitor learns in a different way, and interprets information through the lens of previous knowledge, experience and beliefs." However, the personal context does not exclusively include knowledge gained from free-choice learning.

Falk and Dierking (2000) updated their model (now the Contextual Model of Learning) to include the dimension of time and suggested thinking of their model as:

> "the personal context as moving through time; as it travels, it is constantly shaped and reshaped as it experiences events within the physical context, all of which are mediated by and through the sociocultural context" (Falk and Dierking, 2000, p.11).

So the personal context of the contextual model of learning feels similar to the idea of working knowledge being constructed over a lifetime and being based on personal interests and needs.

Falk and Dierking (2000, p.79) added that the personal context means that each individual arrives at a museum with a personal agenda, which includes "personal interests, values, prior experiences, visit motivations, and expectations". This agrees with the idea of the "Entrance Narrative" proposed by Doering and Pekarik (1996).

Entrance Narrative

Doering and Pekarik (1996, p.20) described the "entrance narrative" as "the internal storyline that visitors enter with." They explained the entrance narrative as having three components:

> "A basic framework i.e. fundamental way that individuals construe and contemplate the world."

> "Information about the given topic, organised according to that basic framework."
> "Personal experiences, emotions and memories that verify and support this understanding" (Doering and Pekarik, 1996, p.20).

The first component of the entrance narrative, the "basic framework", could be similar to parts of working knowledge in that how individuals "construe and contemplate the world" (Doering and Pekarik, 1996, p.20) will depend on understandings, values and perceptions. In their research Doering and Pekarik did not investigate the difference in individuals' basic frameworks but they did suggest that "indirect evidence of its importance" is that museums do not "draw all segments of the population equally" (Doering and Pekarik, 1996, p.20) and formal education is the essential factor in determining whether an individual is likely to visit a museum. Doering and Pekarik went on to hypothesise that the relationship between formal education and museum visiting reflects the influence of formal education on the way that individuals encounter and think about the world and their place in it. This is a very narrow and simplified view and does not take into consideration the contribution of free-choice learning (including lifelong learning). Also, it cannot be assumed that because museum goers generally have the same level of formal education that their "basic framework" is the same.

Although they have not included the influence of free-choice learning in the "basic framework", Doering and Pekarik did think that the close relationship between formal education and museum visiting suggests the value of museum experience in supporting the viewpoints acquired in school. This hints at the importance of museums as a resource in free-choice learning.

The entrance narrative could be seen as the concept of prior knowledge specifically applied to a museum setting.

Prior Knowledge

Prior knowledge has a probable role in "how and why visitors make personal connections with the subject matter presented in an exhibit" (Falk, Dierking and Holland, 1995, p.28). Prior Knowledge is personal to individuals, like working knowledge, “A person’s Prior Knowledge is part of his or her personal identity in society” (Roschelle, 1995, p.47).

Exhibits are often designed with the aim that little prior knowledge is required to use the exhibit. If we knew more about prior knowledge would museums design exhibits differently if they had more information on what people already know? (Falk, Dierking and Holland, 1995, p.30). This may not be easy to investigate:

> “Although it can be predicted with certainty that visitors’ entering knowledge, interests and beliefs can and do affect learning from museums, in exactly what ways is harder to predict” Falk and Dierking (2000, p.80).

Borun, Massey and Lutter (1993) suggested that even people’s misconceptions about science can be addressed through getting to know the audience and taking this into account in exhibit design. Conversely, Davis, Horn and Sherin (2013) stated that:

> “when we design exhibits to explain away or replace misconceptions, we are ignoring the active nature of knowledge construction and setting ourselves up for failure” (Davis, Horn and Sherin, 2013, p.37)

They did agree though that the first step in designing exhibits is to “assess visitors’ current understanding” (Davis, Horn and Sherin, 2013, P.38). In other, words, take their working knowledge into account.

Roschelle (1995, p.37) stated the significance of prior knowledge in the process of learning, “a large body of findings shows that learning proceeds primarily from prior knowledge and only secondarily from the presented materials.” Prior Knowledge is “the raw material that conditions all learning” (Roschelle, 1995, p.41). Yet, how can individuals use their prior knowledge in learning if their prior knowledge is incorrect or flawed? Roschelle described prior knowledge as simultaneously necessary and problematic and called this the paradox of continuity. It was suggested that educators treat prior knowledge as “a set of building blocks, and not an enemy fortress” (Roschelle, 1995, p.42) that “knowledge is best seen as raw material to be refined” (p.48). Working knowledge could also be considered in this way. This fits with the perspective of Davis, Horn and Sherin (2013) (discussed above Page 33) where even incorrect knowledge is seen as something to build on. They viewed misconceptions “not as faulty notions that need to be replaced, but as the building blocks from which expertise is ultimately constructed" (Davis, Horn and Sherin, 2013, p.34). They followed:

> "several modern theories of learning that reconceive misconceptions not as faulty notions that need to be replaced, but as the building blocks from which expertise is ultimately constructed" (Davis, Horn and Sherin, 2013, p.34).

How misconceptions within working knowledge are formed, changed, or reinforced is an interesting area of research. However, it may be useful to gain a better understanding of free-choice learning and working knowledge and their importance before looking more closely at misconceptions. This thesis aims to contribute to this better understanding.

Islands of Expertise

Working knowledge seems to be a generalised, less detailed form of what Crowley and Jacobs (2002) called Islands of Expertise. An Island of Expertise is "a topic in which children happen to become interested and in which they develop relatively deep and rich knowledge" (Crowley and Jacobs, 2002, p. 333). Although this definition specifies children, the idea of Islands of Expertise seems to be suitable for adult learning too.

The main similarities between working knowledge and Islands of Expertise are in the description, "cumulates from many relatively unremarkable moments" and also "most of what they know about a topic they probably learned in smaller moments of practicing, remembering, and exploring" (Crowley and Jacobs, 2002, p. 337).

The BodyWorks exhibits could contribute to an Island of Expertise. It seems likely that some people would have Islands of Expertise in relation to an aspect of health. BodyWorks exhibits would contribute to the process of the creation of an Island of Expertise, described by Crowley and Jacobs (2002) as:

> "repeated exposure to domain-specific declarative knowledge, repeated practice in interpreting new content, making inferences to connect new knowledge to existing knowledge, repeated conversations with others who share or want to support the same interest, and so on" (Crowley and Jacobs, 2002, p.337).

Crowley and Jacobs used the example of a child who is given a Thomas the Tank Engine book for his second birthday and subsequently over time and from many sources and experiences develops an Island of Expertise on trains. “His vocabulary, declarative knowledge, conceptual knowledge, schemas, and personal memories related to trains are numerous, well-organised, and flexible” (Crowley and Jacobs, 2002, p.335).

Working knowledge could perhaps be thought of as an *Archipelago of Expertises*. Developing an Island of Expertise is similar to processes of free-choice learning, especially in that it may be opportunistic. However, “some of the learning may be highly planned and intentional” (Crowley and Jacobs, 2002, p.336). Also, some of the knowledge in an island of expertise may have been gained from formal education and therefore not working knowledge.

While Islands of expertise are straightforward and clearly related to how working knowledge is acquired, Collins and Evans’ (2007) *Periodic Table of Expertises* is more complex and allows for different levels of specialist expertise. The table also links to the ideas of Public Understanding of Science (PUS) and Public Engagement with Science (PES) mentioned already (Page 22). The levels of expertise move from fact-based “beer-mat knowledge” to the “Popular Understanding of Science” which involves a “deeper understanding of the meaning of the information” (p.20) and which Collins and Evans suggest is similar to goals of PUS. The next step is “Primary Source Knowledge” which involves reading of primary literature. The table then moves on to “Interactional expertise” which involves being able to understand and discuss scientific things but not being able to do scientific things. The highest level is “Contributory expertise” which will allow an individual to do an activity with competence (Collins and Evans, 2007, p.35) and requires working within that particular expert domain (Collins, 2013, p.254). All of these stages could involve some kind of free-choice learning, perhaps less so in the contributory level. Another link to free-choice learning is revealed in how interactional expertise is developed: “The transition to interactional expertise is accomplished, crucially, by engaging in conversation with the experts” (Collins and Evans, 2007, p.32). This hints that Public *Engagement* with Science is important, and this engagement is often facilitated by free-choice learning providers (see Page 221).

Cognitive Schema

Falk, Dierking and Holland (1995, p.29) described cognitive schema as “developed by individuals, based on their own perceptions and experiences” and being “affected by our own motivations and interests.” They suggested that a museum or an exhibit can have an impact on or “increase the complexity of” a cognitive schema by: “reinforcement of information and/or relationships in a schema”; “new information or relationships added to a schema”; or “changes in the schema itself” (Falk, Dierking and Holland, 1995, p.29). The way in which exhibits/museums are expected to interact and increase the complexity of a cognitive schema are how we might expect interactions with working knowledge to occur. Reinforcing information in a schema is similar to retrieving working knowledge. New information or relationships being added to a schema is similar to the idea of using working knowledge to understand new information. Changes in the schema are similar to adjusting to working knowledge. The BodyWorks exhibits provide us with a tool to investigate this (see Chapter 4, Page 94).

The way in which Falk, Dierking and Holland suggest that the development of cognitive schema is affected by our motivations and interests, fits with a model from social psychology called the cognitive miser model. The idea behind this model is that “people are limited in their capacity to process information, so they take shortcuts whenever they can” (Fiske and Taylor, 2010, p.13). This model has been related specifically to the communication of scientific ideas by Nisbet and Scheufele who suggest that traditional approaches to informing the public about science are ineffective and only reach “science enthusiasts” because “individuals are naturally cognitive misers” (Nisbet and Scheufele, 2009, p.1768).

If the cognitive miser model is considered alongside free-choice learning it initially doesn’t apply. Free-choice learning always takes place because of a personal interest or a need and this motivation would prevent any shortcuts being taken. Indeed, “the cognitive miser model is silent on the issue of motivations or feelings of any sort, except rapid, adequate understanding” (Fiske and Taylor, 2010, p.13). However, some individuals may be more motivated than others, or have more time and resources than others. Those short on time and skills may seek the shortcuts described in the model. Individuals may have the motivation but need to obtain and understand the information in a hurry. For example, as described by Miller (2010, p.201) as the "just-in-time world" where people engage with science and technology because of "a more immediate need to solve a problem or understand a contested issue."

One of the strategies suggested by Nisbet and Scheufele to overcome a cognitive miserly nature is to provide interest and/or motivation by framing the information being communicated so it becomes more personally relevant. If a better understanding of free-choice learning and working knowledge and their importance can be gained, any connection with the cognitive miser model, and how to deal with it, may be understood.

Working knowledge is a relatively new term and although related to the concepts described above very little research has been carried out to investigate it specifically. The most notable being the study by Falk, Storksdieck and Dierking (2007). The BodyWorks exhibits provided an opportunity to explore working knowledge. The exhibits may be used as a tool to: find evidence of working knowledge; to gain a better understanding of working knowledge; and, to look at the effects the exhibits have on a person's working knowledge.

Working knowledge does seem to overarch all these similar concepts. By investigating working knowledge using the BodyWorks exhibits, the ideas could be added to or developed. All the terms outlined above correspond in some way to working knowledge (and free-choice learning) but there is another related term with a more extensive body of research, including models, definitions and methods of measurement. It is scientific literacy.

SCIENTIFIC LITERACY

The term "scientific literacy" has been around since the late 1950s (Laugksch, 2000, p.72). Its introduction coincided with a time of rapid technological advances in the USA, when public support for science was needed for the space program. In addition it was felt that children needed to be well educated in science in order to prepare for an increasingly scientific and technological society (Laugksch, 2000, p.72). Since the term was introduced right up until recently (for example, Feinstein, 2011) scientific literacy has been an important concept in both empirical and theoretical research in the area of public understanding of science. Falk, Storksdieck and Dierking (2007, p.457) confirmed this saying, “Considerable focus in the area of public understanding of science research and practice has revolved around the concept of science literacy.”

WHAT IS SCIENTIFIC LITERACY?

There are numerous definitions of scientific literacy and what it means to be scientifically literate. These definitions are strongly influenced by the purpose of who is making the definition: social scientists; scientists; informal educators; formal educators. Examples of definitions vary greatly and include:

> “knowing enough about science to be able to judge if the story that you are being told is being told in a fair and accurate way” (Brewer, 2008).

> “not only learning new things, but becoming more aware of and interested in science, developing a broad-based knowing and understanding about science and its relationships with society and ourselves. This comes close to the notion of scientific literacy... ” (Rennie and Williams, 2002, p. 707).

> “Scientific literacy is the ideal situation where people are aware of, interested and involved in, form opinions about, and seek to understand science” (Burns, O’Connor and Stocklmayer, p.190).

> “Might a truly literate citizen be one who, no matter what their scientific understandings, recognises the uniqueness of knowledge and respects an individual’s ability to contribute to those understandings?” (Stocklmayer, 2005, p.18).

> “Scientific literacy should not be taken to mean the knowledge of a lot of science, but rather the understanding of how science really works” (Durant, 1994, p.83).

In a useful and clear paper, Durant (1994) suggested that there are three kinds of definitions of scientific literacy: those based on scientific knowledge and facts; those concentrating on the nature of science, or “how science works”; and, a third approach to scientific literacy, which he described as “how science really works, and concentrates on the social system of science.” Durant concluded that, “We need to consider how a truer picture of science can be conveyed to a general public which has no direct experience of scientific research at all” (Durant, 1994, p.89).

So there is a lack of consensus on what scientific literacy is. Perhaps the most straightforward definition of scientific literacy is that it is knowing something about science.

The lack of agreement on a definition of scientific literacy was emphasised by the publication of Shamos' (1995) book titled "The Myth of Scientific Literacy." Although Shamos was not completely dismissing the idea of scientific literacy, he did think that, "the notion of developing a significant scientific literacy in the general public" "is little more than a romantic idea" (Shamos, 1995, p.215). He did not think scientific literacy was a necessity for the general public, "one does not need to be literate in science to be successful in most enterprises or to lead the "good life" generally" (Shamos, 1995, p.98).

His alternative to scientific literacy was what he calls "scientific awareness" and he provided guidance on how science should be introduced to students in formal education. Shamos' three guiding principles for presenting science to the general student are:

> "Teach science mainly to develop appreciation and awareness of the enterprise that is, as a cultural imperative, and not primarily for content."
> "To provide a central theme, focus on technology as a practical imperative for the individual's personal health and safety, and on an awareness of both the natural and man-made environments."
> "For developing social (civic) literacy, emphasise the proper use of scientific experts" (Shamos,1995, pp.87-89).

These principles are in some ways similar to other ideas in scientific literacy. Rennie and Williams (2002) definition quoted earlier is of a similar notion as Shamos' first principle. His third principle is not dissimilar in purpose to Brewer's (2008) definition. Also, the civic literacy that Shamos referred to comes from a model of scientific literacy developed by Shen (1975), discussed later.

The difference is that Shamos' scientific awareness was in reference to school students hopefully taking their science awareness beyond compulsory education and as such isn't completely relevant to free-choice learning or informal learning. Lucas' (1983, p.1) idea of schools being responsible for providing skills for lifelong learning together with Shamos' scientific awareness could maybe offer a more rounded solution to having students become scientifically literate adults. This would allow the contribution of informal and free-choice learning to be included.

As well as numerous definitions, many models of scientific literacy have been developed. Laugksch (2000) outlined those by: Shamos; Pella, O'Hearn and Gale; Showalter; Shen; Branscomb; Miller; Arons; and, others. Shen's (1975) model is uncomplicated, contains many aspects of more complex models, and seems easy to apply to various contexts including free-choice learning. Shen defined scientific literacy as:

> "an acquaintance with science, technology and medicine, popularised to various degrees, on the part of the general public and special sectors of the public through information on the mass media and education in and out of schools" (Shen, 1975, p.45-46).

Shen believed the public would gain from becoming more scientifically literate as it would enable them to "take better advantage of science's many benefits while avoiding its many pitfalls" (Shen, 1975, p.46). This is in contrast to Shamos' view that the majority of the public do not need to be scientifically literate.

Shen divided all the activities that fit his definition of scientific literacy into three categories: practical; civic; and cultural. Practical science literacy is "the possession of the kind of scientific knowledge that can be used to help solve practical problems" (Shen, 1975, p.46). Civic science literacy involves becoming more aware of scientific issues in order to "participate fully in the democratic processes of an increasingly technological society" (Shen, 1975, p.48). Finally, Shen described cultural science literacy as being "motivated by a desire to know something about science as a major human achievement", "it is to science what art appreciation is to art" (Shen, 1975, p.49).

One important definition of scientific literacy is that used by the OECD (Organization for Economic Cooperation and Development) in their PISA (Programme for International Student Assessment) survey. Its importance is that it draws on a number of other key definitions and models (including some discussed later in more detail, e.g. Bybee, 1997; Koballa et al., 1997;

see Chapter 6). For the purposes of PISA, scientific literacy refers to an individual's:

> "- Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and 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.
> - Willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen" (OECD, 2013, p.100).

The OECD used this definition to develop a comprehensive test of scientific literacy for 15 year olds which assessed scientific competencies, knowledge and attitudes. Although the definition of scientific literacy developed by the OECD is clear, and the measure of scientific literacy comprehensive, it is limited because of its age specificity. More general, universal, not age specific, measures of scientific literacy are discussed below.

IMPORTANCE OF SCIENTIFIC LITERACY

Even though there is no consensus on what scientific literacy actually is, or what it means to be scientifically literate, it is generally agreed that it is a worthy educational goal. The reasons why scientific literacy is important, or why a scientifically literate public is important, were summarised by Laugksch (pp.84-87) and included economic, political, cultural and personal aspects. Economically, a scientifically literate public could ensure a supply of future scientists, engineers and technically trained personnel to contribute to the economic well-being of a nation. Politically, a scientifically literate public could be more supportive of science and have increased confidence in science. There is a strong relationship between science and culture. It has been suggested that scientific discoveries can be enjoyed without being a practicing scientist, in the same way that music can be enjoyed as a listener without being a performer or a composer (Royal Society, 1985, p.10). On a personal level, being scientifically literate can lead to employment possibilities, improved personal decision-making and a better understanding of the norms and values of science. Shapiro (1994) added:

> "an understanding of the basic ideas of science is essential for anyone living in our world because we all make daily decisions that may enlighten

> or burden society, depending on our ability to use information effectively" (Shapiro, 1994, p.xvi).

This view fits with Shen's (1975) thoughts on civic science literacy.

Lewenstein (1992) summarised the distinct reasons for the importance of science literacy and the different goals of having a scientifically literate public:

> "Some of us want a public better able to judge between competing technical arguments on such issues as energy conservation, solid waste disposal, pesticide risk, and social welfare policy. Others of us want a public more capable of distinguishing between logic and trivia in debates about government budgets. Some of us want more young people, of all genders and races, to include science in their dreams about how they will spend their lives. And still others of us want mainly for the public to comprehend the beauty and intellectual challenge of the ideas that we believe are central to science" (Lewenstein, 1992, p.ix).

It is clear that a scientifically literate public is an important objective. The different reasons given by Lewenstein go some way to explaining why there are so many different definitions and models of science literacy. However, all the goals outlined by Lewenstein, can be covered by Shen's uncomplicated model. In addition, more recently, Kanasa and Nichols (2008) seemed to be stressing the importance of Shen's civic literacy, and gave specific examples of science the public should be engaging with:

> "A certain level of scientific literacy is required if citizens are to be able to effectively engage in media and political discussions of the societal implications of new technologies demonstrated by the Human Genome Project, therapeutic cloning, GM crops and livestock, and stem cell research - all advances in biotechnology that will more than likely have a direct impact on the lives of all citizens" (Kanasa and Nichols, 2008, p.1).

These reasons for the importance of scientific literacy are understandable, but does the idea of scientific literacy take working knowledge and free-choice learning into account? Most free-choice learning takes place because of a personal need or interest, individuals are not likely to take part in free-choice learning with the specific aim of supporting the economy or politics of a country.

MEASUREMENT OF SCIENTIFIC LITERACY

It follows that if a scientifically literate public is beneficial, it is then of interest to know how scientifically literate the public actually is. The numerous definitions and models have meant that various techniques have been used to measure the different ideas of scientific literacy. A selection of these techniques is outlined below.

Some measurements of scientific literacy are concerned with assessment in formal education. Although they refer to “scientific literacy” it is actually scientific knowledge that they appear to be measuring. One noticeable thing about the majority of articles is that although they are talking about “scientific literacy” they often do not define what they mean by the term or refer to a particular model of scientific literacy or research on scientific literacy. This suggests that the term could be being used inappropriately and that comparisons between studies are not possible as they mostly have different ideas of what scientific literacy is. This is to be expected, but by not defining what they are referring to when discussing “scientific literacy” it can be quite confusing. Where no definition or model is stated by the author, the research described below has been related back to Shen’s (1975) model for simplicity.

Lucas (1983) used Shen’s (1975) model of scientific literacy as a framework to consider if various types of informal learning were contributing to, or improving, scientific literacy. Lucas remarked that literature about museums does not differentiate between Shen’s 3 types of scientific literacy. However, he believed that there are examples of exhibits that can be thought to contribute to civic and practical scientific literacy and “the typical display is at best a contribution to cultural scientific literacy” (Lucas, 1983, p.12). He added that most long-term exhibits are more likely to be contributing to cultural scientific literacy. “Civic and practical scientific literacy will require changing exhibitions as issues change and new techniques develop” (Lucas, 1983, p.13).

It would be possible to use this framework to look at other exhibits and activities to determine which type of scientific literacy they could be improving, or contributing to. It may then be possible to assess if any contribution has actually been made. For example, are some of the BodyWorks exhibits trying to contribute to practical scientific literacy by giving participants information and skills by which to improve their health?

In terms of future research, Lucas (1983, p.11) suggested research aimed at appreciating what factors increase the understanding of material in a conceptual framework, how an adult's background in science interacts with their viewing of exhibits and exhibitions. This could include the contribution of working knowledge.

Klein et al. (2002) focused on evaluating formal education and the idea of using concept maps as an assessment technique. Although this is an interesting idea, it seemed to be measuring student's understanding of specific topics rather than scientific literacy. However, concept maps might be a useful way of looking at what learning has taken place due to an exhibition such as BodyWorks or a science centre, or museum, visit.

Medved and Oatley (2000) looked at how exhibits from a science centre were remembered by visitors. Although it is not based around a model of scientific literacy some results fit into Shen's model. For example, the fact that some visitors reported a change in behaviour in response to the exhibit would suggest an effect on practical scientific literacy.

In his study, Miller (1998) attempted to measure civic scientific literacy. However, the methods used may also be measuring aspects of practical scientific literacy. Miller suggests that civic scientific literacy should be conceptualised as involving 3 dimensions, previously proposed by Miller in a 1983 paper:

> "a vocabulary of basic scientific constructs sufficient to read competing views in a newspaper or magazine."
> "an understanding of the process or nature of scientific inquiry."
> "some level of understanding of the impact of science and technology on individuals and on society" (Miller, 1998, p.205).

Although Miller has provided a useful tool for measuring civic scientific literacy, he was not looking at how it has been changed by a specific intervention (for example, a visit to a science centre).

Cannon (1992) used "Hirsch's Cultural Literacy: What every American needs to know" to compile a list of terms and phrases that could be considered a basis for general scientific literacy. By doing this Cannon seemed to be defining scientific literacy as what you need to know about science to get by in society. So Cannon was not using a model of scientific literacy or looking at different types of scientific literacy. Knowing and/or understanding a list of science-related terms or phrases does not necessarily indicate an ability to use them in your everyday life. Cannon seemed to be measuring one of the dimensions of civic scientific literacy defined by Miller (1998, p.205), "a vocabulary of basic scientific constructs sufficient to read competing views in a newspaper or magazine."

A study by Shapiro (1994b) outlined an interesting case study in formal education following a student as she tries to understand the topic of light. Shapiro used stimulated video recall, observation and conversation to try to understand what was going on as this student was involved in classroom activities. Although this wasn't looking at scientific literacy it gave an idea of the sort of detailed information that could be gathered from a case study.

Champagne (1992) didn't specifically define scientific literacy but did include the idea that:

> "an essential component of scientific literacy is an information base organised in a way that makes the information applicable to situations encountered in the workplace, and to civic responsibilities as well as to academic problems" (Champagne, 1992, p.844).

She believed that testing of student achievement in science in formal education needs to include assessment of the ability to think about science in real-world contexts. Champagne recommended assessment that is "based on the assumption that knowledge is actively constructed by the child and varies from one context to another" (Champagne, 1992, p.847). This fits with working knowledge.

Korpan (1994) outlined how to use a test that was designed for a specific research project. It focused on how people assess the credibility of brief media reports of medical studies. Participants were asked to read a news item and then list the information they would need or questions they would want answered about the item in order to evaluate it. The results of Korpan's test should determine:

> "what people know about features of scientific research"
> "how, when, and whether people engage in evaluative thinking about these features when reading reports of scientific investigations"

> "how these characteristics of knowledge and thinking vary as a function of age and schooling from adolescence through early adulthood" (Korpan, 1994).

Again, Korpan did not formally define scientific literacy but seems to be looking at Shen's civic scientific literacy. Some of the skills used in evaluating news items could also fit into practical scientific literacy.

Some studies have used previously conceived models in order to assess scientific literacy (Rubba and Andersen, 1978; Laugksch and Spargo, 1996). Rubba and Andersen's research was based around Showalter's (1974) seven dimension definition of scientific literacy. It aimed "to develop, field test and validate an instrument to assess secondary school students' understanding of the nature of scientific knowledge" (Rubba and Andersen, 1978, p.450). This is the first dimension of Showalter's model that has 9 factors, which states "the scientifically literate person understands the nature of scientific knowledge" (Rubba and Andersen, 1978, p.450). Rubba and Andersen consolidated the 9 factors into 6 to produce "A Model of the Nature of Scientific Knowledge." From this model an assessment was developed called the "Nature of Scientific Knowledge Scale." This seems quite a complicated and incomplete way of looking at just one aspect of a model of scientific literacy.

Laugksch and Spargo (1996) developed a test related closely to Miller's three dimensions of scientific literacy. The test is based on the 1989 American Association for the Advancement of Science overview report on literacy goals in science, mathematics and technology, entitled "Science for all Americans". The test, like Miller's model, only seems to be referring to Shen's civic scientific literacy but without mentioning anything similar to practical or cultural literacy. The authors believed that the tests,

> "may open numerous important research avenues such as, for example, whether scientifically literate citizens are able to make "better" decisions related to such issues as diet, health, consumer choices and the environment" (Laugksch and Spargo, 1996, p.137).

This idea of future research relates to the BodyWorks exhibition. For example, do scientifically literate people engage differently with the exhibition?

The techniques described above show that the lack of a definitive definition or model of scientific literacy has led to a variety of things being measured to assess scientific literacy. Shen's model, and the use of it as a framework by Lucas (1983), seems to be the most straightforward way of studying scientific literacy. The three categories of Shen's model: Practical; Civic; and Cultural cover other definitions and ideas about scientific literacy including Shamos' Scientific Awareness.

SCIENTIFIC LITERACY, WORKING KNOWLEDGE AND FREE-CHOICE LEARNING

In an issue of Daedalus devoted to scientific literacy, Graubard (1983) wrote,

> "the term "scientific literacy" lacks all precision, that there are no generally accepted criteria for determining what an individual needs to know to be called scientifically literate, or why it is vital (or even important) for great numbers of Americans to wish to achieve such literacy" (Graubard, 1983, p.231).

He went on to question why anyone should bother worrying about scientific literacy when there is no agreement on what it is or how to measure it. However he suggested that its purpose may be to draw attention to the situation that nobody knows how to deal with and pointed out that there are "no other words will serve as well" (Graubard, 1983, p.233). It was later suggested that that particular edition of Daedalus "propelled the concept of scientific literacy to the forefront of American cultural and political discussions" (Turner, 2008, p.56). With so many definitions, models and measurements, it could be argued that scientific literacy research lacks focus and is wasting time, treading water, debating its own meaning. That "much current effort at the creation of a scientifically literate culture is well-meant, but misdirected" (Durant, 1994, p.84). However, there is a vast body of work based around this term. Despite the lack of consensus, the direction the research has taken and the conclusions it has made are without doubt of value. It could be useful to look at the research from a different perspective. Working knowledge could be seen as what free-choice learning contributes to scientific literacy. Given their (suggested) importance, it could be useful to revisit scientific literacy research from the perspective of free-choice learning and working knowledge. This could perhaps go someway to solving the problem of a lack of consensus.

HEALTH LITERACY

One of the most interesting things about Shen's (1975) model of scientific literacy when considered in relation to the BodyWorks exhibition is that it provides a connection to the idea of health literacy. BodyWorks has obvious links to improving scientific literacy but the topics covered relate to the newer idea of health literacy too. The concepts of scientific literacy and health literacy overlap a great deal. In particular, a model of health literacy by Zarcadoolas, Pleasant and Greer (2003) is very similar to Shen's (1975) model of scientific literacy. Shen's model having the three domains: practical science literacy; civic science literacy; and, cultural science literacy. Zarcadoolas, Pleasant and Greer's model having the four domains: fundamental literacy/numeracy; science and technology literacy; community/civic literacy; and, cultural literacy.

Also, Frisch et al., (2012) included science/scientific literacy when looking at how other literacy domains can add to the defining and measuring of health literacy, referring to Shen, 1975; Durant, 1994; Laugksch, 2000; and Roth and Calabrese Barton (2004). However, for the most part, there is very little reference to either idea by those researching the other.

WHAT IS HEALTH LITERACY?

According to Selden et al. (2000, p.v), the term "health literacy" was first used in 1974 by Simonds in a paper titled "Health education as social history." The concept of health literacy originally seems to have referred to functional literacy, which included basic skills of reading medicine labels, leaflets and making appointments. Fetter (1999, p.226) defined this as, "an individual's ability to read and comprehend information essential to maintaining optimal health."

In 1998 Nutbeam redefined health literacy, changing its definition from:

> "Health literacy represents 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, p.357).

to:

> “Health literacy implies the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions. Thus, health literacy means more than being able to read pamphlets and make appointments. By improving people’s access to information, and their capacity to use it effectively, health literacy is critical to empowerment. Health literacy is itself dependent upon more general levels of literacy. Poor literacy can affect people’s health directly by limiting their personal, social and cultural development as well as hindering the development of health literacy” (Nutbeam, 1998, p.357).

In 2000 Nutbeam took his definition of health literacy further and used research in literacy to work up a model of health literacy. This model has different levels of literacy that “progressively allow for greater autonomy and personal empowerment” (Nutbeam, 2000, p.264). These levels are: functional health literacy; interactive health literacy; and, critical health literacy. Tones (2002, p.289) seemed to disagree with Nutbeam’s model saying that there was, “little if any justification for extending the original formulation of health literacy and incorporating it in re-packaged versions of existing theoretical formulations.”

The simplest description of health literacy is probably “the measure of an individual’s practical ability to make healthy decisions” (Zarcadoolas, Pleasant and Greer, 2006, p.244). Although this excludes useful detail on what the practical abilities might be.

Zarcadoolas, Pleasant and Greer (2003) defined health literacy as:

> “the evolving skills and competencies needed to find, comprehend, evaluate and use health information and concepts to make educated choices, reduce health risks, and improve quality of life” (Zarcadoolas, Pleasant and Greer, 2003, p.119).

They went on to suggest a model for studying health literacy that consisted of four “domains” (p.120):

1 Fundamental literacy/numeracy

2 Science and technology literacy

This domain includes “an understanding that scientific uncertainty is to be expected and that rapid change in the accepted science is possible.” This overlaps with some models of scientific literacy that deal with the expectations of science/nature of science

3 Community/civic literacy

This includes knowledge about sources of information and agendas and how to interpret them so that individuals can become involved in dialogue and decision-making. This seems to follow the same idea as Shen (1975).

4 Cultural literacy

Zarcadoolas, Pleasant and Greer (2003, p.120) also suggested that future research in health literacy should look at how “health communication and education, individual capabilities, and social processes interact to create health literate citizens” and “How health literacy develops and can be fostered.” The individual capacities could be related to working knowledge and health literacy could develop via free-choice learning.

A further paper by Zarcadoolas, Pleasant and Greer in 2005 gave more detail on their model. It also contained the first significant reference in health literacy research to scientific literacy, saying:

> “Researchers focusing on the public understanding and engagement with science are also interested in the relationships between attitudes toward science, attentiveness to science, knowledge, and behavior...Researchers are continuing to develop models of science literacy—including domains such as cultural literacy, civic literacy and practical literacy—as well as further exploring the complex relationships between science and the public (Laugksch, 2000; von Grote and Dierkes, 2000; Pleasant et al., 2003)” (Zarcadoolas, Pleasant and Greer, 2005, p.196).

Zarcadoolas, Pleasant and Greer’s (2006) description of scientific literacy fits best with the civic scientific literacy of Miller (1998) and the practical science literacy of Shen (1975):

> “Scientific literacy refers to the skills and abilities to understand and use science and technology, including some awareness of the process of science” (Zarcadoolas, Pleasant and Greer, 2006, p.56).

Berkman, Davis and McCormack (2010) and Frisch et al., (2012) both provided a useful review of definitions of health literacy. Both sets of authors showed that the term has evolved from basic reading and writing skills to include more complex skills including decision making, communicating, assertiveness as well as attitudes and motivations. However, “the lack of shared meaning for the central term in a field is obviously problematic” (Baker, 2006, p. 878). This was succinctly explained by Schulz and Nakamoto (2005, p.2), “Health literacy has been variously interpreted to include a range of knowledge and skills exercised in a variety of settings."

THE IMPORTANCE OF HEALTH LITERACY

As discussed previously (Page 46) there are reasons for wanting to improve scientific literacy. Similarly, there are reasons for wanting to improve health literacy. Of course, the reasons for the importance of health literacy depend on the definition that you are using. However, if at its simplest health literacy is being able to read, understand and act on health advice, then the following statistic highlighted its importance, "Over 300 studies have shown that health information cannot be understood by most of the people for whom it was intended" (Institute of Medicine, 2004).

Looking more closely, problems associated with low health literacy have been reported as including; less knowledge of disease management and of health-promoting behaviours; poorer health status; less likely to use preventive services (Institute of Medicine, 2004); less health knowledge; lower health status; higher utilisation of health services; higher health care costs (Weiss, 2005, p.23); improper use of medications; inappropriate use or no use of health services; poor self-management of chronic conditions; inadequate response in emergency situations; poor health outcomes; lack of self-efficacy and self-esteem; financial drain on individuals and society; and, social inequity (Zarcadoolas, Pleasant and Greer (2006, pp.1-2).

The problems associated with poor health literacy demonstrate its importance. This is underlined by the reported benefits of good health literacy, which Zarcadoolas, Pleasant and Greer (2005 p.196) stated "impact the full range of life's activities - home, work, society and culture." These benefits reportedly include: clearer communication; better informed decisions; and, the delivery of quality health care services (Paasche-Orlow, Wilson and McCormack, 2010, p.7).

Wills (2009) divided the benefits into clinical, political and educational concerns saying there is:

> "a clinical concern to produce 'good patients' who comply with health messages and access services appropriately; a political concern to produce

> active citizens able to navigate health information, products, services and systems; or an educational concern to encourage informed decision making" (Wills, 2009, p. 4).

On a practical level, Gray (2009, p.334) reported that higher health literacy is associated with a greater likelihood of eating at least five portions of fruit and vegetables a day or being a non-smoker.

A report on health literacy by the Council on Scientific Affairs (American Medical Association, 1999) appears to be the first published work to outline the consequences of poor health literacy and also suggest future research in literacy screening, methods of health education, medical outcomes and economic costs, and understanding the causal pathway of how health literacy influences health. The relationship between poor health literacy and poor health outcomes is not understood. It may involve indirect factors such as poverty or working in hazardous jobs, as well as more direct links such as patients not looking after chronic medical conditions properly (American Medical Association, 1999, p.554).

Indeed, if poor health literacy has been reported in those who have been hospitalised or those with a poorer health status, this may be because those with high health literacy are avoiding healthcare and not becoming a patient because of their good health.

It seems the importance of health literacy is starting to be recognised. In Scotland the Scottish Government produced a health literacy scoping study in 2009 and have now set up a National Health Literacy Group. In England, health literacy was a key component of the Department of Health's health inequalities strategy (Gray, 2009, p.333). Also, Maastricht University hosted the European Health Literacy Study, which was carried out between 2009 and 2012. With the general objectives of this project including: to help "establish the issue of health literacy in Europe" and, to "discuss the overall social and political significance of health literacy" (The HLS-EU Consortium, 2012, p.2). More specifically the project set out to "generate first-time data on health literacy in European countries, providing indicators for national and EU monitoring" and to provide a "comparative assessment of health literacy in European countries"

(The HLS-EU Consortium, 2012, p.2). These objectives indicate that health literacy is starting to be acknowledged as having importance and requiring research attention.

MEASUREMENT OF HEALTH LITERACY

Any estimate of health literacy is dependent on the corresponding definition of health literacy and how it is measured. There are as many ways of measuring health literacy as there are of defining it, including; The Test of Functional Health Literacy in Adults (TOFHLA) (Parker et al., 1995); the Rapid Estimate of Adult Literacy in Medicine (REALM) (Murphy et al., 1993); and, the Newest Vital Sign (Weiss et al., 2005). Measuring health literacy is important in order to evaluate programs and to estimate the problem of low health literacy. However, with limited resources available, it could be argued that it is more important to focus on improving health literacy than trying to measure it.

As discussed with regards to scientific literacy, the lack of a definitive definition, or model, has meant that measurement has been difficult and/or flawed. Most tests of health literacy have utilised tests of basic literacy (or what would be termed Fundamental Health Literacy in Zarcadoolas' 2003 model) and have therefore not produced a full assessment of health literacy. However, models do provide a useful framework for studying scientific and health literacy in specific situations. In particular, Lucas (1983) uses Shen's model to review how informal learning (including in science centres and museums) is contributing to scientific literacy. Also, Zarcadoolas, Pleasant and Greer (2005) used their model of health literacy to analyse selected communications and official government informational efforts during the anthrax threat in the United States in 2001. It is possible that these models (or others) could be used as a framework to investigate the relationship between scientific and/or health literacy and the BodyWorks exhibition.

DEVELOPMENT OF HEALTH LITERACY RESEARCH

"Health literacy is a relatively recent focus of study and, as such, appears still to be in a developmental rather than a mature stage of analysis" (Schulz and

Nakamoto (2005, p.8). Health literacy research is wide and varied, it has many definitions and models:

> "Ironically, as the field of health literacy has expanded in scope and depth, the term "health literacy" itself has come to mean different things to various audiences and has become a source of confusion and debate" (Baker, 2006, p.878).

Also, the papers referring to, or discussing, health literacy and its ideas may not be included in the main health or medical journals and may not even specify that they are discussing health literacy. Papers can appear in publications concerning: nursing; public health; health communications; marketing; literacy studies; cancer; psychology; gerontology; psychology; education; and more (Peerson and Saunders, 2009, p.286).

In the US in June 2004, the participating Institutes, Centers and Offices of the National Institutes of Health (NIH) and the Agency for Healthcare Research and Quality (AHRQ) invited research grant applications on health literacy. The invitation stated:

> "Increased scientific knowledge of interventions that can strengthen health literacy and improve the positive health impacts of communications between healthcare and public health professionals (including dentists, healthcare delivery organizations, and public health entities), and consumer or patient audiences that vary in health literacy, is needed" (Department of Health and Human Services, 2004).

Published research on health literacy has increased in subsequent years. However, the majority of research is from the USA. According to a study into research in the area of health literacy by Kondilis et al. (2008, p.1) health literacy was a research area that is "considerably neglected in the EU." They found that European countries produced less than one third of health literacy research when compared to the U.S.

Paasche-Orlow, Wilson and McCormack, (2010) again highlighted the increase in research in health literacy by looking at the number of references for "health literacy" as a topic, which showed that there was "tremendous growth of research in this field." They stated that,

> "in the 5 years between 1986 and 1990 there are 129 references in Pubmed." compared to "between 2006 and 6/6/2010, there are already 1576 references returned" (Paasche-Orlow, Wilson and McCormack, 2010, p.6).

The development of the research may have come to a similar point as scientific literacy research, where there are many definitions and models, with confusion over what health literacy really means. Indeed, some researchers seem to be suggesting that health literacy itself is a term too many, and is perhaps a simply a combination of some older terms (Tones, 2002; Wills, 2009).

The lack of consensus in health literacy research is similar to that of scientific literacy and so again, it could be worthwhile to revisit health literacy from the perspective of free choice learning and working knowledge. This fits with Zacadoolas, Pleasant and Greer's (2003) proposal that:

> "Investigating how health communication and education, individual capacities, and social processes interact to create health literate citizens is exciting and important. Broadening the lens through which we investigate these complex abilities is the next step in learning how health literacy develops and can be fostered" (Zarcadoolas, Pleasant and Greer, 2003, p.120).

HEALTH LITERACY, FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

There is very little discussion of free-choice learning and/or working knowledge in health literacy research, but they must have a relationship. Working knowledge must be part of health literacy, or have an influence on it, because it includes attitudes, beliefs, values, behaviours, knowledge and understanding. Specifically, we all have our own ideas of what good health is. Additionally, our own experiences, knowledge, values and feelings with regards to our health and the health of friends and family mean that health literacy is firmly based on working knowledge. Importantly, being health literate does not necessarily correspond with good health. I may know why and how smoking is bad for my health but continue to smoke regardless of my knowledge and understanding. In other words, values, attitudes and beliefs are also important. As Zarcadoolas, Pleasant and Greer (2005, p.195) stated, there is "a long and yet unfinished history of investigating how individual capabilities and social processes explain or predict health."

As health literacy is linked to working knowledge it would be useful to investigate its models and definitions from the perspective of working knowledge and free-choice learning. Also, the similarities between health literacy and scientific literacy should be looked at not least to look for areas of best practice that could be shared. These ideas seem to agree with Schulz and Nakamoto (2005) when they say:

> "there is a need to explore expanded visions, particularly a vision that highlights the ultimately subjective nature of a person's interaction with health information" (Schulz and Nakamoto, 2005, p.8).

This study can be part of this expanded vision by investigating health literacy ideas from the perspective of working knowledge and looking at what the fields of scientific literacy and health literacy can learn from each other.

In summary, research in scientific literacy and health literacy show a similar lack of consensus. Again, it is of worth to revisit health literacy from the perspective of free-choice learning and working knowledge. The fields of health literacy and scientific literacy seem to have developed at different speeds and in different directions. Examining the evolution of the two terms with regards to their definitions and models may provide clues as to which direction the areas could now take as well as best practice that could be shared between the two areas.

SUPPORT FOR RESEARCH

One thing the fields of public understanding of science, scientific literacy and health literacy, have in common is that confusion reigns. There are clear overlaps between many of the ideas outlined above and perhaps work could be done to decide on the terminology and models to be used in the field. There is a need for some work to narrow down the terminology and models into a more cohesive field. This would allow research to be shared within and across these related fields.

Bitgood, Serrell and Thompson (1994) agreed:

> "authors/speakers are reinventing ideas and proposing solutions they think are original, when they could be building on existing ideas and helping advance them further" (Bitgood, Serrell and Thompson, 1994, p.86).

Bell et al. (2009) added:

> "There is an interdisciplinary community of scholars and educators who share an interest in developing coherent theory and practice of learning science in informal environments. However, more widely shared language,

> values, assumptions, learning theories, and standards of evidence are needed to build a more cohesive and instructive body of knowledge and practice" (Bell et al., 2009, p.305).

The ideas of working knowledge and free choice learning have some part to play in the different arenas, but there has not been enough work done to start to suggest what role they will perform. "Research on free-choice science learning is in its infancy, both directionally and theoretically" (Martin, 2001, p.187).

It is important for free-choice learning settings/providers that the process of developing working knowledge is better understood. Falk, Storksdieck and Dierking (2007) proposed that more research is required to understand the public's working knowledge of science:

> "the key to future success in public science education depends upon achieving a more accurate understanding of the where, when, how, why and with whom of the public's science learning, across their lifespan and the myriad settings in which they learn science" (Falk, Storksdieck and Dierking, 2007, p.464).

and:

> "future efforts to understand and support the public's understanding of science will require approaches that take into account individual differences and the unique personal and context-specific nature of knowledge" (Falk, Storksdieck and Dierking, 2007, p.465).

As far back as 1982 Falk was writing:

> "The more we understand about where, how, and why people learn science, the easier it will be to design educational materials for learning across the age- and life-span" (Falk, 1982, p.83).

Hein underlined the importance he placed on understanding visitor experiences,

> "I believe that focusing on visitors, the meanings they attribute to their experiences, and their understandings, is the most useful way to develop exhibitions and programs that will allow visitors to have satisfying museum experiences and allow museums to maximise the inherent potential of objects to contribute to human growth and learning" (Hein, 1998, pp.12-13).

This view was supported by Leinhardt and Knutson who said:

> "In the last decade there has been a constant call for an expanded vision of museum learning, one that focuses on what visitors contribute to the process" (Leinhardt and Knutson, 2004, p.51).

More recently, Falk and Dierking (2010, p.489) again stated the importance of free-choice learning and how their research shows that "free-choice learning experiences represent the single greatest contributors to adult science knowledge." However, they once more commented on the need for further research saying:

> "Insufficient data exist to conclusively demonstrate that free-choice science learning experiences currently contribute more to public understanding of science than in-school experiences, but a growing body of evidence points in that direction. There certainly are insufficient data to refute the claim that free-choice learning is vitally important" (Falk and Dierking, 2010, p.493).

With regards to what is known about learning science outside of school, Martin (2004) also pointed out the need for more research:

> "When it comes to non-school contexts for learning science, less is known about how the instructional setting or people's everyday experiences with nature affect their knowledge, understanding, and interest in fundamental ways" (Martin, 2004, S73).

Falk and Dierking (2002) stressed the importance of free-choice learning as it is "the single most dominant form of learning" (p.6) and "the most common type of learning in which people engage" (p.9). They added that despite of its importance the fact that it occurs mostly "outside of the imposed structure and requirements of schools, universities, or workplaces makes it at once extremely interesting and chronically underrecognised" (Falk and Dierking, 2002, p.9).

Hein (1998) explained the importance of understanding how visitors interact with museums:

> "In order for visitors to grow and learn from their museum experiences, we need to understand these experiences sufficiently so that we can shape them. We need to understand what meaning visitors make of their museum experiences"(Hein, 1998, p.2).

He adds:

> "The need to consider what meaning visitors make of their museum experience comes from two different sources: the increasing importance of the educational role of museums; the increasing pressure on museums to justify their existence" (Hein, 1998, p.3).

The fact that entrance to many museums in the UK is now free means that they are more accountable to the Government who subsidise the free admission. Other free-choice learning providers with entrance charges, such as Glasgow

Science Centre, must justify their activities to their funders. This was confirmed by Bitgood, Serrell and Thompson (1994, p.65) “Along with the greater availability of educational exhibits has come more emphasis on accountability and evaluation.” Frankel (2001) believed that research done in free-choice learning environments could help free-choice learning make a stronger case to the public policy community.

Previously the impact of free-choice learning providers has been measured using, among other techniques, Generic Learning Outcomes (GLOs). GLOs take into account learning theory that recognises that learning includes change and development in emotions, skills, behaviour, attitudes and values (Research Centre for Museums and Galleries, 2003). Looking at changes to working knowledge may provide an alternative measure of impact.

Furthermore, Feher and Diamond (1990, p.28) stated additional outcomes of doing research in science centres and museums, “research activity fosters the cross-fertilisation of ideas and the involvement of professionals from other disciplines in museum activities.” Also, research “enhances the intellectual stature of science museums and their role as centres for innovation” (Feher and Diamond, 1990, p.28).

Falk and Storksdieck (2005) emphasised the importance of doing research into learning in science museums saying:

> “Few activities will be more important to 21st century free-choice science education institutions in general and science museums in particular than meaningfully understanding the learning they facilitate” (Falk and Storksdieck, 2005, p.745).

Bell et al. (2009) added that although it is important to study the impact of science learning in informal environments it may be even more important to look at how science learning occurs across a range of environments (formal and informal). They proposed that more research should look at learner’s “cross-cutting experiences” as current work is divided (formal and informal) in ways that “are at odds with how people routinely traverse settings and engage in learning activities” (Bell et al., 2009, p.312). Muscat (2001, p.202) discussed the need to “quantify the affective and cognitive impact of free-choice models of educational practice and conduct research that examines learning in a broader context." Leinhardt and Knutson (2004, p.17) also agreed with the "need to examine how informal settings fit into a larger picture of how we expand knowledge and wisdom over time."

Working knowledge could also be useful in trying to gain an understanding of how free-choice learning can be integrated into formal education and how formal education can provide skills for free-choice learning.

> "Another area of general agreement was that research on informal learning in museums should relate people's museum experiences to other educational experiences, effectively placing museums and museum learning in a "larger societal context" (Falk, Dierking and Holland, 1995, p.23).

and:

> "The more we understand about where, how, and why people learn science, the easier it will be to design educational materials for learning across the age- and place-span" (Falk, 1982, p.83).

The BodyWorks exhibition is perfectly placed to investigate free-choice learning, working knowledge and their importance. BodyWorks provides an opportunity to explore working knowledge and how individuals construct knowledge by adding experiences, learning, opinions, etc. from different sources together. An insight into this working knowledge and the resources people use to gain this knowledge may provide valuable information for advancing the research field, measuring impact of free-choice learning providers, justifying the existence (and funding) of providers and improving activities and exhibits in science centres and museums. This follows from Falk, Storksdieck and Dierking's (2007) suggestion that:

> "by more deeply understanding where, how, when, why and with whom the public comes to learn science, science educators should be able to become more strategic, and able to leverage limited resources and access by actively building upon the public's existing science and technology learning needs and interests" (Falk, Storksdieck and Dierking, 2007, p.464).

SUMMARY

Although free-choice learning and working knowledge are relatively new terms, their importance seems to be indicated by how they overlap and integrate with so many previous ideas and research. However, empirical research on their importance is required. The BodyWorks exhibits provide an opportunity to investigate free-choice learning and working knowledge with the goal of contributing to a better understanding of their importance.

In addition, free-choice learning and working knowledge provide a new perspective with which to revisit the extensive work carried out in the fields of scientific literacy and health literacy. This could result in a sharing of best practice between fields and innovative directions for future research.

Therefore the research questions to be addressed in this thesis were:

1. Can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?
2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?
3. What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?
4. Can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

IN THE NEXT CHAPTER...

... theoretical issues that arise when researching free-choice learning are considered with the purpose of placing the current study, and its research questions, within a methodological perspective.

CHAPTER 3 - WHAT ARE THE THEORETICAL DIFFICULTIES IN RESEARCHING FREE-CHOICE LEARNING?

At this point the researcher's positionality with respect to this work should be noted. Having previously worked in science centres and studied for a postgraduate degree in Communicating Science the researcher has experience and positive views toward free-choice learning. This background has provided the interest and motivation to research this area. In addition, this has inclined the researcher to evaluate free-choice learning in a way that will be of practical use to others. As the researcher has not worked for a free-choice learning provider for around six years they have a more critical and reflective stance on the area.

The researcher's ontological and epistemological position draws upon interpretivism. As a result, this work takes people's meaning-making and social interactions to be part of the phenomena of the world and aims to look at what people think and do. Therefore this research begins with individuals and sets out "to understand their interpretations of the world around them" (Cohen, Manion and Morrison, 2011, p.18). Accordingly the methods used in this work involve gathering data from people and so are likely to be naturalistic and involve interviews and observations (Mackenzie and Knipe, 2006) as evidence to help address the research questions.

The literature review guided this thesis from looking generally at free-choice learning and working knowledge of science to the following more specific questions:

1. Can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?
2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?
3. What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?
4. Can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

The first two questions lend themselves to empirical inquiry, whereas the revisiting of previous research is of a more theoretical nature. Theoretical frameworks and methodological issues of the empirical research are now discussed and leads to the development of methods of data collection and analysis appropriate to the research questions.

It initially seemed like a straightforward task to place the ideas and definitions of working knowledge and free-choice learning into an existing methodology or theoretical framework. After further thought, it was realised that the task is a difficult one and that both working knowledge and free-choice learning span numerous educational paradigms and theories of learning, knowledge and teaching. Of course, this has had implications for the methodological approach and the methods used in the investigation.

Free-choice learning and working knowledge are considered below in terms of major theories in an attempt to tie down the most suitable theoretical framework on which to pin the current study, its research questions and methods. As far as possible, methodologies that have been previously discussed, or applied, in relation to free-choice (or informal) learning environments have been used. There were two reasons for this, the first being a simple attempt to constrain the methodology to one area. Methodologies from overlapping areas including, communication studies, risk communication and, of course, formal education could be explored but by concentrating on free-choice learning some focus was provided. Secondly, the background of the researcher is in free-choice learning and so experience and interest lie mainly within this field.

LEARNING

Perhaps the first concept that needed to be tied down and defined is that of learning itself. Despite it being an essential term, it is difficult to find definitions of what is meant by learning within the free-choice learning research. Anderson, Lucas and Ginns (2003) reported that:

> "Explicit definitions of what is meant by the term learning have been notably absent from much of the published literature on learning in museums and similar locations during the 1990s" (Anderson, Lucas and Ginns, 2003, p.178).

Falk and Dierking (1995, p.10) also mentioned that defining learning "has generated considerable debate within the museum community." This lack of consensus on a definition of learning is perhaps a contributing factor to the theoretical issues discussed below as well as problems with measuring the impact of free-choice learning resources. If one wants to measure "learning" you need to know what you mean by "learning".

The Oxford Dictionary's (2010) definition of learning "the acquisition of knowledge and skills through study, experience, or being taught" covers free-choice learning in so much as it can contain study, experience, or being taught. Other definitions of learning go beyond simply the acquisition of knowledge and include the processes of that knowledge being assimilated and accommodated into existing knowledge. For example, Falk and Dierking (1992) stated that:

> "Learning involves more than mere assimilation of information; it requires the active accommodation of information in mental structures which permit its use at a later time" Falk and Dierking, 1992, 113).

They also emphasised three additional dimensions of learning: personal; social; and, physical contexts. These are part of the Contextual Model of Learning, discussed below (Page 75).

Leinhardt and Knutson (2004) also described the integration and change of learning:

> "Traditionally, in both the cognitive and constructivist views, learning has been defined by psychologists and educators as some level of cognitive change: reorganisation of familiar ideas, concepts, facts, and procedures; acquisition of new ideas; and abandonment of false or faulty ideas" (Leinhardt and Knutson, 2004, p.4).

Although these definitions are useful, they are concentrating on cognitive change. Working knowledge contains more than simply cognitive elements of skills and knowledge. Put quite simply, Falk, Storksdieck, and Dierking (2007, p.455) described science learning as "broadly defined to include attitudinal and behavioural change, as well as changes in conceptual understanding." In other words, science learning is not just about learning facts and concepts; it also involves changes in attitude, values, beliefs and includes aesthetic understanding and psychomotor skills (Falk and Dierking, 2002, p.5). This corresponds with the idea of working knowledge.

So definitions that include the more affective side of learning are more appropriate to working knowledge. Jarvis, Holford and Griffin's (2003) definition is moving in this direction:

> "Human learning occurs when individuals, as whole persons (cognitive, physical, emotional and spiritual), are consciously aware of a situation and respond, or try to respond, meaningfully to what they experience and then seek to reproduce or transform it and integrate the outcomes into their own biographies. In this instance, biography is the totality of our experience, which is an integrated combination of the cognitive, emotive and physical, and learning is the process through which individuals grow and develop" (Jarvis, Holford and Griffin, p. 67, 2003).

Indeed, the term "biography" used in this definition seems to be a comparable idea to that of working knowledge.

So a definition of learning that fits with free-choice learning and working knowledge should include the aspects of accommodation and assimilation as well as allow for the affective side of learning. In addition, it should be remembered, "learning is both a verb and a noun, a process and a product" (Falk and Dierking, 1995, p.10).

For the current study, an operational definition of the process of learning from the perspective of working knowledge could be:

> The process of learning occurs when an experience interacts with an individual's working knowledge in such a way that it reinforces, adjusts, or adds to that working knowledge.

This definition of course takes for granted that working knowledge contains affective aspects as well as cognitive and physical. In other words, working knowledge includes not only facts, understandings, skills but also, opinions, attitudes, beliefs. It should be emphasised that the process of learning is individual:

> "learning is highly individualistic in nature, we believe that no two visitors will have the same prior knowledge or learning experiences in the museum" (Anderson, Lucas and Ginns, 2003, p.196).

and also, the process of learning occurs over time, it is iterative:

> "Learning that occurs today depends on yesterday's learning and is the foundation for tomorrow's learning. The cumulative, iterative process of learning emphasises the importance of time" (Rennie, 2007, p.130).

The operational definition used here does not concern itself with whether the knowledge is reinforced, adjusted, or added to with correct or incorrect information. All learning, whether correct or flawed, contributes to the construction of working knowledge. This definition allows for the consideration that, as described by Davis, Horn and Sherin (2013, p.32), “being “wrong” is an inescapable part of learning.”

THEORETICAL/METHODOLOGICAL ISSUES IN FREE-CHOICE LEARNING

There is a lack of consensus on the most applicable theoretical perspective to apply to free-choice (or informal) learning. This has lead to a range of theoretical frameworks being used and in some cases it is unclear which framework is being applied as none are explicitly stated.

Back in 1994, Bitgood, Serrell and Thompson were already noting the problems with theoretical frameworks in the area:

> “No theories or practical advice for the field have sprung into consciousness fully formed, clearly defined, and universally accepted. Rather, the process is one of muddling: slowly dealing with the issues when time and funding allow, making progress, falling short of lofty objectives, arguing and making mistakes” (Bitgood, Serrell and Thompson, 1994, p.85).

The lack of consensus and unclear nature of the research may be explained by a number of issues mentioned in the literature. The main issues appear to be: too many potential theoretical perspectives; concentration of work on evaluation rather than research; and, difficulties in applying formal perspectives to informal environments.

TOO MANY POTENTIAL PERSPECTIVES

One problem with choosing one particular methodology with which to investigate free-choice learning is that the learning can take place in any number of ways. It could fit anywhere from behaviourist ways of learning through to constructivism to self-directed learning. When given the choice to learn how and when and where we want to, everyone will learn differently. It is difficult to tie this to one theory. Without a teacher people will “teach” themselves how they want. As stated in the operational definition of learning for this study, learning is individual. “Learning is a personal process, it is different for each person” (Rennie, 2007, p.128).

Bell et al., (2009) discussed this problem and suggested that behavioural, cognitive and sociocultural perspectives have all influenced the design of informal learning environments and as a result:

> “a number of theoretical views are in play in the research and they are not particularly well integrated. This limits the degree to which the study of learning science in informal environments functions as a field” (Bell et al., 2009, p.31).

Despite the issues with theoretical frameworks being raised and discussed back in 1994 (Bitgood, Serrell and Thompson, 1994; Crane, 1994b), over fifteen years later the same problems exist. In 2010 Phipps published a useful review of research on informal science education and free-choice learning between 1997 and 2007. She found that although research in informal and free-choice science learning is becoming more sociocultural and constructivist in nature, research has also been in the behaviourist and experiential paradigms. It is perhaps a problem for free-choice learning that it can span so many paradigms and this may be the reason that Phipps (2010, p.17) found that, “Many authors were not explicit in their definition of learning or the theoretical underpinnings of their studies.” Maybe it is just too difficult to tie down free-choice learning to one paradigm. Free-choice learning can take place in a vast number of ways in a vast number of places. To tie it down to one paradigm would be like tying formal education to a single theoretical framework. However, the choice between using an imperfect paradigm and not doing the research at all should be an easy decision to make. As Bitgood, Serrell and Thompson explained:

> “All theories are flawed, but that does not mean that they are not useful. By being hesitant to use imperfect paradigms or becoming paralysed with a fear of error and bias, museum practitioners can do the worst: nothing” (Bitgood, Serrell and Thompson, 1994, p.88).

and:

> “Will there ever be agreement in the field of visitor studies in the right thing to measure and the right way to measure it? Probably not, but there really doesn’t need to be for the field to make progress” (Bitgood, Serrell and Thompson, 1994, p.89).

In an almost opposing view to the problem of too many potential theoretical perspectives, Crane suggested the problem might be that within free-choice learning there is a lack of theory. Crane (1994b) suggested that informal learning is "undertheorised" and that we need to ask what are the theories and principles that guide informal learning:

> "As the informal learning field grows, researchers need to demonstrate a much greater willingness to take risks in developing new models and methodologies" (Crane, 1994b, p.186).

Also, more recently, while outlining two large studies of informal learning by the Wellcome Trust (the results of which will become available during the completion of this thesis, see Page 265), Sir John Holman wrote:

> "Education often suffers from an excess of theory and a shortage of pragmatism, but informal learning is one field where I believe we do need a better theoretical framework" (Holman, 2011).

Bitgood, Serrell and Thompson (1994, p.86) also suggested that researchers may not be familiar enough with the work that has been done before leading to reinventing ideas rather than "building in existing ideas and helping advance them further." This is evidenced in the number of ideas found in the current study that are similar to working knowledge and also the range of definitions and models in the area of scientific literacy looked at later (Chapter 6).

CONCENTRATION OF WORK ON EVALUATION RATHER THAN RESEARCH

Schauble, Leinhardt and Martin (1997, p.3) also discussed how research in informal learning in museums lacks coherence however they suggested this might be partly due to research concentrating on evaluation rather than being "grounded in theory or motivated by the goal of constructing a cumulative knowledge base."

Bitgood, Serrell and Thompson (1994) discussed how confusion between the terms evaluation and research may have meant that evaluation studies have received criticism unfairly for their lack of theoretical research practices. The search for a measurable, quantifiable impact and the need to present these and to be accountable to funders could be what has held back on exploratory, more qualitative studies on free-choice learning.

From first look the research carried out in this thesis could be viewed as being accountable to funders. The PhD work and the BodyWorks exhibition both being funded by GlaxoSmithKline. However, the funding for the research was not based on it providing an evaluation of BodyWorks. Glasgow Science Centre have carried out their own evaluation of the exhibits. The only stipulation of the funding of the PhD being that the research included the BodyWorks exhibits. The advantages and disadvantages of using these exhibits is discussed in depth later (Page 239).

However, the pressure for some free-choice learning providers to be accountable to their funders exists elsewhere. This may create tension between the necessity of carrying out evaluation and the desire to research. The fact that there is still a need for an accepted measure of impact of activities (see, for example, Lloyd et al., 2012; Falk et al., 2012) suggested more research is needed before useful and comparable evaluations can be completed. Despite not being an evaluation this study has considered that working knowledge could in some way be used as a measure of impact. However, it certainly hasn't set itself out as an evaluation to test if the aims of the BodyWorks project have been met. In fact, the aims of the exhibits were not looked at by the researcher until after the empirical research was completed and analysed (see Page 145).

Perhaps publication of work such as the Framework for Evaluating Impacts of Informal Science Education Projects (Friedman, 2008) and the Learning Impact Research Project (LIRP, 2002; RCMG, 2003) have gone some way towards measuring impacts so that other, more experimental/theoretical, research can be developed separately.

DIFFICULTIES IN APPLYING FORMAL PERSPECTIVES TO INFORMAL ENVIRONMENTS

Bitgood, Serrell and Thompson (1994) also pointed out the problem with using the wrong methodology for the wrong situation. Specifically, "formal education strategies are bound to be difficult and inappropriate in settings that lack structure and contain a diverse audience" (Bitgood, Serrell and Thompson, 1994, p.86). As the majority of theoretical frameworks are based in formal education, and not free-choice learning, this is going to be a regular difficulty. Schauble, Leinhardt and Martin (1997) also discussed how learning research has not involved informal contexts and the difficulties associated with trying to apply formal learning research to informal settings stating that “assumptions and methods are often inadequate for the very different learning challenges and opportunities in museums” (Schauble, Leinhardt and Martin, 1997, p.3).

Martin (2001) agreed with this problem saying:

> “The problem of studying an uncontrolled environment as well as the problem of identifying mental tools people bring to bear in those settings can also be extremely different from those in schools, which have been well-studied. Research tells us that free-choice learning does appear to have certain distinct characteristics that would be missed if we applied only traditional methods of research” (Martin, 2001, p.192-193).

As mentioned by Phipps (2010) informal researchers are sometimes not explicit in stating a particular theoretical framework for their work. This may be because researchers in the free-choice arena avoid theories rooted in formal education as they see it as distant and in many ways opposite to the background of free-choice learning. The lack of theories based specifically in free-choice learning mean there is no framework to fit their work.

There has been one notable framework developed to describe learning in free-choice learning environments. The Contextual Model of Learning (CML) (Falk and Dierking, 2000) suggests that learning has personal, social and physical contexts and that it occurs over time. The personal context of the model has been discussed here previously (Chapter 2, Page 35) as being related to the idea of working knowledge. However, Falk and Dierking (2000, p.11) stated that the contexts are “not really separate, or even separable” suggesting the framework should be considered as a complete framework.

The CML contains eight key factors that influence learning. Of these, this current study seems to be concentrating on “Prior knowledge, interests and beliefs” located within the Personal Context. In other words, only one eighth of the CML is specifically relevant at this point, so it is probably not the ideal framework for this study.

The CML is a useful framework for research in that it helps us to know "where and how to look for learning" (Falk and Dierking, 2000, p.149). It is also useful in that it appears to be straddling socioculturalism and constructivism perspectives and so can be used to look at learning by both groups and individuals. The constructivist perspective is seen when Falk and Dierking (2000, p.12) described all learning as "a cumulative, long-term process, a process of making meaning and finding connections." Whereas the sociocultural perspective is covered by the description, "All learning is built upon previous learning, not just of the individual, but of the entire society in which that individual lives" (Falk and Dierking, 2000, p.43).

Falk and Storksdieck (2005) showed that the CML can be useful for looking at experiences in museums. However, they did think that it needed more work:

> "Although we believe the current Contextual Model of Learning to be an excellent first step in describing the complexity of museum learning experiences, we are willing to believe that it is not yet a mature or complete framework" Falk and Storksdieck, 2005, p.771).

Phipps (2010) reported that the CML is increasingly being used as a framework for research in informal learning. However, sociocultural and constructivist perspectives still dominate. These perspectives are now discussed in terms of working knowledge and free-choice learning.

CONSTRUCTIVISM

As discussed briefly in the Literature Review (Page 31) when thinking about working knowledge, and free-choice learning, it is the constructivist area of educational theory that immediately seems most appropriate. Many researchers have discussed informal or free-choice learning from this viewpoint. Some think museums and constructivism are a perfect match, for example Hein (1998) and Jeffery-Clay: "Museums may be the perfect environments in which to use constructivist theory and observe meaningful learning" (Jeffery-Clay, 1998, p.5).

The following definition of constructivism fits with working knowledge and the process of building up personal knowledge in everyday or free-choice environments:

> "construes learning as an interpretive, building process by active learners interacting with the physical and social world. It is a psychological theory of learning that describes how structures and deeper conceptual understanding come about, rather than one that simply characterises the structures and stages of thought or one that isolates behaviours learned through reinforcement" (Twomey Fosnot, 1996, p.30).

Hein (1998) discussed learning in museums in terms of constructivism. His description of constructivism as "learning that requires active participation of the learner" (Hein, 1998, p.34) is similar to Falk's (2001, p.7) description of free-choice learning as "self-paced and voluntary" and of working knowledge as "generated by the learner's own interests and needs" (Falk, Storksdieck, and Dierking p.464). Also, the way in which Leinhardt and Knutson (2004, p.4) described constructivist learning as emphasising "the role of the learner in actively seeking and building knowledge upon his or her prior knowledge and beliefs" is similar to Falk, Storksdieck, and Dierking's (2007) idea of working knowledge being generated by a learner's personal "interests and needs" (p.464) and constructed over a lifetime (p.458). Similarly, Shapiro (1994, p.8) described the role of the learner in the constructivist perspective as, "not to passively receive information, but to actively participate in the construction of new meaning" and "approaches to teaching and learning should begin by understanding what it is that learners bring to learning" (Shapiro, 1994, p.xiv).

Hein (1998, pp.34-35) pointed out that "All of us interpret nature and society differently, depending on our own background and experience." Dierking et al. (2003) had a similar view in relation to the construction of science knowledge, stating that the experiences children and adults have "dynamically interact to influence the ways individuals construct scientific knowledge, attitudes, behaviours, and understanding" (Dierking et al., 2003, p.109). It could be said that working knowledge is the "scientific knowledge, attitudes, behaviours, and understanding" described by Dierking et al. (2003, p.109) and it is constructed from the "background and experience" mentioned by Hein (1998, p.35). Dierking et al. (2003, p.109) summarised this saying, "Learning in general, and science learning in particular, is cumulative, emerging over time through myriad human experiences."

Falk (2001) described a simple example of how science knowledge might be constructed:

> "an individual's understanding of the physics of flight might represent the cumulative experience of completing a classroom assignment on Bernoulli's principle, reading a book on the Wright brothers, manipulating a science centre exhibit on lift and drag, and watching a television programme on birds. All of these experiences are combined, often seamlessly, by the person to construct a personal understanding of flight; no one source of information was sufficient to create this understanding, nor was one single institution solely responsible" (Falk, 2001, p.14).

It is the contribution of free-choice learning to this understanding that forms working knowledge. This is an example of how "All of our learning happens continuously, from many different sources and in many different ways" Falk and Dierking (2002, p.10).

When discussing theories of teaching, Hein (1998) described constructivism in a way that related it closely to working knowledge and some of the questions this present study aimed to answer in relation to the BodyWorks exhibition:

> "If people construct knowledge, then we have to ask: what knowledge resides in their minds, regardless of the formal structure of the subject? It becomes much more important to look at the learner, and to ask: what ideas does this learner have, regardless of formal education?; what are visitors' previous experiences?" (Hein, 1998, pp.36-37).

Pope and Gilbert (1983, p.193) suggested that science education should take into account the role of personal construction in the development of scientific knowledge. Although they suggested this in terms of formal education, the idea of personal construction or personal constructivist perspective has appeared in the informal learning literature (For example, Afonso and Gilbert, 2006).

One aspect of constructivism that is particularly suitable for describing working knowledge is John Dewey's Theory of Experience. It is appropriate because, like working knowledge, it is not only describing cognitive learning but also the more affective aspects of learning. This was commented on by Jarvis, Holford and Griffin:

> "One of the major strengths of this approach to teaching and learning, is that the whole person does the experiencing rather than just the individual's mind or body. By the whole person we mean the cognitive, the physical, the emotional and the spiritual: that is, the individual's

> knowledge, skills, attitudes, values, beliefs, emotions and senses" (Jarvis, Holford and Griffin, 2003. p.55).

Jarvis, Holford and Griffin (2003, p.66) also discussed how experiential learning takes place in everyday life, "sometimes deliberately but often incidentally." This is similar to Falk, Storksdieck and Dierking's (2007, p.459) description of free-choice learning and how "some of what we learn we learn rather incidentally, without consciously wanting to learn."

The following passage written by Dewey (1938) is comparable to how we would describe working knowledge being developed:

> "As an individual passes from one situation to another, his world, his environment, expands or contracts. He does not find himself living in another world but in a different part or aspect of one and the same world. What he has learned in the way of knowledge and skill in one situation becomes an instrument of understanding and dealing effectively with the situations which follow. The process goes on as long as life and learning continue" (Dewey, 1938, p.44).

As well as Dewey's Theory of Experience, George Kelly's Personal Construct Psychology is also applicable to working knowledge. Novak links Dewey and Kelly by suggesting:

> "Dewey provides the basic ontological and social grounding for a perceptual pedagogy, and Kelly supplies the potential psychological principles necessary for implementation" (Novak, 1983, p.327).

Pope and Gilbert (1983) discussed the role of Personal Construct Psychology in terms of science education. They described how Kelly proposed that every individual has their own "representational model of the world" (Pope and Gilbert, 1983, p.197) to allow them to make sense of it. They described how Kelly's idea of personal constructs are "used by a person to describe present experience and to forecast events" (Pope and Gilbert, 1983, p.197). This is how we would expect working knowledge to be used. In particular, their outline of how Kelly sees the uniqueness and constantly changing constructs, is very closely related to the idea of working knowledge:

> "Kelly's main emphasis is of the uniqueness of each person's construction of the world and the construct systems each will evolve and continue to evolve in order to import meanings of their experiences" (Pope and Gilbert, 1983, p.197).

Shapiro (1994, p.xv) also discussed Kelly's Personal Construct Theory (PCT) and how he proposes that we view an individual as "a person who views the world in his or her own unique manner and whose view has individual integrity."

If we look again at the operational definition of learning for this current study (Page 70) it can be seen that this corresponds with the perspective of Kelly's PCT. In particular, PCT relates to this definition in terms of learning being a process, occurring over time, including affective aspects and involving the reinforcing, adjusting or adding to working knowledge. With regards to learning as a process, Kelly's PCT has been described as a "psychology of processes" (Salmon, 203, p.312) and that Kelly focused on "the general processes by which people made sense of and navigated the social world" (Fransella and Neimeyer, 2003, p.27).

PCT allows for learning to have affective aspects, for working knowledge to include not just facts and understandings, but also opinions, attitudes, beliefs: "Kelly's theory can deal with feelings and emotions equally as well as it deals with thoughts or cognitions" (Chiari and Nuzzo, 2003, p.59).

PCT is closely related to learning involving the reinforcing, adjusting or adding to working knowledge. This is seen specifically in Kelly's constructive alternativism which he explained as: "all of our present perceptions are open to question and reconsideration" (Kelly, 1970, p.3). Salmon described this as "the shifting of meanings" and knowledge as "temporary and open to change" (Salmon, 2003, p.312). Fromm saw Kelly's construing, as "an ongoing flow of countless discriminations between events of all kinds" (Fromm, 2003, p.321).

PCT also relates to Falk's ideas of free-choice learning in terms of learning taking place from experiences and events. Kelly's Experience Corollary describes this as "a person's construction system varies as he successively construes the replications of events" (Kelly, 1970, p.12). PCT also fits with free-choice learning and of individuals learning all the time, with their own motivations. Fromm (2003) says, "As Kelly put it, people do not need to be pushed or pulled to learn. People in this view are not forced to deal with the ongoing events in their lives, they just cannot help doing it" (Fromm, 2003, p.321).

The personal nature of PCT matches with the individual nature of working knowledge. In particular, Kelly's Individuality Corollary simply states how "persons differ from each other in their constructions of events" (Kelly, 1970, p.9). Bannister describes this as:

> "Our worlds are different, not simply because we have experienced or are experiencing different events but because we interpret differently the events we do experience" (Bannister, 2003, p.34).

Also worth noting is that the current thesis is set out to investigate free-choice learning and working knowledge of science and in PCT Kelly views *man as a scientist*. Bannister outlines this as:

> "Your experiments/behaviour will cast various lights on your hypotheses/expectations - sometimes you will be right, sometimes you will be wrong and sometimes you will find the outcome of your ventures totally irrelevant to the terms in which you frame them. Then you will modify, change, reformulate your theory/notions of what you are like, and what other people are like, and what the world is like" (Bannister, 2003, p.34).

The hypotheses and expectations here could be working knowledge and the experiments/behaviour the free-choice learning which modifies, changes or reformulates your theories/notions (working knowledge). This again correlates with the operational definition of learning for the current work (Page 70) where the process of learning involves working knowledge (theories/notions) being reinforced, adjusted or added to (modified, changed, reformulated) following interaction with an experience (experiments/behaviour).

By aiming to find evidence of, and gain a better understanding of, free-choice learning and working knowledge (research questions 1 and 2) this study may add evidence and understanding to the idea of man as a scientist. Fromm suggests this is important to PCT:

> "Seen from a personal construct view this is a question yet to be answered: How do people manage to process the overabundant input of information to make it personally meaningful knowledge?" (Fromm, 2003, p.326).

When considering the learning that is emergent from individuals' informal learning experiences Anderson, Lucas and Ginns (2003) made use of a human constructivist view of learning. In ways this fits with the current study, for example it:

> "recognises that individuals' present conceptions are products of diverse personal experiences, observations of objects and events, culture, language, and teachers' explanations" (Anderson, Lucas and Ginns, 2003, p.180).

The significant difference between Anderson, Lucas and Ginns' work and this present study is that the former examined learning that emerged from a museum-based experience, whereas, this current study looked at learning prior to the museum experience (interaction with BodyWorks exhibits) being brought out by the experience. Yet how Anderson, Lucas and Ginns (2003, p.181) described the human constructivist view as recognising "the individual's prior knowledge and personal active involvement in knowledge construction" certainly fits with working knowledge.

Although constructivism fits with working knowledge and it is widely discussed in terms of free-choice learning environments, it is not the only paradigm to fit. Leinhardt and Knutson (2004) suggested that a problem with the constructivist view is seeing it as the *only* way to explain or understand learning:

> "It cannot be argued that learning is not a process of accommodation of new information and ideas. But it can be argued that there may be more to the story and more that is of interest to educators to be considered" (Leinhardt and Knutson, 2004, p.4).

Despite the wide use and consideration of constructivism by free-choice learning researchers, Phipps (2010) reported that some research in this area is becoming more sociocultural in nature.

SOCIOCULTURALISM

In their paper titled "A Framework for Organizing a Cumulative Research Agenda in Informal Learning Contexts", Schauble, Leinhardt and Martin (1997) suggested a sociocultural framework as a suitable theoretical approach for directing informal learning research. Their arguments for sociocultural theory are applicable to the idea of working knowledge in a number of ways. In particular, they suggested that:

> "this perspective throws light on the variability of learning, processes of learning, and the role of learning in personal history and the pursuit of meaning" (Schauble, Leinhardt and Martin, 1997, p.4).

The variability of learning would be related to the individual nature of working knowledge, and the processes of learning include how working knowledge is developed, changed and added to. Perhaps personal history is related to how personal experiences contribute to an individual's working knowledge and the pursuit of meaning could be how working knowledge is developed because of a personal interest or need.

Schauble, Leinhardt and Martin (1997) didn't include the constructivist perspective, not even with the purpose of dismissing it. This was despite the way that constructivism could be seen to overlap with their framework in places. For example, in the way they described sociocultural theory as developmental and having:

> "emphasis on identifying the role of meaningful encounters and events in the sweep of a person's life history, including investigation into how that meaning may shift at different points in the life span" (Schauble, Leinhardt and Martin, 1997, p.4).

This causes Schauble, Leinhardt and Martin's framework to feel limiting as it was set out as sociocultural, but hinted strongly at ideas based in constructivism without discussing any overlap.

It should be noted at this point that the socioculturalist perspective seems appropriate to the theme and content of the BodyWorks exhibition. In particular, how learning about health is often in response to a social problem or issue. The paper that was the starting point for this current study described an approach to considering science understanding as an asset-based, sociocultural view (Falk, Storksdieck and Dierking, 2007). Yet, when proposing further research both the constructivist and sociocultural perspectives seem to have been included. They suggested "approaches that take into account individual differences and the unique personal and context-specific nature of knowledge" (Falk, Storksdieck and Dierking, 2007, p.465). These would seem to be constructivist in nature. But suggesting we need to know more about "myriad settings" (p.464) in which science is learnt, seems to be from a more sociocultural perspective.

Cobb (1996) tried to explain the overlap of the two perspectives:

> "sociocultural analyses involve implicit cognitive commitments, and vice versa. It is as if one perspective constitutes the background against which the other comes to the fore" (Cobb, 1996, p.45).

It remains unclear as to which paradigm is most appropriate for (or has the most support in) free-choice (informal) learning.

CONCLUSION

Working knowledge seems to straddle both constructivism and socioculturalism. The idea of building and intertwining new experiences into existing knowledge and forming personal, individual ways of knowing and thinking is clearly set into the constructivist's point of view. However, the social settings and interactions in which this takes place and the cultural background and history that affects these processes, adding meaning and significance to knowledge and learning, mean that the sociocultural perspective cannot be ignored, particularly the fact that we learn from and with other people. So if our data collection methods are from the position of a constructivist theory of learning, there will be an underlying sociocultural perspective that, although not being investigated, must be kept in mind, and have its contribution acknowledged.

The discussion above outlines the difficulty in placing free-choice learning, working knowledge and this study into an existing theoretical framework as the ideas seem to span several perspectives. However, to ensure the current study is accessible, comparable and useful it is important to tie the data collection and analysis to a theoretical framework. Schauble, Leinhardt and Martin clearly explained the importance of an underlying theory:

> "Theory is essential to keep such an enterprise from spinning off into a mere collection of unrelated investigations, because theory highlights the questions and issues worthy of exploration, points to what is central in the research findings, and provides the integrating frame that serves to define a coherent portrait from a series of independent investigations" (Schauble, Leinhardt and Martin, 1997, p.3).

As this study aimed to investigate the processes of individuals' working knowledge development it aligned itself with the constructivist perspective, and in particular the personal constructivist perspective. The methods used to do this must focus on the mental processes and models located within the individual. No method will give the complete picture of exactly what is going on inside someone's head but methods must be chosen to obtain the most accurate picture possible.

So I proceeded from the personal constructivist perspective but remain aware that what interests people, their needs and what they choose to learn depends on cultural and social issues. This seems to go along with the following view from Dewey:

> "For inspite of itself any movement that thinks and acts in terms of an ism becomes so involved in reaction against other isms that it is unwittingly controlled by them. For it then forms its principles by reaction against them instead of by a comprehensive survey of actual needs, problems, and possibilities" (Dewey, 1938, p.6).

IN THE NEXT CHAPTER...

... methods of data collection and analysis that can contribute to the first two research questions of this study and fit with a personal constructivist perspective are considered.

CHAPTER 4 - METHODS AND PROCEDURES USED IN THE EMPIRICAL PART OF THIS STUDY TO INVESTIGATE FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

The following chapter explains how the methods of data collection and data analysis for the empirical research in this thesis were selected. It describes a small pilot study that was conducted in order to assess the suitability of these methods. In particular, the pilot study was completed to find out if semi-structured interviews could provide data on people's free-choice learning and working knowledge following use of the BodyWorks exhibits. In order to balance any weaknesses of the semi-structured interviews, other data collection methods were also tested and are considered below.

The discussion of theoretical perspectives (Chapter 3) concluded that this study would be carried out from a personal constructivist perspective. The data collection methods and methods of analysis reflected this perspective. In order to study individuals' working knowledge it seemed immediately relevant to use interviews as a means of data collection. Indeed, Shapiro (1994) appeared to be suggesting that from George Kelly's personal construct perspective, unstructured conversation is a suitable research technique:

> "The research approach advocated by Kelly is a framework for conversing with the individual...The caring guide makes an effort to understand the person's perspective. This is a collaborative effort. The subject is not told what he or she believes or how he or she is construing events, but an effort is made by both parties, to understand, through conversation, how the individual is making sense of circumstances and thus preserve the integrity of his or her experience" (Shapiro, 1994, p.11).

Hein also provided support for interviews to be used as a data collection method from a constructivist perspective:

> "By allowing subjects more freedom to talk as they wish, using the entire responses in analyses, and reporting representative samples as part of research findings, naturalistic researchers employ an alternative approach that capitalises on the unique quality of human experience" (Hein, 1998, p.72).

Interviews correspond with the individual nature of working knowledge and how free-choice learning emphasises the learner's control over the learning. Interviews allow individuals to talk about what is important to them. The use of interviews corresponds with a suggestion by Falk and Dierking (2012, p.1076) that looking at working knowledge of science requires “more qualitative methods that allow individuals themselves to self-select and direct data collection.”

PILOT STUDY

To test the suitability of interviews as the main data collection method for this study a short pilot study was carried out. The pilot study aimed to investigate the type of information that could be gained from interviewing adult visitors who had used some of the BodyWorks exhibits. The pilot would reveal if it is possible to bring out in conversation details of individuals’ working knowledge in relation to the exhibits, as well as information about free-choice learning. In other words, the research question for the pilot study was: Can the BodyWorks exhibits be used to investigate free-choice learning and working knowledge?

Although the main aim of the pilot study was to test interviews as means of data collection, it would also test the researcher in their ability to carry out useful interviews and, importantly, give the researcher practice in the skill of carrying out interviews. Hein (1998, p.124) suggested that interviewing is a skill to be learned, the skill being that, “Interviewers need to ask the right questions and not lead their interviewees. They must also learn to listen rather than talk.”

INTERVIEWS

The interviews conducted during the pilot study were semi-structured. Straightforward structured questions were asked at the start of the interview to put the subject at ease (see Appendix 2, Interview Schedule). These questions provided background information on: age; level of science education; the subject’s interest in science; and, how knowledgeable they feel about science. Following these structured questions, an unstructured conversation was initiated by asking the participants if they found any of the exhibits more interesting than the others and why. The aim of this unstructured part of the interview was to allow the participant to talk freely about what they related the exhibits to and to bring out in conversation some information on their working knowledge.

To continue the conversation, participants may also have been asked to say what they thought an exhibit was trying to show, if an exhibit reminded them of anything they had seen before or what other exhibits they had used. These questions provided the researcher with the opportunity to prompt or probe the interviewees. Prompts are used to make sure they say as much as they can and probes are used to ask for clarification or more detail on any information given by the participant. The importance of prompts and probes is well described by Drever:

> "The purpose of prompts and probes is to help people to say what they want to say. Prompts are directed towards what they know but have not yet mentioned. They encourage people to talk and to jog their memory but they must not put words into people's mouths or pressurise the interviewees to come up with something. Probes are directed at what people have already said, asking them to clarify and explain, but not as a rule to justify or defend their position" (Drever, 2003, p.23).

By allowing participants to talk freely about what they feel is important to them the need for participants to say the "right thing" should be reduced. In other words, during unstructured interviews participants are more likely to say what they think rather than what they believe the interviewer wants to hear. However, there is still a small chance that responses could be prompted by the interviewer causing bias, and participants trying to please. Hein (1998) noted that:

> "Many observers have noted that museum visitors, like other respondents, are eager to please, and tend to give what they consider an "acceptable" response or what they think the interviewer wants to hear" (Hein, 1998, p.124).

For any interviewer there is a tension between getting the information and not leading the subject. To avoid leading, the purpose of the interviews here was introduced to interviewees as being to do with "research on the exhibits" rather than "research into your working knowledge of the topics in the exhibits." Also, questions like "do you know?" or "do you think?" were avoided as much as possible in favour of open questions that allowed interviewees to talk about what was at the front of their minds or what was important to them. These steps aimed to remove any feeling that the interviewee was being tested or under pressure to say something or that the interviewer was looking for a specific answer. The interviewer did not look at the aims of the BodyWorks exhibits prior to the data collection and analysis to avoid any chance of leading the interviewees towards talking about the aims.

Dierking and Pollock suggested that semi-structured interviews will give information on working knowledge by providing a broader assessment of "understanding, interest, attitudes and beliefs, because the people interviewed do much of the talking, using their own words" (Dierking and Pollock, 1998, p.45). Questionnaires could have provided similar information to the structured questions at the start of the interviews. However, questionnaires were not appropriate for this study as it was not looking for a list of facts of what the participant knows. This study aimed to let participants talk freely, revealing their own personal working knowledge with regards to the BodyWorks exhibits. Unstructured interviews are more likely to reveal an individual's understandings, perceptions, attitudes, opinions and behaviours and this fits with the interpretivist stance of the researcher (see Page 67). Jones (2004) described this clearly:

> "For to understand other persons' constructions of reality we would do well to ask them (rather than assume we can know merely by observing their overt behaviour) and to ask them in such a way that they can tell us in their terms (rather than those imposed rigidly and a priori by ourselves) and in a depth which addresses the rich context that is the substance of their meanings (rather than through isolated fragments squeezed onto a few lines of paper)" (Jones, 2004, p.258).

With participants directing the conversation and talking freely about what they want to, any bias was minimised. This bias was addressed by using other data collection methods, which may completely remove the pressure to say the right thing (see other methods considered, Page 96).

Another potential problem with using interviews for data collection is that individuals may not be able to verbally convey what they are thinking. Some individuals may find it difficult to articulate their thoughts and memories. Stocklmayer and Gilbert discussed the difficulties in investigating people's mental models:

> "Access can be gained to visitors' expressed models, those produced when mental models are placed in the public domain, for example through speech. However, it is entirely possible that the act of expression itself changes the associated mental model. As can be seen, work in this field is demanding for the researcher can never be entirely sure of the mental

> status of any representation that is identified" (Stocklmayer and Gilbert, 2002, p.838).

Bitgood, Serrell and Thompson (1994, p.87) had similar views, suggesting that informal learning may not always "promote articulate immediate verbal formulations" and advised that new data collection methods are required:

> "Visitors often find it hard to say what they expect, experience, or learned from a brief encounter with an exhibit. More experiments with different techniques to help visitors articulate their mental connections are needed" (Bitgood, Serrell and Thompson, 1994, p.87).

In an effort to allow those who may not be able to explain their thoughts verbally to share their thoughts, other methods of data collection were considered for this study (see Page 96). Also, by easing participants into the interview with straightforward, objective questions, and then allowing them to discuss what they consider to be important, a more accurate representation of what people are thinking was acquired.

PILOT STUDY DATA COLLECTION

A selection of seven exhibits from the BodyWorks exhibition was positioned in Glasgow Science Centre on a Saturday and Sunday (17/04/2010 and 18/04/2010). The exhibits were: Arm Endurance; Balance Board; Blocked and Normal Arteries; How Much Is Water?; Heart Beat Drum; Vertical Jump; and, Reaction Timer (see Appendix 1 for example photos and descriptions of exhibits). These exhibits were chosen because, from experience, science centre staff believed they would create the most discussion. In addition, some were chosen to attract people towards the exhibits and others were chosen for practical reasons, for example, size or available electricity supply.

It must be noted at this point that the main drawback with the pilot study was that of self-selection. The participants in the pilot were all visitors to Glasgow Science Centre. They had all chosen to visit the science centre, and chosen to *pay* to visit, and therefore could be assumed to have an above average interest in science. The results from such a group of people cannot be considered to be a valid representation of the general public as a whole. In the main study, a more representative sample was acquired by interviewing individuals who had used the exhibits at a number of public (free of charge) events and locations, as well as further data collection at the science centre. Use of additional methods also contributed to a more representative sample.

Over the course of the pilot study a total of 12 individuals were interviewed during 11 interviews (one couple asked to be interviewed together). The participants were visitors to the science centre who after being observed by the researcher and seen to use at least two of the BodyWorks exhibits were asked if they would like to take part in the study. The participants were then given time to read a Plain Language Statement (Appendix 3) explaining the study before deciding if they would proceed with the interview. The interviews were conducted with people immediately after they had used the BodyWorks exhibits, in close proximity to the exhibits.

Those approached for interview were limited to adults. This was partly to avoid time consuming consent forms but mainly because adults have spent longer out of formal education and therefore it is assumed would have had more opportunity to take part in free-choice learning and develop their working knowledge. Additionally, much of other research in science learning has focused on children (Falk and Dierking, 2012). Other methods used in the main study (see other methods considered, Page 96) included data from children.

The interviews were audio recorded (with signed consent) and transcribed by the researcher at a later date. The transcribed interviews were then analysed (as described below) in order to consider the research questions.

PILOT STUDY DATA ANALYSIS

As well as piloting semi-structured interviews as a method of data collection for this study, the pilot also permitted the trial of methods of analysis. From the personal constructivist perspective the data was analysed understanding that individuals would interact with the exhibits in different ways, partly due to their personal working knowledge. However, similarities and patterns can be uncovered, as Bitgood, Serrell and Thompson explained:

> "While each person's museum experience is unique, there are many shared human reactions and response patterns (e.g. attention, memory, reasoning, feelings and motor skills) that can be systematically studied and described. While there is no such thing as "the average visitor", averages (e.g. time

> spent, or number of exhibits stopped at) can suggest trends and allow comparisons to be made between different samples" (Bitgood, Serrell and Thompson, 1994, p.64).

The main reason for using focused coding rather than a grounded approach with open coding was to link the current work with previous research. Specifically, as described below, Falk's definitions of working knowledge and free-choice learning (Falk, 2001; Falk, Storksdieck and Dierking, 2007) and the proposal from the Annapolis conference (Falk, Dierking and Holland, 1995). The use of focused coding also allowed the consideration of a rigid structure that could potentially be used again for research and as a measure of impact.

In future research a grounded approach may provide new categories or themes to look at working knowledge and free-choice learning. In particular, the dividing of working knowledge into facts, understandings, values or perceptions was carried out to provide focus for the analysis and also to test a relatively straightforward potential measure of impact. Open coding is likely to provide more categories of working knowledge. However, in this work focused coding using definitions and suggestions for further research provided a lens through which to analyse the data and connect it with previous work (e.g. Falk, Storksdieck and Dierking, 2007; Falk, Dierking and Holland, 1995).

FOCUSED CODING - WORKING KNOWLEDGE

In order to investigate the importance of working knowledge the interview transcripts were examined for any evidence of working knowledge. This was a somewhat subjective analysis but was made more objective by using Falk, Storksdieck and Dierking's (2007, p.464) definition of working knowledge as confirmation of evidence, i.e. "knowledge generated by the learner's own interests and needs." Any data that fitted this definition was coded as working knowledge. If people interacting with the BodyWorks exhibits were found to be using or referring to their working knowledge when discussing the exhibits, this could be considered as an indication of its importance.

To gain an insight into the content of individuals' working knowledge the interview transcripts were further examined. Any coded working knowledge in the data were coded as facts, understandings, perceptions and values. This was to meet with the aim of achieving a better understanding of working knowledge. Facts were coded when any expression of knowing a statement or fact was shown. For example, your heart beats faster when you do exercise, or, fatty foods are bad for you. Understandings were coded when knowledge of an understanding or process was shown. For example, your heart speeds up when you do exercise to get more oxygen to your muscles, or, fatty foods can make your arteries narrow and it more difficult for blood to pump through them. Perceptions were coded when an individual stated something that they thought about the content of the exhibits. For example, when they said “it seems” or, “I presume” or, “it’s probably”. Finally, values were coded when the individual stated something personal to them. For example, “I’m interested in” or, “I feel” or, “I believe.” As well as providing a better understanding of working knowledge, this may show us if the exhibits are interacting with a particular aspect of people’s working knowledge more than others. See Appendix 4 for an example of a coded interview transcription.

FOCUSED CODING - FREE-CHOICE LEARNING

Although it was assumed that the working knowledge identified in the data is a result of free-choice learning, specific analysis of the data for evidence of free-choice learning was also carried out. Falk, Storksdieck and Dierking (2007, p.456) described free-choice learning as “learning that individuals engage in throughout their lives when they have the opportunity to choose what, where, when and with whom to learn.” Falk (2001, p.7) described the “unique characteristics” of such learning as “free-choice, non-sequential, self-paced, and voluntary.” These characteristics were used as criteria to analyse the data for evidence of free-choice learning, i.e. data fitting these criteria were coded as free-choice learning.

In addition, the interview data was used to gain a better understanding of the nature of free-choice learning. Falk, Storksdieck and Dierking suggested that:

> “by more deeply understanding where, how, when, why and with whom the public comes to learn science, science educators should be able to become more strategic, and able to leverage limited resources and access by actively building upon the public’s existing science and technology learning needs and interests” (Falk, Storksdieck and Dierking, 2007, p.464).

The data coded as free-choice learning was analysed and coded for evidence of where, how, when, why and with whom free-choice learning takes place. This was to meet with the aim of achieving a better understanding of free-choice learning. This also fits with meaning making from a Personal Construct Theory perspective as described by Fromm:

> "The focus of learning as personal construing is on making meaning. It is not just on what the students are supposed to learn (topics, items and so forth) but on how they learn it and how they make sense of information in a personal way" (Fromm, 2003, p.321).

FOCUSED CODING - INCREASE IN COMPLEXITY OF WORKING KNOWLEDGE (Annapolis proposal)

During the 1994 Public Institutions for Personal Learning conference funded by the National Science Foundation, (sometimes known as the Annapolis conference), discussions on how learning should be investigated in museums took place. These discussions have been summarised by Falk, Dierking and Holland (1995) and included recommendations of research questions to be considered in the future. These suggestions included the research question, "Does the experience that people have in the exhibit/museum increase the complexity of their cognitive schema?" (Falk, Dierking and Holland, 1995, p.29).

This question is clarified as follows,

> "The outcomes that would qualify as "increases the complexity of a person's cognitive schema" are:
> reinforcement of information and/or relationships in a schema
> new information or relationships added to a schema
> changes in the schema itself, e.g., its importance or our perception of its structure" (Falk, Dierking and Holland, 1995, p.29).

This suggestion for future research is relevant to this current study because the term "cognitive schema" is comparable to the idea of working knowledge (Chapter 2, Page 41). More importantly, from the theoretical perspective of personal construct theory, this proposal fits with Kelly's idea of man as a scientist, experimenting and changing knowledge as a result. The reinforcement, adding and changing in schema corresponds with Kelly's Experience Corollary:

> "The unit of experience is, therefore, a cycle embracing five phases: anticipation, investment, encounter, confirmation or disconfirmation, and constructive revision" (Kelly, 1970, p.12).

To apply the proposal from the Annapolis conference to the present study the term “cognitive schema” was substituted with working knowledge. The suggestions above of “outcomes that would qualify as “increases the complexity of a person’s cognitive schema” were then used as a coding scheme to look for evidence of increasing the complexity of a person’s working knowledge in the data collected. The coding became:

- **reinforcement** of information and/or relationships in working knowledge
- new information or relationships **added** to working knowledge
- **changes** in the working knowledge itself, e.g., its importance or our perception of its structure.

This provided a way of investigating how individual’s working knowledge interacted with the BodyWorks exhibits and gaining a better understanding of working knowledge. Importantly, the structure of the proposal, and the idea of increasing the complexity of working knowledge, also corresponds with the operational definition of learning established for this study:

> “The process of learning occurs when an experience interacts with an individual’s working knowledge in such a way that it reinforces, adjusts, or adds to that working knowledge.”

Or, more simply, the process of learning involves an increase in the complexity of an individual’s working knowledge.

Also, reinforcement, additions, and changes to working knowledge were considered alongside the coding of working knowledge as facts, understandings, perceptions and values (see Page 139). This fitted with the aim of gaining a better understanding of working knowledge by showing if a particular aspect of working knowledge was affected by the exhibits in a particular way. For example, it may be that most of the additions to working knowledge were facts or that most examples of reinforcement of working knowledge were values.

Working knowledge	Free-choice learning	Free-choice learning details	Increase in complexity of working knowledge
Fact Understanding Value Perception	Where How When Why With whom	e.g. in a gym	Add Reinforcement Change

Table 4.1 Codes used in analysis of transcribed interviews.

In summary, each transcribed interview in the pilot study was analysed and coded using the codes shown in the table above (see also Appendix 4). Any working knowledge displayed or mentioned by the participant was coded as **fact**, **understanding**, **value** or **perception**. The interview transcripts were then examined for specific mention of free-choice learning. This free-choice learning was coded as **where**, **how**, **when**, **why**, and **with whom**. Any specific details of this free-choice learning were noted, e.g. why – for someone's health, where – a gym. The working knowledge was then coded (based on the Annapolis proposal) for increases in complexity of working knowledge, as **add**, **change**, **reinforcement**. In future work additional coders could be utilised to assess the intercoder reliability of this coding scheme.

OTHER DATA COLLECTION METHODS CONSIDERED

As discussed above, there were limitations in the use of semi-structured interviews as a means of data collection in the current study. The main limitations were that participants may have had difficulty in articulating thoughts and memories and that participants may have felt pressure to say the "right thing". In order to deal with these problems other methods were considered. Finding an appropriate additional data collection method could balance out the limitations and increase confidence in results through triangulation.

COMMENT CARDS

Comment cards were tested alongside the semi-structured interviews in Glasgow Science Centre. The comment cards were placed beside the exhibits and pencils were provided for people to complete the cards. The comment cards (Appendix 5) provided space for participants to complete the phrase, ”The exhibits remind me of...” by writing or drawing.

Bell et al. (2009) reported how Raphling and Serrell (1993) asked visitors to complete the phrase ”It reminded me that...” as part of a questionnaire. Bell et al. (2009, p.61) reported that this prompt “tends to elicit affective responses from visitors.”

The limitation of the cards was that, just as it may be difficult for some people to verbalise their thoughts, it might be difficult for some people to write or draw their thoughts. For some, completing a comment card may seem like more effort, and time commitment, than a short interview.

By leaving the cards unattended and participants free to complete them alone, the pressure to say the right thing was removed. Unfortunately, by leaving the cards unattended it was found that people were not likely to complete the cards and it was found some even gave them to young children to draw on. However, if people were to be handed the cards and encouraged to complete them, the pressure to say the right thing can reappear. This is also time consuming.

Glasgow Science Centre had used the comment cards as part of their own evaluation when the exhibits were taken into schools. This data would have been of use to this study, as it would have provided information from children. However, Glasgow Science Centre staff reported that the cards were not as useful as hoped, mainly because the schoolchildren would often not think and complete the card for themselves but would copy each other’s cards, or simply write down an example given by staff. This resulted in a very small number of different comments on the cards despite being completed by a large group.

So it was mainly for practical reasons that the comment cards were not used in the main data collection.

AUDIO RECORDING

A book edited by Leinhardt, Crowley and Knutson (2002), looked at learning in museums by focusing on conversations. They viewed conversations as "both process and the outcome of museum learning" (Leinhardt, Crowley and Knutson, 2002, p.ix). This is based in the sociocultural perspective. The audio recording of people's conversations while using the exhibits would reduce any pressure to say the right thing and could also provide a more natural and relaxed situation than in an interview with a researcher.

The same seven exhibits as used in the pilot study were set up in the Glasgow Science Centre and an inconspicuous microphone connected to a digital voice recorder was placed between the exhibits. Visitors were made aware that audio recording was taking place by signs placed around the exhibits. It was hoped that the signage would not inhibit natural conversation. The setup was then left to record the conversations of anyone using the exhibits for five hours. The recording was then transcribed at a later date.

Unfortunately the audio recording took place on a Saturday when the Glasgow Science Centre had surprisingly few visitors. Visitors that day were also drawn to other workshop and live show activities. As a result, there were very few conversations recorded and almost no data obtained. In addition, the transcription of the audio recordings was found to be very time consuming.

It was decided that audio recording of conversations would not be used for data collection in the main study. This was because of the time consuming nature of transcribing the recordings and the risk of very few data being obtained. However, this method of data collection should not be ruled out in future work as it has the potential to provide an insight into individual's working knowledge. As Allen (2002, p.301) stated, analysing visitor conversation is "a fertile but costly complement to more traditional methods from visitor studies."

STAFF DIARIES

The staff that facilitate the BodyWorks exhibition meet and interact with a large number of people of different ages and backgrounds. They meet with more people than the researcher ever could and acquire a wealth of useful information. The aim of the staff diaries and follow-up interviews was to capture this information. Hein (1998) believed that a constructivist perspective suggested that staff should be involved in studying visitors:

> "The Constructivist Museum will view itself as a learning institution that constantly improves its ability to serve as an interpreter of culture by critical examination of exhibitions and programs. The most rational manner in which to do this is for staff to become engaged in systematic examination of the visitor experience; in short, to carry out visitor studies" (Hein, 1998, p.178-179).

Rennie and Johnston (1997) found staff to have a good understanding of visitor behaviour and that staff hold a wealth of information. So it should be worthwhile to utilise staff in data collection for the current study.

Staff diaries are a subtle way of recording comments of interest from the public and schoolchildren. Staff can make notes and then discuss with the researcher the interaction between individuals, the exhibits, and the staff. Of particular interest would be any reference made by people of their working knowledge during conversation with staff. Also, the questions that people asked the staff members could be useful. As Bell et al., (2009) explained:

> "Questioning is widely regarded by educators as one of, if not the, central inquiry behaviours that support learning in informal environments" (Bell et al., 2009, p.144-5).

Staff facilitating the exhibits were briefed on the aims and ideas of the study and advised on what details to make note of in the diary provided (see Appendix 6). Additionally, the staff diary entries were used as a stimulus to produce more data during recorded follow-up interviews with the staff. These interviews were recorded and transcribed by the researcher at a later date (see Appendix 7).

After an initial four weeks of diary keeping, the follow-up interviews suggested this was a useful method of data collection. Also, Glasgow Science Centre were keen for the diary keeping to continue as a method of staff development.

Therefore, the staff diary keeping continued and the data collected and reported in the main study.

PILOT STUDY - DISCUSSION

It should be reiterated at this point that the main aim of the pilot study was to test the suitability of semi-structured interviews as a means of data collection and to assess the type of information that could be gained from these interviews. Therefore, the data collected has been analysed and will be discussed primarily in relation to this aim.

In terms of the practicalities of using interviews in this study, the pilot study revealed that the interviews were more time consuming than originally anticipated. It therefore took longer than expected to carry out a number of interviews. This was mostly because of the need to watch potential participants to ensure that they interacted with more than one of the exhibits. In addition, the interviews were much shorter than anticipated. Participants were keen to talk but soon wanted to move on and carry on with their visit to the science centre. This was both an advantage and a disadvantage. It was an advantage as more interviews can potentially be carried out. However, it was disadvantageous as it meant less time to obtain useful data from the participants.

WORKING KNOWLEDGE

All of the participants interviewed showed evidence of working knowledge in relation to the exhibits. Evidence of facts, understandings, perceptions and values were obtained. This suggests that semi-structured interviews are a suitable means of data collection for this study. In some cases it was difficult to be confident that the participant's knowledge was from free-choice learning (rather than school or work) and therefore working knowledge. Also, sometimes participants could not recall why they knew something saying, "I just know". However, the fact that so few mentioned school or work, suggests that the interviews were providing evidence of working knowledge.

FREE-CHOICE LEARNING

All participants referred to some type of free-choice learning during their interview. Two participants mentioned work and two mentioned school. This suggests that semi-structured interviews are a suitable means of data collection for investigating free-choice learning in this study. It was also possible to use the evidence of free-choice learning to look at, where, how, when, why, and with whom, free-choice learning took place.

INCREASE IN COMPLEXITY OF WORKING KNOWLEDGE (Annapolis proposal)

The data showed evidence of the three categories of increase in complexity of working knowledge, i.e. reinforcement of information and/or relationships in working knowledge; new information or relationships added to working knowledge; and, changes in the working knowledge itself, e.g., its importance or our perception of its structure. However, it was difficult to analyse and identify the category of changes in the working knowledge. This is not clearly defined in the Annapolis proposal. It could be argued that working knowledge being reinforced or added to indicates a change in the working knowledge, and a separate category for changes is not required. Where a change has been recorded it may be argued that it could have been recorded as a reinforcement or an addition to working knowledge. However, it may be that in this small pilot study, data providing an example of a clear and definite change was not collected.

It could also be argued that a reinforcement of working knowledge could be seen as an addition to working knowledge. Although the participant already has that knowledge, they are adding to it as it is being seen in a different setting or through a different experience.

PILOT STUDY - SUMMARY

The pilot study showed that semi-structured interviews can be used to investigate working knowledge and free-choice learning of people using the BodyWorks exhibits. It revealed the kind of information that can be gained and analysed by this method. It also demonstrated that staff diaries can be used as an additional method to support the data from the interviews and to attempt to overcome some limitations of the interviews, most notably interview bias and the lack of data from children.

Ideally, another method of data collection would be used to provide further support for results through triangulation. However, as discussed above, other methods were unsuitable for this study, mainly because of constraints on resources. For future research, audio recording of conversations at the exhibits may be the most useful additional data collection method.

Most importantly the pilot study indicated that further data collection and analysis is worthwhile. As the same methods utilised in the pilot study were used in the main data collection and analysis, these two sets of data can be combined. So, the data collected in the pilot study was added to the data collected during the main study and is included in the main analysis and discussion.

MAIN DATA COLLECTION

INTERVIEWS

The pilot study showed that a great deal of information can be gained from interviewing visitors who have used BodyWorks exhibits. The data collected as part of the pilot study will be added to that collected in the main study.

Interviews were carried out by the researcher at the following locations: Clydebank Shopping Centre, Greater Glasgow (October 2010); Forge Shopping Centre, Greater Glasgow (October 2010); Grangemouth Science Festival evening event (March, 2011); and, Glasgow Science Centre (April, 2011). A total of 58 individuals were interviewed (including 12 from the pilot study carried out in Glasgow Science Centre, April, 2010). It was important to include interviews out with science venues/events (i.e. the shopping centres) as it could be argued that those visiting science venues or events would have more interest in science or be more knowledgeable about science.

The interview recordings varied in length up to around seven minutes. The length of the interview mainly depended on the participant and if they had time to talk or wanted or needed to move on.

The interviews were audio recorded (with signed consent) and transcribed by the researcher at a later date. The transcribed interviews were then analysed (as described above, Page 85) to consider the research questions. An example of a transcribed interview can be found in Appendix 4.

STAFF DIARIES

As described previously (Page 91) a number of data collection methods in addition to the semi-structured interviews were piloted. As discussed the use of staff diaries and follow-up interviews as a data collection method was found to be most useful to the study.

The staff diaries provided an opportunity for comments to be recorded without the pressure of an interview. This additional data collection method has been used to try to overcome any bias and to make it easier for people to express their working knowledge. This triangulation of methods provided increased confidence in results. In addition, the triangulation presented a more complete picture of working knowledge by contributing data from children and from settings outside of the science centre.

Initially, four members of staff were briefed and provided with diaries. However, changes of staff meant that a new member of staff was briefed and the diary passed on to them. This meant that one of the diaries was kept by three different members of staff. During the period of diary keeping (October 2010 - July 2011) the three constant staff members were interviewed 4/5 times each. The other (changing) staff members were interviewed less often. In total 59 pages of diaries were collected and 18 follow-up interviews carried out. Examples of diary entries and transcribed follow-up interviews can be found in Appendix 7.

The changes in staff along with varied levels of commitment to the diaries meant that they were not as successful a data collection method as anticipated.

However, the comments recorded by the staff and their follow up interviews provided some useful examples to add to the data collected by interviewing those using the BodyWorks exhibits. In particular, staff noted some interesting comments from children. These comments are included in the analysis and discussion of results (Chapter 5).

REFLECTION ON DATA COLLECTION

The interviews used in this study worked well. People seemed relaxed during the short interview and were happy to talk freely about experiences and memories. As the next chapter will show, relevant data were collected and this contributed to answering the research questions.

As discussed previously (Page 103) the staff diaries did not provide as much data as expected. This was mainly due to practical reasons, including staff changes, and the diaries are likely to be beneficial to further research. However, in this work the diaries did provide useful examples to support the interview data.

It should be noted again that these data collection methods were chosen both to provide data to answer the research questions and also to fit with the theoretical framework. The personal constructivist perspective meant that data needed to be collected from individuals because “Persons differ from each other in their constructions of events” (Kelly, 1970, p.9) and “This central idea offers its own explanation for the mysterious but everyday fact that people respond to the same situation in very different ways” (Bannister, 2003, p.34).

The data needed to be collected in a way that allowed people to talk about what was important to them and why rather than seeking out a correct answer:

> “Kelly did not propose a detailed list of human needs, motives, conflicts or ideals that presumably hold for all people, but instead focused on the general processes by which people made sense of, and navigated, the social world” (Fransella and Neimeyer, p.27).

As well as looking for evidence of free-choice learning and working knowledge (research question 1) this work also aimed to gain a better understanding of these (research question 2). This is based in the idea of Personal Construct

Theory and the process of individuals taking information and making it relevant to them:

> "Seen from a personal construct view this is a question yet to be answered: How do people manage to process the overabundant input of information to make it personally meaningful knowledge?" (Fromm, 2003, p.326).

If the study had been based on a sociological framework other data collection methods would have been employed. For example, the audio recording would have been particularly useful and interviews may have been carried out in groups rather than individually. This would have allowed a comparison between different types of social groups including families, friends, and school groups.

The differences between evaluation and research have been discussed previously (Page 73). However, it should be noted that the data collection methods for an evaluation of the BodyWorks exhibits would have been different than for this research. An evaluation would focus on measuring to what extent the aims of the exhibits have been met. The data collection and analysis is not concerned with the aims of the exhibition. This is discussed in more detail in the next chapter (Page 145).

DATA ANALYSIS

The data collected via the semi-structured interviews was analysed using the same coding schemes described in the pilot study (Page 91). This allows the data to be used to investigate working knowledge, free-choice learning and increases in complexity of working knowledge.

The data obtained from the staff diaries and follow up interviews are more qualitative in nature. This data was analysed using the same focused coding applied to the semi-structured interview data. The data from staff was then used to provide examples to support the interview data and also examples from children. It also supported the interview data by offering data that have not been subject to any interview bias.

IN THE NEXT CHAPTER...

... the data collected and analysed using the methods described above are presented and discussed in terms of the first two research questions of the thesis.

CHAPTER 5 - THE RESULTS AND ANALYSIS OF THE DATA COLLECTED ON FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

INTRODUCTION

In this chapter the data obtained using the methods set out in Chapter 4 are presented and analysed. Firstly, general background results are presented including: age; level of science education; and, self reported knowledge and interest in science of the participants. The results are then analysed and discussed in order to contribute to the first two research questions of this thesis:

1. Can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?
2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?

The data are presented in relation to these questions under headings as follows: evidence of working knowledge; a better understanding of working knowledge; evidence of free-choice learning; a better understanding of free-choice learning; and, increase in complexity of working knowledge. These results are then summarised and the final section of this chapter involves a comparison of the results with the goals and objectives of the BodyWorks exhibits.

GENERAL RESULTS AND ANALYSIS

In total, 56 interviews were undertaken during the pilot study and the main study, with 58 individuals being interviewed (two couples asked to be interviewed together). 19 males and 39 females were interviewed.

When the data were being collated to be transferred to tables, it was decided that the number of participants showing evidence of an aspect under investigation would be used as a measure rather than the number of instances. This is because often participants repeated themselves during interview and also some talked for much longer than others. By using the number of participants showing evidence of an aspect any bias caused by these factors is removed.

Age	**16-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60+**	**Total**
No. of participants	0	2	13	21	7	15	58

Table 5.1 Age of participants.

Level of education	**General/ GCSE/ Standard Grade**	**A-Level/ Higher/ Adv. Higher**	**College**	**University**	**Unknown**
No. of participants	27	14	3	7	7

Table 5.2 Highest level of science education.

		Not at all				**Very**
		1	**2**	**3**	**4**	**5**
No. of participants	**Interested in science**	2	7	17	17	15
	Knowledgeable about science	8	24	19	6	1

Table 5.3 How interested in and how knowledgeable about science participants stated they were.
NB when a participant swayed between two levels the lower was noted for consistency (e.g. 3/4 noted as 3).

KNOWLEDGE AND INTEREST IN SCIENCE

At the start of each interview participants were asked a structured series of questions (see Interview Schedule, Appendix 2). The main purpose of this was to settle the participants into a conversation with relatively straightforward, easy to answer questions. One of these questions involved stating how interested in science they were according to a scale. This was followed by answering how knowledgeable they were about science on the same scale. Table 5.3 shows that participants reported a higher interest in science than being knowledgeable about science. When each participant was looked at individually, it was found that 78% of participants stated a higher interest in science than how knowledgeable they were, only 3% reported a higher knowledge than interest, and 19% gave the same score for knowledge and interest. This is similar to a result reported by Durant, Evans and Thomas:

> "levels of British and American public interest in science, technology and medicine are relatively high; but levels of knowledge are far lower" (Durant, Evans and Thomas, 1989, p.11).

and also, Miller:

> "in 1988, more than 80 percent of those interviewed declared themselves interested or very interested in science, but only 20 percent thought they were well informed in this area" (Miller, 2001, p.117).

This suggests people want to know more about science. Durant, Evans and Thomas (1989) suggested:

> "For science, technology and medicine, it appears that many people perceive a gap between themselves and a world of learning about which they would like to know more" (Durant, Evans and Thomas, 1989, p.11).

Rowan described this positively as:

> "this gap between interest in science and feeling well informed may indicate a continuing desire for engaging in explanatory discourse" (Rowan, 1992, p.132).

However, this is based on self-reported knowledge of science. In reality, people may play down their knowledge of science or may know more than they think they do. In a study that measured scientific literacy (the problems with measuring scientific literacy are discussed elsewhere, Page 47) results showed:

> "a consistent and descending pattern in scientific literacy for groups with high, medium and low interest in science" (Lin, Hong and Huang, 2012, p.38).

The self reported lack of knowledge about science is discussed again later (Page 141) in relation to the evidence found for increasing the complexity of working knowledge. The results providing evidence of working knowledge are now presented and described.

EVIDENCE OF WORKING KNOWLEDGE

As described in the methodology, (Page 91) the interview transcripts were coded for evidence of working knowledge. The coding showed that 98% of participants showed some evidence of working knowledge when discussing the BodyWorks exhibits during interview following their use of some exhibits.

It should be noted that only one participant did not show evidence of working knowledge however they did refer to free-choice learning saying, “I suppose you see them on all these em medical programmes you watch...” (H4 - Female, 40-49). So although not providing specific evidence of working knowledge it could perhaps be assumed that some working knowledge has been gained through watching the “medical programmes.”

Additional support for the evidence of working knowledge was found in the coding for free-choice learning. When coding the transcripts for evidence of free-choice learning, only 16% of participants mentioned work, 3% mentioned college, and 10% mentioned school (Table 5.5). This provides additional evidence of the knowledge mentioned by the participants being gained from free-choice learning, and therefore working knowledge, as Falk, Storksdieck and Dierking (2007, p.464) described it, “knowledge generated by the learner’s own interests and needs.”

The examples below from staff diaries and staff interviews support the interview data and show that school aged children also displayed evidence of working knowledge when discussing the BodyWorks exhibits:

- “A primary 5 boy was talking about heart attacks and strokes and then in a film he saw a man use two electric plates to prevent a heart attack” (Staff B, Interview 4).
- “A primary 6 girl said that her gran had to get her leg amputated because of blocked arteries and she smoked and had diabetes” (Staff B, Interview 4).
- “My granny is diabetic and her pancreas doesn’t make insulin so she needs injections” (P5 child - Staff C, Diary Page 4).
- “I’ve seen a sheep’s intestines because my dad brought them home one day” (P3 child - Staff C, Diary Page 6).
- “a girl knew that liquid inside your ears spins when you do and makes you dizzy because it doesn’t stop spinning straight away. She

> had seen it on Nina and the Neurons" (P4/5 child - Staff E, Diary Page 1).

The examples provided in the staff diaries show that it is not just adults who used working knowledge to make sense of the exhibits. This is of interest as it may have been assumed that school aged children would be more likely to refer to knowledge gained in school when talking about the exhibits. Of course, these are qualitative examples and more data regarding the schoolchildren's working knowledge would be required to make firm conclusions on this. The examples suggest further work on this would be worthwhile.

The fact that most participants showed evidence of working knowledge of science seems to contradict their self reported knowledge of science (see Table 5.3). This suggests people are more knowledgeable about science than they think they are, or perhaps are willing to report that they are. It is possible that some people consider their knowledge about science to be mostly made up of what they have been taught in formal education, and so don't include any working knowledge when thinking about their science knowledge.

The results gave a strong indication that people know more about science than they think they do and that people are gaining knowledge through free-choice learning. Martin (2001, p.197) raised the interesting point of "whether the learner is in on the learning." Perhaps if people were more aware of the importance of free-choice learning as a learning source, and more aware of their own participation in free-choice learning, they would feel more knowledgeable. In other words, if they recognised free-choice learning as a way of gaining knowledge and were aware of the extent of their own working knowledge, they would report knowing more about science. If the public are aware of free-choice learning and feel part of it this could have a positive effect and, as described by Martin (2001, p.197), "create a coherent message, practice and culture of free-choice learning."

As the majority of participants (98%) provided evidence of working knowledge during the interviews, it can be inferred that working knowledge is important in understanding and relating to the BodyWorks exhibits. The participants were using or referring to their own personal working knowledge when discussing the exhibits. The results suggest that people use their working knowledge when confronted with new information, or information that is presented in a new way. Bell et al. (2009, p.162) described this as learners attempting to personalise and integrate science learning experiences with their own identity and values. Falk and Dierking (2000) described people constantly attempting to place what they encounter into their past experience. From the perspective of Kelly's Personal Construct Theory, this is related to the Experience Corollary and using one's present constructions to understand new experiences. A better understanding of working knowledge may be gained by looking at the data more closely and dividing the working knowledge into categories.

A BETTER UNDERSTANDING OF WORKING KNOWLEDGE

The data suggested that working knowledge is important, but can more information on the content of individual's working knowledge be gained from these data? In an effort to understand the content of individual's working knowledge in the current study, the interview transcripts were further examined and coded. Examples of working knowledge were coded as facts, understandings, perceptions and values. Although it was sometimes difficult to distinguish between these categories, all examples of working knowledge in the data were coded as one of the categories. Of course, working knowledge could be divided into more groups, or different groups, than just facts, understandings, perceptions and values. Using these four groups made the analysis in this study uncomplicated. A future study could use open coding to suggest subsets of working knowledge, these may include things such as attitudes, skills, or behaviours.

To understand the differences in the subsets more clearly, the following are some examples of each of the categories:

<u>Facts</u>

- [when talking about high blood pressure] "I know you could take a stroke or something like that" (C1, Subject 1 - Female, 60+).
- "Well it pumps the blood through your system and the heart beat is the number of, well it's the number of times it goes in a minute" (H6 - Male, 60+).
- "I know that the slower your heart the fitter you are" (J2 - Male, 30-39).

Understandings

- [when talking about blood pressure and strokes] "It could be through the roof and you don't know you've got it but apparently if it's in your, it's a family trait then it just follows down generations so I've been told. So my parents had it so now I've got it" (C1, Subject 1 - Female, 60+).
- [talking about how exercise effects the heart] "Well it usually lifts your heart rate so it helps it to, your body to work better, perform and releases different things in it to make you feel better" (D2 - Female, 60+).
- "Well I think probably at the gym for sort of fat burning is your heart not to be a certain, in between a certain range for burning fat and getting fitter" (G5 - Female, 30-39).

Perceptions

- [talking about using the grip strength exhibit] "I'm presuming it's just because I'm getting older and maybe because I'm not doing the things that I used to do" (D2 - Female, 60+).
- [talking about using the Mindball exhibit] "Technology seems to be advanced enough for stuff like that to be going on" (F4 - Male, 30-39).
- [talking about competitiveness in using Grip Strength and Reaction Timer exhibits]"Yeah, you'll probably find it's a male thing as well" (G4 - Male, 30-39).

Values

- "Nah, anything like that I'm very interested in and I'll look at it and read about aye. I love all that kind of a stuff" (D1 - Female, 60+).
- "I'm pragmatic and logical" (G1 - Male, 40-49).
- "I mean, I am interested in the history of science" (I4 - Male, 50-59).

	Facts	Understandings	Perceptions	Values
No. of participants	17	54	20	8

Table 5.4 Number of participants (total number of participants = 58) showing evidence of working knowledge as divided into subsets: facts; understandings; perceptions; and, values.

In the data, understandings were mentioned most often (93% of participants), followed by perceptions (34% of participants), then facts (30% of participants) and finally values (14% of participants) (Table 5.4). Although this suggests that working knowledge is mostly made up of understandings it is impossible to say conclusively that this is the case. It could be that understandings are the most easily reported working knowledge. Or, perhaps people are more willing to mention an understanding; it is less open to scrutiny than a fact and less personal than a perception or a value. Also, the BodyWorks exhibits may have been designed to increase or reinforce understandings rather than facts, perceptions or values (this is discussed later, see from Page 145).

Although it cannot be said for sure that working knowledge consists mostly of one category or another, the categories are useful for further data analysis. The four categories (facts, understandings, perceptions and values) are utilised later to investigate if they are used in different ways in increasing the complexity of an individual's working knowledge (Page 139).

The fact that working knowledge can be divided up like this and evidence was found of all subsets is important. It shows that working knowledge is not just what we know (facts and understandings) but also what we think and feel (perceptions and values). It is perhaps because of the more affective parts of working knowledge, what we think and feel about the aspects of science that we encounter, that people can remember and recall events in great detail, including facts and understandings.

The interview data showed that when discussing their working knowledge, individuals could often recall detailed information and facts. Some participants could recall in detail interactions they had with medical professionals, for example:

> "And I think quite often, I don't know whether you realise or not, whether you look into things like that because a lot of these complaints are hereditary. The first thing they asked me when I had the TIA was, I'm 60 now I was 59 at the time, and they asked you know has this ever happened to your mum or dad, both of them you see, and you know from that point onward I just consider myself lucky that, in Ipswich at that particular time they had just started a new thing on the ambulances, the paramedics instead of taking you, if they suspected a stroke, instead of taking you to the hospital they brought that to you, they actually did that on the ambulance. Cos I was at work at the time and the ambulance stayed in the car park and everyone thought... and what it was they put the canula in and there was a doctor and there was a paramedic, all what had to be, and the ambulance was kitted out. And I'd lost all down my left side and by 6 o'clock that night they all started to return back and I and so I just think if they hadn't been doing that, that was in the first two weeks, within two weeks of that happening, there have been quite a lot of reports down there that this did save quite a lot of people and make a big difference. I mean we're only about ten to fifteen minutes away from a hospital but because they administered what they needed to immediately that did help so, yeah" (B5 - Female, 60+).

Leinhardt and Knutson (2004) also noted this detailed recollection and described it as follows:

> "It is quite amazing throughout our study of museum visitors to see the trajectories of conversations that begin with an object and end up in the recounting of a long-forgotten anecdote or personal memory. These personal moments, we feel, are just as important to the value of a museum experience as learning about the content of the exhibition per se" (Leinhardt and Knutson, 2004, p.16).

This ability to recall details of personal events and associated working knowledge seems to underline the importance of working knowledge (and free-choice learning) for understanding the exhibits and their content. Indeed, it indicates the importance of working knowledge when confronted with any new information. This hints at the benefits of including working knowledge in formal education. If working knowledge is used when confronted with new information and is also related to remembering detailed information and facts, it seems obvious that it should be considered in formal education.

Dewey discussed the use of prior knowledge in education in a similar way to how working knowledge could be utilised in formal education:

> "it is a cardinal precept of the newer school of education that the beginning of instruction shall be made with the experience learners already have; that this experience and the capacities that have been developed during its course provide the starting point for all further learning" (Dewey, 1963, p. 74).

The results providing evidence of free-choice learning are now described.

EVIDENCE OF FREE-CHOICE LEARNING

Type of learning discussed	Free-choice learning	Work	School	College
No. of participants	54	9	6	2

Table 5.5 Number of participants (total number of participants = 58) discussing different types of learning.

The coded data showed that 93% of participants provided evidence of free-choice learning during interview following use of some of the BodyWorks exhibits (Table 5.5). This is an indication of the importance of free-choice learning and this importance is emphasised by the fact that only 29% of participants mentioned knowledge acquired in more formal learning environments, i.e. from work (16% of participants), school (10% of participants), or college (3% of participants). This suggests that most people are making use of knowledge gained through free-choice learning when using the exhibits, i.e. working knowledge.

The free-choice learning evidenced in the interviews corresponds with the description of free-choice learning by Falk (2001). He described the unique characteristics of such learning as “free-choice, non-sequential, self-paced, and voluntary” (Falk, 2001, p.7). The free-choice learning resources discussed by subjects during interviews, including gym visits, television, *Nintendo Wii* games console, seem to match the characteristics of being voluntary, and mostly non-sequential and self-paced.

Most participants described experiences, some recalled facts, that they had acquired out of school and, although it would require further interviewing of the participants to be absolutely sure, we can be almost certain that this was voluntary. Although we can speculate that the experiences were “self-paced” and “non-sequential” further interviewing would be necessary to confirm this. For example, one individual related the Balance Board exhibit to core strength and equipment they had seen in their gym. It is likely that they went to the gym and acquired this knowledge voluntarily, but we cannot be certain. It is also likely this knowledge gain was “self-paced” and “non-sequential”, but without further discussion we cannot be positive.

There were also cases where the participants could not remember where they gained information from, for example:

> “Och, that’s just general information, I mean, I, you know, who knows where you pick it up, I mean, it’s just general knowledge” (C2 - Female, 60+).

This would be explained by the working knowledge that Falk, Storksdieck and Dierking (2007, p.459) described as “some of what we learn we learn rather incidentally, without consciously wanting to learn.”

The way in which knowledge is added to from a variety of sources over time makes it difficult to know where one gained a particular piece of information. Also that information may have been reinforced by a variety of sources. As Falk and Needham (2011, p.3) described, “the cumulative nature of learning makes attribution challenging.”

The fact that only 7% of participants did not mention any free-choice learning (and only 29% mentioned formal learning environments) suggests that a lot of knowledge comes from free-choice learning (and is therefore working knowledge). Indeed, Falk, Storksdieck and Dierking (2007, p.465) suggested that, “a majority of all lifelong science learning occurs outside of school.” The low percentage of participants that referred to school or college in the current data (14%) could be explained by the fact that these were adults and they have not attended school for some time, and are therefore perhaps more likely to recall more recently gained knowledge. However, data from schoolchildren recorded in staff diaries appears to give support to the importance of free-choice learning. Almost all examples recorded by staff in diaries or reported in staff interviews, referred to free-choice learning. This agrees with work by Bamberger and Tal (2007, p.93) who investigated students in science and natural history museums and found that “connecting the content of the visit to the school science curriculum was barely referred to.” Of course, in this study, it may be that staff only recorded examples from free-choice learning rather than examples referring to school learning.

In a study of Scottish schoolchildren by Stark and Gray (1999) it was found that 8 and 9 year olds were using a wide range of out-of-school sources for science knowledge. However, the use of other sources declined as pupils moved through late primary and early secondary years. Stark and Gray suggested that this could be because of a growing emphasis on school learning and a lack of encouragement to develop interests through alternative sources. They proposed that this could be improved:

> "Greater integration of formal and informal contexts may go some way to address the issues of confidence and access to alternative sources of knowledge raised by these findings" (Stark and Gray, 1999, p.82).

Free-choice learning is clearly an important source of knowledge. The data here suggest that it may be a more important source of knowledge than formal learning environments. This corresponds with Falk, Storksdieck and Dierking's (2007) findings:

> "The data suggest that even though science is taught in school, the science the public knows is not exclusively, nor even perhaps primarily, learned in school, or at least the public perceives other sources to be of equal importance in learning about science and technology" (Falk, Storksdieck and Dierking, 2007, p.463).

More recent results also support this:

> "Even assuming that reality is almost certainly more complex than these findings suggest, there is no escaping the fact that adult free-choice experiences explained more than twice the variance of formal schooling" (Falk and Needham, 2013, pp.446-447).

However, it may be the case that working knowledge is more easily accessed than knowledge gained from formal environments. This could be because of the nature of how it is gained: voluntarily, self-paced, non-sequential. The more rigid structure of formal learning (mostly involuntary, externally-paced and sequential) may make it more difficult to relate to new information and events. This was alluded to by Dewey (1963, p.26) in discussing his theory of experience, "experiences may be so disconnected that, while each is agreeable or even exciting in itself, they are not linked cumulatively to one another."

This does not mean that formally acquired knowledge does not provide a base on which working knowledge can be built. These are generalisations, there are of course some formal environments that provide learning that is, to some extent, voluntary, self-paced and/or non-sequential, for example, some distance learning courses. Also, learning in a voluntary, self-paced, non-sequential way will not suit everyone, and perhaps those more suited to formal learning may be the same individuals who access knowledge gained in formal environments when discussing the BodyWorks exhibits. It would be of interest to look at how preferred learning styles correlate with exhibit interaction.

This may also be related to the idea of transfer, i.e. using knowledge gained in one situation in another: “Transfer refers to knowledge being applied in new ways, in new situations, or in familiar situations with different content” (Schunk, 2012, p.317).

In terms of transfer in informal and free-choice contexts, Bell et al. reported:

> “there are documented cases showing that people who participate in a designed educational experience can generate, explain, and apply new knowledge to new examples and think in generalities (abstractions) about phenomena both familiar and new” (Bell et al., 2009, p.139).

It is difficult to say whether in all instances of free-choice learning discussed by the participants learning had taken place - it depends on the definition of learning. The definition of learning suggested in the methodology for use in this current study was,

> “The process of learning occurs when an experience interacts with an individual’s working knowledge in such a way that it reinforces, adjusts, or adds to that working knowledge” (Page 70).

With regards to whether learning took place when the participants interacted with the BodyWorks exhibits, the fact that the majority refer to their working knowledge when discussing the exhibits suggests that the experience of using the exhibits is interacting with their working knowledge. Therefore, according to the definition above, learning has taken place. This was looked at in closer detail when investigating increases in complexity of working knowledge, below (Page 126).

A BETTER UNDERSTANDING OF FREE-CHOICE LEARNING

There is evidence of the importance of free-choice learning in the data but can these data provide a better understanding of free-choice learning? Falk, Storksdieck and Dierking suggested that:

> "by more deeply understanding where, how, when, why and with whom the public comes to learn science, science educators should be able to become more strategic, and able to leverage limited resources and access by actively building upon the public's existing science and technology learning needs and interests" (Falk, Storksdieck and Dierking, 2007, p.464).

Information regarding this suggestion was obtained in the interviews undertaken in the present study and is now discussed. The examples of free-choice learning coded in the data were coded again according to whether they provided evidence of where, how, when, why and with whom the free-choice learning took place.

	Where	How	When	Why	With whom	None
No. of participants	42	4	0	51	13	4

Table 5.6 Number of participants (total number of participants = 58) providing evidence of: where; how; when; why; and, with whom free-choice learning took place.

Table 5.6 shows that a lot of participants provided evidence of where (42) and why (51) free-choice learning took place. Fewer participants showed how and with whom free-choice learning took place. No participants discussed when learning took place. These numbers become more useful as where, why, and with whom are looked at in more detail.

WHERE

Where	No. of participants
At home	18
Doctor/Hospital/Dentist	16
Museum/Science centre	9
Gym	6
Fair/arcade	5
First aid class	2
Martial arts class	2
Community dancing event	1

Table 5.7 Where free-choice learning took place.

As discussed above, the majority of participants (93%) in this study mentioned some type of free-choice learning. The definition of free-choice learning means that it can be broadly assumed that this learning took place outside of school. This corresponds with the fact that the average person does not spend a great deal of their life in formal education. Falk and Dierking put a percentage on this and stated:

> “Average Americans spend less than 5 percent of their life in classrooms and an ever-growing body of evidence demonstrates that most science is learned outside of school” (Falk and Dierking, 2010, p.486).

In simple terms, free-choice learning is most likely to have occurred outside of formal education or work. During the interviews in this study formal education (school, college) was referred to by 14% (8/58) of participants and work was mentioned by 16% (9/58) of participants. These figures agree with Falk and Deirking’s (2010, p.489) assertion that “schooling ranks at the bottom of significant sources of adult science knowledge.”

To compare this with Falk, Storksdieck and Dierking’s (2007, p.462-3) research, they also found that the majority of their participants (43%) claimed to have learned science or technology that they were knowledgeable about through some kind of free-choice learning experience. However, in their study around a third (34%) claimed they had learned about a particular area of science through formal education and about a quarter (23%) said it was through work.

Looking more closely at where free-choice learning discussed by the participants is taking place (Table 5.7) it is seen that most participants referred to knowledge gained at home. This makes sense as it could be assumed that home is where we spend most of our time. It should be noted that it is assumed that those discussing watching television, or playing video games, are doing so at home. The next most mentioned place for free-choice learning was at a doctor's surgery or hospital. This could be partly because trips to the doctor occur more frequently than other events with learning potential.

It is also likely that *where* results were due to the content of the BodyWorks exhibits concentrating on health related topics. If the interviews had been carried out after use of exhibits on, for example, electricity, it is likely different results would have been obtained. It is an obvious next step in this research to carry out the same data collection and data analysis using exhibits on different science topics.

Durant, Evans and Thomas (1992) looked at people's interest in medical topics and found that medical science was top in terms of self-reported interest even for those who have a low understanding of science. They explained this as follows:

> "The conclusion that medical science is more prominent in people's minds than other kinds of science is not, in itself, particularly surprising. After all, few things interest or concern people more than their own health; and this is reflected in the fact that medical stories make up a very large proportion of all science-related news and feature articles in the media" (Durant, Evans and Thomas, 1992, p.173).

There may be a positive feedback loop in operation, where people are interested in their own health and therefore medical science and so the media tend to concentrate on this aspect of science and technology, which in turn increases interest in medical science. Free-choice learning providers may be able to take advantage of this interest by using medical topics to introduce other areas of science and technology. To choose one example, medical imaging could be used to introduce some topics in physics and chemistry. It could be considered a wasted opportunity to not utilise people's interest in this way.

The alternative view is that the BodyWorks exhibition content is very focused or narrow and doesn’t allow people to link the exhibits to other, more varied, or seemingly unrelated, subjects. Stocklmayer (2005, p.16) thought this may happen in some cases, “I believe that if an exhibit is too contextualised, it provides for limited connections and may impede broader meaning-making.”

Despite the content of the exhibits causing bias towards medical environments, the fact that many participants referred to very personal experiences should not be dismissed. As mentioned earlier, the affective parts of working knowledge may allow for detailed recollection.

HOW

How learning took place in the instances discussed by participants was difficult to ascertain, especially when participants were describing personal experiences. Only 7% of participants specifically mentioned how learning took place and they all referred to reading. For the other participants, we can make assumptions about how the learning took place. For example, those mentioning television probably learned through watching and listening, or perhaps discussing with others. Those mentioning video games may have learnt through play. However, the personal experiences described by participants, for example, interactions with healthcare staff, could have involved learning by a number of means including: questioning; researching; listening; watching; discussing; experiencing; or, copying.

As mentioned before, some free-choice learning takes place without the learner setting out to learn, as Falk, Storksdieck and Dierking (2007, p.459) described as “some of what we learn we learn rather incidentally, without consciously wanting to learn.” Perhaps this learning takes place instinctively through a variety of methods. Uncovering these methods may provide information on preferred learning styles and the most effective learning styles.

WHEN

No data on when free-choice learning took place were obtained from the interviews. However, the nature of free-choice learning suggests it takes place in free/spare time outside school and work hours. There were some examples of free-choice learning taking place during or as a result of work but not actually learning required by work. For example, B4 (Male, 40-49) talked about needing good reflexes for his work as a crane driver, C1 (Female, 60+) talked about how her husband's work has affected his health.

WHY

Why	No. of participants
For leisure	32
Concerning own health	28
Concerning someone else's health	6
In relation to driving	2
Having left body to science	1
To help children's education	1

Table 5.8 Why free-choice learning took place.

In most cases it was difficult to establish in such a short interview **why** learning took place but again inferences can be made. It can be reasonably assumed that the majority of watching television and playing video games are done for leisure. Even if a television programme is watched because it is educational, it is still done in leisure time and as a free-choice learning experience. It is also assumed that participants visit the gym for leisure. Of course, some may visit a gym for their health and some may not think of a gym visit as a free-choice experience!

When a reason for learning was alluded to (Table 5.8) it was mostly for leisure and secondly due to an interest in health (both their own and others). The interest in health obviously reflects the content of the exhibition but it is a perfect example of the type of experience that was explained by Falk and Dierking (2010, p.489) as "the many events in life, often highly personal, which demand increased understanding of science "right now." Or as described by Miller (2010, p.204) as seeking information "in a just-in-time mode in response to a perceived need." This would involve a more intentional kind of free-choice learning, where people actively seek out information because of a need to know. This is also a good example of Shen's (1975) Practical Science Literacy and has connections to the idea of health literacy (as discussed in Chapter 7).

Afonso and Gilbert (2006, p.1540) made an interesting point with regards to visitors retrieving information when using exhibits. They suggested that when interacting with an exhibit people may be more likely to retrieve information that they coded when in a similar mood. So if people view the exhibits as entertaining, they will retrieve information that they gained as part of an entertainment or leisure experience. This study's results for where (Table 5.7) and why (Table 5.8) free-choice learning took place seem to support this.

Considering why learning has taken place may lead to three types of free-choice learning. In one type learning occurs almost as a by-product of an activity, the individual has not set out to deliberately learn or gain information. As Falk, Storksdieck and Dierking (2007, p.459) described as “some of what we learn we learn rather incidentally, without consciously wanting to learn.” In the second type of free-choice learning, individuals actively aim to gain information, or learn, because of an interest in something. For example, someone interested in trains may attend an exhibition on steam trains to learn more about that topic. The third type of free-choice learning involves actively seeking out information because of a need. That need could be to solve a problem, or to understand an issue. Examples might include learning how gas boilers work to carry out an emergency repair or looking for information on a health issue to better understand treatment.

WITH WHOM

With Whom	No. of participants
Children (inc grandchildren)	5
Parent (inc in-laws)	4
Spouse	4
Friend	1

Table 5.9 With whom free-choice learning took place.

Limited data were obtained suggesting **with whom** free-choice learning had taken place, Table 5.9. When mentioned, it was mostly family that took part in free-choice learning together. Further work to determine with whom free-choice learning takes place would be useful for free-choice learning providers. Learning in groups, even small family groups, would be different to those learning alone. For example, providing materials for a family group would require catering for a range of ages and allowing for discussion of the materials.

It is important to note that a person's working knowledge is developed from a variety of free-choice learning experiences and providers. Others have previously suggested this should be considered as an infrastructure for science education as a whole (St. John and Perry, 1993) or just for free-choice learning (Muscat, 2001). In addition, all these experiences interact with each other (and with formal education) across contexts and with time, in other words, "Learning does not respect institutional boundaries" (Falk and Dierking, 2000, p.130). So although we look at one element in isolation, it should be remembered that a learner is "experiencing a variety of informal learning experiences throughout her life" (Crane, 1994, p.187) and we should consider "how that one component synergistically interacts with other components in the community" (Falk, 2001, p.11). Miller (2001) suggested:

> "The literature illustrates that single free-choice science education activities have few significant effects. But recognising that individuals select from these resources as if they were a smorgasbord and tailor their menus to their own interests and needs provides an important analytic and programmatic insight into free-choice science education" (Miller, 2001, p.112).

To gain further understanding of working knowledge, the data was analysed in terms of increasing the complexity of working knowledge.

INCREASE IN COMPLEXITY OF WORKING KNOWLEDGE (Annapolis proposal)

As described in the methodology (Page 91) the data were coded for increases in complexity of working knowledge as adapted from the proposal by Falk, Dierking and Holland (1995). Three different increases in complexity of working knowledge were coded: **reinforcement** of information and/or relationships in working knowledge; new information or relationships **added** to working knowledge; and, **changes** in the working knowledge itself, e.g., its importance or our perception of its structure. This will contribute to the second research question of this thesis: Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?

	Reinforcement	Added	Changes	None
No. of participants	53	16	6	2

Table 5.10 Number of participants (total number of participants = 58) showing evidence of **reinforcement** of information and/or relationships in working knowledge; new information **added** to working knowledge; and, **changes** in the working knowledge itself, e.g., its importance or our perception of its structure.

The results (Table 5.10) show that reinforcement was the most common increase in complexity shown by participants, followed by adding to working knowledge and then changes in working knowledge. Two participants did not show any evidence of increasing the complexity of their working knowledge. It should be noted that both of these participants reinforced knowledge they had gained from their jobs. These results are now discussed under each coding.

REINFORCEMENT

The interview transcripts revealed that the majority of subjects, 91% (53/58) showed evidence of increasing the complexity of their working knowledge by reinforcement when interacting with the exhibits.

<u>Examples of Increasing complexity of working knowledge by reinforcement of information and/or relationships in working knowledge</u>

- "I've sort of known about the hardening and the thinning of the arteries and cholesterol and there's been a lot about hydrogenated fat..." (A1 - Female, 40-49).
- [talking about Heart Beat Drum exhibit] "No just whenever if you go to the doctor's you see things and that about it" (D2 - Female, 60+).
- "Well the thing on the miners just now because they took their heart beats, they were monitoring them coming up from under the, the Chile thing" (D3 - Female, 60+).
- "Well the heart beat, I've been at the doctor's I have slightly elevated, eh, what is it, cholesterol. My cholesterol is slightly, slightly elevated just now" (E2 - Male, 50-59).
- "I've seen if you watch medical programmes on TV and you see people getting their arteries inflated with splints or vents or what they're called just things like that" (G4 - Male, 30-39).
- "Eh my mother had a double heart bypass so yes I know a wee bitty about it from that" (G6 - Female, 40-49).

- [talking about Heart Beat Drum exhibit} “I feel as if I was in my Tae Kwon do class” (H5 - Male, 30-39).
- “Em you sort of see people in sports like if it’s the 100 metres the reaction time after the gun going off” (K5 - Female, 40-49).

It was not only adults that provided examples of increasing the complexity of working knowledge by reinforcement, the following were recorded by staff in diaries or reported in staff interviews:

Examples of reinforcement of working knowledge noted in staff diaries or reported in follow-up staff interviews:

- “Reminds me of weightlifting. My dad does weightlifting. He is very fat. Weightlifting makes you strong” (P2 girl - Staff B, Diary Page 8).
- “It’s just like whack-a-mole” (P1 boy - Staff B, Diary Page 16).
- “This is just like how you measure earthquakes by measuring tiny changes” (P5 boy - Staff B, Diary Page 19).
- “Is that the pancreas? My Granny’s diabetic and her pancreas doesn’t make insulin so she needs injections” (P5 child - Staff c, Diary Page 4).

These results fit with previous suggestions that science learning is mostly, “an expansion and elaboration of existing understandings” (Falk and Storksdieck, 2010, p.208) and:

> “most learning has more to do with consolidation and reinforcement of previously understood ideas than with the creation of totally new knowledge structures” (Dierking et al. 2003, p.110).

and, in discussing free-choice learning:

> “In this context, learning tends to take the form of confirmation of existing understandings, attitudes, and skills in order to allow the individual to be able to say: “Okay, I now know that I know/believe that” (Falk and Dierking, 2012, p.1075).

Stocklmayer and Gilbert discussed a similar idea to reinforcement, which they termed “remindings”. They found that “when using an exhibit, a visitor has a reminding of a similar experience that forms the basis for interpreting the exhibit” (Stocklmayer and Gilbert, 2002, p.835). The importance of this was explained by Hein:

> “For visitors to have a positive experience, their interaction with the contents of the museum must allow them to connect what they see, do and feel with what they already know, understand and acknowledge” (Hein, 1998, p.153).

Also, Doering and Pekarik explained this in terms of their Entrance Narrative model:

> "When the museum visitor seeks confirmation and validation, a detail in an exhibition resonates in the mind or the heart of the visitor because of some prior connection with that idea, image, or object" (Doering and Pekarik, 1996, p.21).

It would be expected that if an individual can connect the content of an exhibit to something they are already familiar with, thus reinforcing their working knowledge, then they will be more able to understand and/or relate to the exhibit. This suggests that if an exhibit can be designed in a way that it reinforces an individual's working knowledge, that exhibit may be more effective in achieving its objectives. Stocklmayer and Gilbert thought this is what would happen in relation to PAST (Personal Awareness of Science and Technology):

> "If the experience is drawn from the visitor's everyday world, then strong links may be drawn between the experience and the target so that learning more about the target takes place" (Stocklmayer and Gilbert, 2002, p.854).

Also, Doering and Pekarik's Entrance Narrative model:

> "suggests that the most satisfying exhibitions for visitors will be those that resonate with their experience and provide information in ways that confirm and enrich their views of the world" (Doering and Pekarik, 1996, p.20).

Falk and Dierking agreed with this:

> "The more connections between what happens in the museum and what happens to people in their everyday lives, the higher the probability that the information presented will be remembered and used later in the visitor's life" (Falk and Dierking, 1992, p.153).

Also:

> "people learn best those things they already know about and that interest them, and people are interested in those things they learn best" (Falk and Dierking, 1992, p.100).

Perhaps reinforcement was the most common increase in complexity as it requires the least cognitive effort on behalf of the participant. It is much easier to agree with something or to say to oneself, "Yes, I know that" than to try to understand something new and add to working knowledge. This would fit with the cognitive miser model mentioned earlier (Page 41) which suggests that "the capacity-limited thinker searches for rapid, adequate solutions rather than for slow, accurate solutions" (Fiske and Taylor, 2010, p.13). Even more difficult would be to change the structure of our working knowledge, by realising that we no longer agree with a perception or value, or that our understanding is wrong or flawed, and to amend it. Perhaps participants actively avoided the effort of adding to or changing working knowledge. This is discussed further using the Paradox of Continuity later (Page 135).

Importantly, these results correlate with the perspective of Personal Construct Theory. Although Kelly's Experience Corollary suggests that constructions can be changed, this depends on the person's system being open to change:

> "While the Experience Corollary suggests that a man can revise his constructions on the basis of events and his invested anticipations of them, there are limitations that must be taken into account. He must have a construct system which is sufficiently open to novel events to let him know when he has encountered them, else the experience cycle will fail to function in its terminal phases. He must have a system which also will admit the revised construct that emerges at the end of the cycle" (Kelly, 1970, pp.12-13).

Kelly also provides another reason why reinforcing is more evident than adding or changing working knowledge: "A confirmation gives one an anchorage in some area of his life, leaving him free to set afoot adventuresome explorations nearby" (Kelly, 1970, p.12).

It could be argued that simply by reinforcing working knowledge by using the exhibits, working knowledge was also being added to through the creation of new links or additional meaning to existing working knowledge. A reinforcement could be argued to be the adding of a new relationship or association or providing interest. Afonso and Gilbert (2006, p.1540) put forward that, "The fact that retrieved memories can lead to an interest in a target represents a learning outcome" (Afonso and Gilbert, 2006; also, Burns, O'Connor and Stocklmayer, 2003; Gilbert 2001).

This suggests that reinforcing and adding to working knowledge could be combined and represented as one factor. However, it may be more useful to consider reinforcing and adding to working knowledge separately if the idea of increasing the complexity of working knowledge is to be applied to other topics and exhibits/activities. It is possible that other exhibits may produce a different pattern of reinforcing and adding to working knowledge. For example, there may be more adding to working knowledge with exhibits that aim to communicate facts, and more reinforcement with exhibits that communicate questions or problems. Keeping reinforcement and adding to working knowledge separate could be a more useful tool for museums and science centres to evaluate the impact of particular exhibits or activities. When interacting with an exhibit some people will add to working knowledge, some will reinforce knowledge and some will have changes in working knowledge. St. John and Perry believed this is a useful idea in evaluating exhibits stating that:

> "evaluation efforts should not be focused on measuring what visitors learn or remember, but rather on understanding how they use the museum resources and the ways in which they make meaning out of their experiences" (St. John and Perry, 1993, p.63).

Crane also hinted at this suggesting that informal learning research needs to move away from:

> "traditional reliance on test scores and quantitative methods toward qualitative methods that get closer to the reality of the learning process" (Crane, 1994, p.186).

More recently, Martin (2004, p.S76) added that it is difficult to think about learning outside of school as we "tend to treat right answers and test scores as the only "scientific" evidence of learning."

ADD

The results showed fewer participants adding to their working knowledge (28% of participants) than reinforcing their working knowledge (91% of participants).

<u>Examples of Increasing complexity of working knowledge by new information or relationships **added** to working knowledge</u>

- [talking about How high can you jump? Exhibit] "I couldn't believe that I'd been off the ground as long as it said I had" (A6 - Female, 40-49).
- "...well that was the first time I'd ever used anything like that. I'd never used anything like that before" (C4 - Female, 60+).
- "Cos I smoke and it's actually quite a shock to, like when I blow, when I blew into that machine and it went straight to red straight away kind of thing it was different to know like what I'm putting into my body when I smoke kinda thing" (D4 - Female, 20-29).

- "Just when you hear about blocked arteries and you know what it is, well I certainly know what it is in theory but whenever you actually do that and understand what the difference is" (F2 - Female 30-39).
- "I was surprised at how hard it was to pump because it was slightly thinner I would have to say" (G5 - Female, 30-39).
- "Well I was quite surprised that you know it said if you can grip to 100, on both hands that would be the same, if you can grip to 100 then that's a good grip, which surprised me" (I1 - Female, 60+).

There were not many examples of adding to working knowledge reported in staff diaries or staff interviews. This was probably due to the limitations of the method rather than a lack of people adding to their working knowledge. In particular, staff were briefed to note down relationships that people made with the exhibits and examples of people's working knowledge rather than specific examples of people adding new working knowledge. However, some examples were obtained including,

<u>Examples of adding to working knowledge noted in staff diaries or reported in follow-up staff interviews:</u>

- "A lot of people seem really surprised by the sizes of the liver and stuff" (Staff D, Interview 1).
- "I thought a blockage meant no blood could go to your heart" (P4-7 child - Staff F, Interview 2).

The fact that there were fewer examples of adding to working knowledge than reinforcing working knowledge may simply be because people know everything about this topic and therefore have nothing to add/change, only reinforce.

The data collected may show less evidence of adding to working knowledge than reinforcing working knowledge because, as some studies on learning in museums suggest, learning happens in the long-term. For example, Falk and Dierking (2000), "It is only after weeks and months, and sometimes years, that events unfold sufficiently so that visitors can appreciate the significance of those in-museum experiences" (Falk and Dierking, 2000, p.129) and Schauble, Leinhardt and Martin (1997, p.3) "learning effects of a museum visit may have a very long "cycle time," sometimes emerging years after the encounter occurs." Indeed, Falk (2001, p.11) suggested that only by framing the experience with the exhibits in the context of the person's whole life can we begin "to truly understand the nature and impact of that experience."

Others have emphasised how the process of learning is cumulative, occurring over time, and so “the visit experience cannot be regarded as an isolated event” (Rennie, 2001, p.111) and “experiences occurring after the visit frequently play an important role in determining, in the long term, what is actually “learned” in the museum” (Falk and Storksdieck, 2005, p.746). It takes time to incorporate new experiences into working knowledge as Dierking et al. (2003) described:

> “it can take days, weeks, or even months for new experiences to be sufficiently integrated with prior knowledge before learning is measurable let alone noticeable even to the learner” (Dierking et al 2003, p.110).

Perhaps additions to working knowledge because of the BodyWorks exhibits will appear in future research.

It is also likely that it is easier to retrieve and/or articulate or explain previous working knowledge than new working knowledge. In other words, the working knowledge recently gained from the exhibits may not yet be processed adequately to be communicated. This is one of the main problems with interviews as a method of data collection. Stocklmayer and Gilbert suggested that interactions with exhibits should be considered over the long-term:

> “This is to allow for reflection on the experience to take place, for allied experiences to be encountered and recognised as such, and for a visitor to have opportunities to explain the experience to others” (Stocklmayer and Gilbert, 2002, p.852).

Of course, there will have been learning that the data collection has missed. This will not only have included learning that happens in the long term, and learning that was not reported by the participants, but also other outcomes for example, learning of skills, including skills for learning in a free-choice learning environments such as, “how to use an interactive exhibit...” (Bell et al. 2009, p.66) or, “how to “do” a particular kind of museum or even how to contrast and compare objects or display characteristics among museums” (Leinhardt and Knutson, 2004, p.68).

One subtle effect that the exhibits may have would be to empower an individual to add to their working knowledge in the future. This has been noted by previous researchers:

> "even participants whose learning is not evident in a pre-post design may take away something important: the potential to learn later" (Bell et al., 2009, p.62).

> "The emergent interest may also have a long-term outcome manifested by a predisposition to learn more about a target after the visit" (Afonso and Gilbert, 2006, p.1540).

> "even an unusual or unfamiliar experience in a museum, one that is intellectually inaccessible at the time of the visit, may contribute to later enlightenment" (Hein, 1998, p.154).

This effect clearly calls for more research into the long-term effects of museum visits to gain a better understanding of how working knowledge is formed.

Another issue with the data collected in the current study was that it couldn't be said for certain that working knowledge was being added to, unless the participant specifically stated it is new to them. So, there is the possibility that some adding to working knowledge may have been coded as reinforcement (and vice versa).

As discussed above, reinforcement of working knowledge could be seen as adding to working knowledge. As Hein (1998, p.156) said, "It is not only difficult but almost impossible to learn something without making an association with familiar categories." If we had included reinforcement in the adding to working knowledge then almost all of the participants would have added to their working knowledge 56/58 (97%). (The two participants not included in this figure reinforced knowledge that they had gained from their work).

The results indicated that BodyWorks is reinforcing much more than adding to working knowledge. This may have been the content of and the aims of the exhibits. However reinforcement is learning, not just adding, or changing working knowledge. As Falk and Dierking (1992) described, it is a,

> "misguided notion that learning is primarily the acquisition of *new* ideas, facts, or information, rather than the slow, incremental growth of existing ideas and information" (Falk and Dierking, 1992, p.98).

Falk and Needham (2011) raised an important point with regards to this, the fact that society places more significance on gaining new knowledge over reinforcing existing knowledge. So if science centres and their exhibits are mostly reinforcing knowledge then they may not be receiving adequate credit for their educational value:

> "we tend to place greater value on educational experiences that provided first exposure to a topic than we do to experiences that provided essential support and understanding that allows a topic to become deeply known. Since schools tend to be places where most science concepts are first presented, this societal bias represents a particular challenge to free-choice learning institutions such as the California Science Centre that appear to particularly support the building and strengthening of knowledge" (Falk and Needham, 2011, p.10).

CHANGE

In the data collected 10% (6/58) of participants showed evidence of change in their working knowledge, much fewer than those increasing the complexity of their working knowledge by reinforcing or adding to it. The examples shown below show that the changes were subtle changes in understandings, this is analysed further (Page 139) when discussing the content of working knowledge and increases in complexity.

<u>Examples of Increasing complexity of working knowledge by **changes** in the working knowledge itself</u>

- "I was just saying to my wife there I says it just shows you that Wii's absolute rubbish... Because it tells you your good at balance and then you go on that, that's quite difficult" (B2 - Male, 50-59).
- "...things you don't really think about suddenly become a lot more real, do you know what I mean..." (B5 - Female, 60+).
- "Surprisingly I was stronger with my left hand and I didn't think I would be" (I5 - Female, 40-49).
- [talking about the liver] "It's much bigger than anticipated" (K4 - Female, 40-49).

<u>Examples of changes in working knowledge noted in staff diaries or reported in follow-up staff interviews:</u>

- "I thought a blockage meant no blood could go to your heart" (P4-P7 child - Staff F, Interview 2).

Paradox of Continuity

The fact that less evidence of changes in working knowledge was found compared to reinforcement may be explained by the *paradox of continuity*. Working knowledge is clearly important in understanding and using exhibits (all participants except one showed evidence of working knowledge). However, what if the scientific content of that working knowledge is incorrect or flawed? As discussed above with regards to reinforcement (Page 130), learners are more likely to construct an idea that agrees with their own prior knowledge, so exhibits could provide confirmation of incorrect concepts. Rennie and Williams (2006, p.872) described this as people making use of new knowledge by restructuring it to fit with their own needs and circumstances. McWilliams described this as a part of Personal Construct Theory in that "Due to our desire for consistency and predictability. We resist change, and we often attempt to incorporate new understanding into our existing framework" (McWilliams, 2003, p.82).

Roschelle (1995) described this in terms of prior knowledge as the *paradox of continuity*. The paradox being that prior knowledge appears to be both necessary for understanding the concept but also a problem in that it might reinforce a misunderstanding of the concept. Roschelle suggested that the paradox of continuity can be overcome by seeing prior knowledge "not as a cause of errors or success but rather as the raw material that conditions learning" (Roschelle, 1995, p.41). In other words, "Museum experiences cannot eliminate or disable prior knowledge, but rather must work with it" (Roschelle, 1995, p.48).

The paradox of continuity is similar to Dewey's principle of continuity of experience:

> "the principle of continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after" (Dewey, 1963, p.35).

Dewey also described the same problems that occur with the paradox of continuity:

> "So far, however, we have no ground for discrimination among experiences. For the principle is of universal application. There is *some* kind of continuity in every case" (Dewey, 1963, p.35).

Falk seemed to be suggesting that working knowledge and the paradox of continuity should be considered in exhibit design:

> "Exhibits are often designed so that no prior knowledge is needed, or assume that people have minimal knowledge about the subject; but would

> we design differently if we found out how much and what people know already?" (Falk, Dierking and Holland, 1995, p.30).

The paradox of continuity suggests that it will be more difficult to design exhibits and activities that aim to change working knowledge rather than those that aim to add to or reinforce working knowledge. Regardless of the aims of the exhibition, the results here support this, showing the BodyWorks exhibits were more likely to reinforce or add to working knowledge than to change it.

Previous work has supported two approaches to the paradox of continuity one being to actively try to change misconceptions and one to use misconceptions and to build on them. Borun, Massey and Lutter (1993) found that people's misconceptions, or naive notions, about gravity could be changed using front-end evaluation to design hands-on exhibits. Whereas, Davis Horn and Sherin (2013, p.32) argued that "being "wrong" is an inescapable part of learning" and "learning is not a process of replacing misconceptions with correct theories."

Davis, Horn, and Sherin's approach fits more closely with the idea of working knowledge, with it being continually added to and adjusted and, in particular, with its individual nature. It also corresponds with the personal constructivist paradigm as:

> "A basic tenant of all constructivist theories of learning maintains that new knowledge is built from existing knowledge" and "Thus, any account of learning which has the form delete the old knowledge, replace it with the right knowledge is no account of learning at all" (Davis, Horn, and Sherin, 2013, pp.34-35).

They went as far as to say:

> "When we design exhibits to explain away or replace misconceptions, we are ignoring the active nature of knowledge construction and setting ourselves up for failure" (Davis, Horn, and Sherin, 2013, p.37).

Importantly the key to both these approaches is front-end and/or formative evaluation. This takes into account the importance of working knowledge and free-choice learning by including it in exhibit design. This was described by Davis Horn and Sherin as follows:

> "An iterative program of interviews can keep curators, exhibit designers, and docents aware of visitor thinking and help keep museums reactive to their visitors. The goal of this visitor research is not to find out what visitors are lacking so that post-visit studies can evaluate an exhibit's

> success. Instead, this research is meant to empower the designers to empathize with visitors and to recognize the useful ideas that an exhibit might utilize to aid in learning" (Davis, Horn, and Sherin, p.38).

This corresponds with how Nisbet and Scheufele (2009) suggested using frames to try to overcome the cognitive miserly nature of individuals (see Page 41). The framing aims to make a communication personally relevant thereby providing motivation to put effort into understanding it. Without this motivation individuals may follow the cognitive miser model and take shortcuts to understanding which can result in misconceptions:

> "People adopt strategies that simplify complex problems; the strategies may not be correct or produce correct answers, but they emphasise efficiency" (Fiske and Taylor, 2010, p.13).

Nisbet and Scheufele seem to support front-end evaluation when considering frames for communications:

> "any science communication efforts need to be based on a systematic empirical understanding of an intended audience's existing values, knowledge, and attitudes, their interpersonal and social contexts, and their preferred media sources and communication channels" (Nisbet and Scheufele, 2009, p.1767).

It could be argued that there would be fewer misconceptions or naive notions if people developed good skills for free-choice and lifelong learning during their formal education. Skills in researching, evaluating and decision-making may minimise misconceptions.

Content of working knowledge and increases in complexity of working knowledge

As discussed previously, the content of working knowledge can be investigated by dividing examples into facts, understandings, perceptions and values. These categories can be used to look more closely at increases in complexity of working knowledge to establish if the increases and categories are connected in any way.

	Reinforcement	Add	Change
Facts	15	0	0
Understandings	51	14	6
Perceptions	15	1	1
Values	5	1	1

Table 5.11 Content of working knowledge and increases in complexity of working knowledge.

The content of the examples of reinforcement of working knowledge appears to follow the general pattern of evidence of working knowledge, (Table 5.11) in that the majority of examples were understandings followed by facts and perceptions and then values. However, the pattern for adding to working knowledge and changing working knowledge appears to be different. Almost all examples of adding to or changing working knowledge were understandings. There were no examples of adding facts to working knowledge or changing facts. There were very few examples of adding to or changing perceptions or values. This suggests that it is easier to add or change understandings rather than facts, perceptions or values.

However, it could be that the BodyWorks exhibits were aiming to add to or change understandings. The exhibits may have had no aims related to adding to or changing facts, perceptions or values. This will be investigated further later (Page 145) when the original aims of the BodyWorks exhibits are discussed together with and compared to the data.

Knowledge and Interest in science and increases in complexity of working knowledge

The data obtained on participant's self-reported knowledge and interest in science (Table 5.3) can be used to further investigate the increases in complexity of working knowledge.

	Reinforcement	Add	Change	None
5 or 4	29	9	4	2
3	16	4	2	0
1 or 2	8	3	0	0

Table 5.12 Participants' interest in science compared to increases in complexity of working knowledge.

The table shows more increases in complexity of working knowledge in those individuals who said they were more interested in science (4 or 5 on the scale). This suggests that those who reported that they were more interested in science were more likely to increase the complexity of their working knowledge. However, the two individuals who did not increase the complexity of their working knowledge also reported that they were interested in science. Looking more closely at these individuals it is found that both of them reinforced knowledge that they had gained from work. This may suggest their interest in science is because of their jobs or that they relate most of their science knowledge to their jobs.

It seems to make sense that those who are more interested in science are likely to pay more attention to the exhibits, put more effort into using them and therefore increase the complexity of their working knowledge. This result fits with the cognitive miser model (see also Page 41) which suggests people with less interest will put less effort into understanding and will seek the quickest understanding (Fiske and Taylor, 2010). The big problem for free-choice learning providers is how to attract the attention of those who are less interested in science. Nisbet and Scheufele (2009) recommended that one way to create interest in science communication is to frame the information so that it becomes personally relevant to the individual (see Page 42).

It would be interesting to know what the participants who reported that they are not interested in science think that science is. There must be individuals saying they are not interested in science as the only interaction they think they have had with science is at school. Maybe that was not a pleasant experience.

	Reinforcement	Add	Change	None
5 or 4	7	1	1	0
3	15	4	3	2
1 or 2	31	11	2	0

Table 5.13 Participants' knowledge of science compared to increases in complexity of working knowledge.

The table shows more increases in complexity of working knowledge in those individuals who said they were not knowledgeable about science (1 or 2 on the scale). This suggests that those who believe themselves to be less knowledgeable in science were more likely to add to their working knowledge. Or, alternatively, those who are more knowledgeable have less to learn. This seems to contradict Falk and Dierking's suggestion that:

> "To the extent that learning appears to require both previous experience and subsequent reinforcement, it follows that people with greater previous experience are likely to learn more than people with less experience" (Falk and Dierking, 1992, p.125).

However, it is similar to Falk and Storksdieck's finding that:

> "The more a visitor knew about life science when they entered the exhibit, the less they tended to gain cognitively from the visit, at least in the short term" and "individuals with the least prior knowledge showed the greatest gains" (Falk and Storksdieck, 2005, p.759).

Again, it would be interesting to know what those reporting to be less knowledgeable in science think that science is. It could be that people are more knowledgeable than they think they are, or are willing to report that they are.

SUMMARY OF RESULTS AND ANALYSIS

WORKING KNOWLEDGE

The data collected and analysed showed that individuals' working knowledge is important in interacting with the BodyWorks exhibits. Despite this being a small study, the fact that all the participants interviewed (except one) showed evidence of working knowledge suggests that working knowledge is important in science learning and understanding. The importance of working knowledge is reinforced by the significance of free-choice learning.

The way that working knowledge seems to be utilised when confronted with new information, or information presented in a different way, suggests that working knowledge may be useful in formal education. Recognising that pupils may be using working knowledge, rather than information they have been formally taught, when new ideas are being presented could be useful when planning lessons. In addition, the detailed recollection of information seen in working knowledge may be of interest to formal education. If the processes and types of learning used to acquire such detailed information could be identified, this could again help in planning teaching in formal environments.

The working knowledge evidenced above was mostly made up of understandings. It would be interesting to see if this is related to the content of the BodyWorks exhibits or if it is different for other themes and topics. The way in which the exhibits were an effective tool to bring out working knowledge in the interviews suggests that further work may be possible using different exhibits or activities and different topics.

FREE-CHOICE LEARNING

The data showed that free-choice learning is an important source of knowledge, i.e. working knowledge, which is used when interacting with the BodyWorks exhibits. This suggests that free-choice learning is important in science learning and understanding, and that the input from formal learning environments is less important than may be expected.

The data suggest that most free-choice learning takes place at home, with relatives, for the purpose of leisure. Healthcare settings were also shown to be an important source of working knowledge about science. This may be specific to the topics covered in the BodyWorks exhibits. However it is of interest to note how much free-choice learning takes place in these settings. In particular, this is of relevance to the idea of health literacy discussed in later chapters (7 and 8).

The study has given us a better understanding of free-choice learning, showing the range of resources people use to gain science knowledge and that some are more utilised than others. This study agrees with Falk, Storksdieck and Dierking

(2007) that free-choice learning is a significant contributor to science knowledge. The fact that only 14% referred to science they had learned in school or college seems to underline the importance of free-choice learning. These data correspond with Falk Storksdieck and Dierking's finding that:

> "Informal education resources such as books, television, life experiences and museums were reported utilised as frequently, or more frequently, than were formal education sources" (Falk, Storksdieck and Dierking, 2007, p.463).

It must also be noted that free-choice learning experiences do not occur in isolation. They interact with each other and with formal education.

INCREASE IN COMPLEXITY OF WORKING KNOWLEDGE

Most increases in complexity of working knowledge evidenced following use of the BodyWorks exhibits were through reinforcement. This suggests it may be more difficult to change or add to working knowledge. However, it may be that the content of the exhibits lends itself to reinforcement.

The idea of increasing the complexity of working knowledge fits with the operational definition of learning described in the methodology:

> "The process of learning occurs when an experience interacts with an individual's working knowledge in such a way that it reinforces, adjusts, or adds to that working knowledge" (Page 70).

This suggests that as 97% of participants increased the complexity of their working knowledge, then these participants showed evidence of learning (according to the operational definition of learning) as a result of using the BodyWorks exhibits. This is similar to Falk and Dierking's results that:

> "strongly supports the premise that museum learning experiences facilitate some degree of learning in virtually all participants, although not necessarily exactly the learning an educator or developer would predict, or even necessarily hope for" (Falk and Dierking, 2000, p.173).

Looking at how people are increasing the complexity of their working knowledge may provide a way for science centres and other free-choice learning providers to evaluate their exhibits and activities. The importance of working knowledge would suggest that any interaction with an individual's working knowledge, or increase in its complexity, could be a potential measure of the impact of an activity or exhibit. Also, this study suggests that it may be more difficult to change working knowledge than to add to, or reinforce it. This has implications for exhibit design with regards to the Paradox of Continuity (discussed above, Page 135). Although it is difficult to change misconceptions, they cannot be ignored in the designing of an exhibit; they should be seen as a starting point for the interaction between the visitor and the exhibit.

GENERAL

Although the BodyWorks exhibits provided this study with evidence of the importance of working knowledge and free-choice learning, it would be useful to look for evidence with other exhibits, covering other science topics. It seems reasonable to assume that people may have more working knowledge about health than other science subjects, for example, mechanics, astronomy, evolution. Previous work has found that learning topics related to personal health, such as human biology or medical discoveries, were considered more interesting by schoolchildren and adults than other general science topics (Lin, Hong and Huang, 2012). Also, children reported being more confident in biological sciences and Stark and Gray (1999) suggested this could be because the topics are directly relevant and, importantly for this study, “the concepts involved are likely to have been acquired and developed in a range of settings”(Stark and Gray, 1999, p.80).

In fact, individuals may choose to engage with science because of a medical need (Stocklmayer and Gilbert, 2002, p.851). Seeking out health knowledge would fall into what Falk and Dierking (2010, p.489) described as one of “the many events in life, often highly personal, which demand increased understanding of science “right now.” The personal nature of health knowledge may increase its importance to an individual and this may affect how that knowledge is remembered and used. McManus explained this as:

> “an individual’s use of, and indeed retention of, any particular concept in his or her thinking is affected as much by what that individual values and feels about that particular concept as it is by his or her understanding of it” (McManus, 1993, p.108).

Health is something that everyone has experience of and has their own personal knowledge of. This is clear in the fact that all participants in this study showed evidence of working knowledge in relation to the BodyWorks exhibits. It is difficult to imagine that the exact same result would apply for exhibits on another subject.

The importance of free-choice learning and working knowledge, as shown in the results, suggests that it may be useful to use them as a lens through which to revisit previous research in the public's understanding of science. As it is one of the biggest fields of research in public understanding of science, working knowledge and free-choice learning will be used to review definitions and models of science literacy (Chapter 6).

COMPARISON WITH GOALS/OBJECTIVES OF BODYWORKS EXHIBITS

This study did not set out to be an evaluation of the BodyWorks exhibits. The problems associated with differentiating between evaluation and research have been discussed in the methodology section (Page 73). However, it is of interest to compare some of the results to the objectives set out for the exhibits. The researcher did not look at the written objectives or descriptions of the exhibits until this point in the research so as not to be biased in analysis of the results or to make assumptions with regards to data. Paperwork describing the outreach exhibition and its specific exhibits can be found in Appendix 8.

The BodyWorks outreach exhibition was described as:

> "A four-year funded Life & Health Outreach programme. supported by GSK. The project will support to teachers, pupils and family audiences across Scotland to effectively engage with the new Scottish Curriculum for Excellence; and ideals of healthy living choices to inspire people to improve the quality of their lives. With emphasis on the 'Our Living World' component of the curriculum, this programme will utilise specially designed tabletop exhibits and activities to support effective learning and teaching in science" (GSK Outreach Programme PID v11.doc).

> "The exhibition is primarily aimed at late primary and early secondary school pupils, approximately 9 to 14 years. However, there will be a few exhibits that are targeted specifically at early years and these will not be taken out to older children" (GSK exhibit development.doc).

The first point to note is that the exhibition was primarily aimed at engaging with the Curriculum for Excellence and school pupils. As described in the Methods (Chapter 4) the main data collection in this study was confined to adults, with limited data from children being obtained from the staff diaries and interviews. The main reason for this was that it is assumed that adults have had longer to develop working knowledge and experience free-choice learning. For this reason alone, the data obtained in this study is not relevant to an evaluation of the exhibition as it does not involve the main target audience. However, the BodyWorks exhibition is also offered into the community and to a general public audience. Which prompts the question, is it possible for the exhibits to cover the needs and expectations of both school and public groups? It could be argued that exhibits that are designed to compliment a curriculum are not truly free-choice. Is this a missed opportunity? For example, if a schoolchild encounters BodyWorks exhibits at a community event they are encountering topics they will have studied, or will study, at school. This could be seen as a perfect way of reinforcing school material by presenting it in a different context and fashion. The results here have supported the importance of reinforcement in learning. Alternatively, this could be seen as a missed opportunity to engage the child in new material, and add new knowledge on the topics. Also, Falk and Dierking (2000) supposed that:

> "When museums try too hard to mimic compulsory education or force specific learning agendas on the public, they undermine their own success and value as learning institutions" (Falk and Dierking, 2000, p.138).

It is always going to be difficult for exhibits to be of interest to both children and adults. In general, from observation, BodyWorks seems to achieve this. However, there may be some adaptations that could be made when the exhibition is being used by a general audience (both adults and children). For example, the data showed that a lot of people related their own health and medical experiences to the exhibits. It would be expected that most adults would have had more of these experiences than children. Perhaps the exhibit information should be adapted to include more on health experiences when being used by adults. This would fit with the recommendations of Jeffery-Clay (1998) that:

> "Visitors must be brought into the experiences somehow, and they need to find their own meaning from the exhibits" (Jeffery-Clay, 1998, p.6).

and:

> "To create a truly constructivist setting, museums must develop exhibits that get visitors involved, relating to them, to their lives, and to their past experiences" (Jeffery-Clay, 1998, p.6).

This is not straightforward and as Tulley and Lucas (1991, p.534) stated, “The problem for designers is to build exhibits which use the experience of the visitors in a meaningful way.”

It would be difficult to know at what level to aim the content of a public exhibition. The data in this study suggested that the majority of people have studied science to GSCE/Standard grade level. Also, the gap between interest in and knowledge of science suggested that people want to know more about science, so perhaps new information and challenging material is what they would like.

The data showed that the majority of people interviewed had some working knowledge of the material in the exhibition. The fact that the staff diaries showed that children also had working knowledge of the content suggests that perhaps the exhibition is suitable for all ages. That is, if one of the objectives had been to interact with people's working knowledge.

The data also suggested that most people are making use of knowledge gained through free-choice learning when interacting with the BodyWorks exhibits. This is perhaps something to think about when designing exhibit content. In particular, the BodyWorks exhibits were designed to compliment school curriculum, yet it is not knowledge gained from school that people are using to understand the exhibits. More importantly, the data from the staff diaries provided some evidence that schoolchildren are using knowledge gained from free-choice learning i.e. working knowledge, when understanding the exhibits. This is not to say that matching content to the curriculum is unnecessary, as the schoolchildren may show future gains in knowledge related to the curriculum or may become more interested in the topics of the curriculum. However, it does suggest that free-choice learning should be considered. In fact, the curriculum should take into account the importance of free-choice learning.

GENERIC LEARNING OUTCOMES

Glasgow Science Centre (GSC) used Generic Learning Outcomes (GLOs) to set out aims and objectives for the BodyWorks exhibition. GLOs are a tool used to measure the impact of learning (RCMG, 2003). The generic categories in GLOs provide a scheme for the gathering, analysis and interpretation of the evidence of learning (LIRP, 2002).

The GLOs stated for the BodyWorks exhibition were:

> "Knowledge and understanding – the visitor will gain an understanding of their body and how it works. They will learn the reasons why it is good to maintain a healthy lifestyle. The visitor will make sense of why it is good to keep fit, eat healthily, not smoke etc, and make links between bad lifestyle and ill health, weight gain, ageing etc.
> Skills – visitors will learn physical skills, by showing them how to improve grip strength etc.
> Attitudes and values – the exhibition may change visitors' opinions about health and healthy living: they may change their mind about smoking, eating fatty foods, not exercising etc.
> Enjoyment, inspiration and creativity - this exhibition will be fun and potentially inspiring"
> (GSK exhibit development.doc).

The aims set out for the exhibition can be compared to the data of this study. However, it is imperative to keep in mind that this data cannot be considered to evaluate the exhibits for a number of reasons: the study was not designed to measure if aims were being met; the participants in the study were not the main target audience of the exhibition; the aims of the BodyWorks exhibits were not stated in terms of interacting with people's working knowledge.

In terms of Knowledge and Understanding, GSC stated that after using the BodyWorks exhibits, "the visitor will gain an understanding..." and understandings were the type of working knowledge mentioned most often by participants, as discussed above (Page 112). The results show that 28% of participants added to their working knowledge i.e. gained. As discussed above, this relatively small number could be due to a number of reasons: learning happens in the long-term; new working knowledge may be more difficult to retrieve and/or articulate; the participants may have been empowered to learn later. Also, if we include reinforcement in the adding to working knowledge, 97% of participants have added to their working knowledge, i.e. gained.

In terms of Attitudes and Values, GSC, stated that after using the BodyWorks exhibits, "the exhibition may change visitors' opinions..." The results suggested that 10% of participants showed evidence of change in their working knowledge.

Also, there were very few examples of adding to or changing perceptions or values. As stated above, this could suggest that it is easier to add or change understandings rather than facts, perceptions or values.

As the BodyWorks exhibition is an outreach project it will be reaching people with varied interests and knowledge in science. Whereas, an exhibition within a science centre may, in general, reach more people with a greater interest in science - they have chosen to visit a science centre. Therefore, it is important to consider that the data collected suggested that those who reported that they were more interested in science were more likely to increase the complexity of their working knowledge. How could the exhibits benefit those with low interest in science? Falk and Dierking suggested that:

> "The task for the exhibition team is to build structures that enable visitors to traverse the paths from current knowledge and experience to hoped-for knowledge and experience" (Falk and Dierking, 1992, p.137).

Also of importance when considering general audiences, with varied knowledge of science, is that the data suggested that those who believe themselves to be less knowledgeable in science are more likely to add to their working knowledge. Or, possibly, those who are more knowledgeable have less to learn. If the exhibits are aimed at those with low knowledge of science, are those with more knowledge being overlooked? Roschelle (1995) pointed out the difficulties faced by designers in providing for an audience with varied knowledge:

> "Due to the pervasive influence of prior knowledge on learning, good designers of interactive experiences need to cultivate a sensitivity to the different points of view that learners will bring to an experience" (Roschelle, 1995, p.47).

SUMMARY

Although the data did not evaluate the BodyWorks exhibits, and also this was a small study that supports further research, there are some points that may be of use in the designing of new exhibitions. During formative evaluation of new exhibits it would be useful to look at the types of working knowledge people are using when interacting with the exhibits and how these relate to stated objectives or aims. Of course, as working knowledge is unique to every individual it would be impossible to cater for all. As Osborne (1998) pointed out:

> "The problem for museum educators is that individuals arrive in museums with such a vast range of conceptions and social histories that it is impossible to document all of them" (Osborne, 1998, p.9).

However, key themes, or sources of free-choice learning could be considered. As discussed above (Page 137) formative evaluation is also crucial in recognising people's misconceptions. Also, the importance of free-choice learning and working knowledge suggest that they should be taken into account alongside formal curriculum outcomes.

IN THE NEXT CHAPTER...

…working knowledge and free-choice learning will be used as a lens through which to revisit models and definitions of scientific literacy. This will contribute to the third research question of this thesis: "What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?"

CHAPTER 6 REVISITING SCIENTIFIC LITERACY THROUGH THE LENS OF FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

The results described and discussed in the previous chapter have provided empirical evidence for the importance of free-choice learning and working knowledge. The importance suggests that it may be worthwhile to use the ideas of free-choice learning and working knowledge as a theoretical perspective from which to revisit related areas of research.

Of the terms outlined in the literature review as being similar to working knowledge, scientific literacy is the most widely used and researched. This research has resulted in a number of models and definitions of scientific literacy. The results of the current study (see Chapter 5) have provided support for the importance of free-choice and working knowledge and therefore they should be a useful lens through which to revisit the research in scientific literacy.

The following is an examination of models of scientific literacy and how they correspond with the ideas of working knowledge and free-choice learning. This is carried out to address the third research question: What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?

Despite many definitions, scientific literacy is generally concerned with the public having some knowledge of science. Working knowledge makes up the part of scientific literacy that has been gained through free-choice learning. The term scientific literacy was introduced in the 1950s and was most probably first published by Hurd in 1958 in *Science Literacy: Its meaning for American schools* (Laugksch, 1999). However, the ideas behind scientific literacy had been published earlier, for example, “Scientific education of the layman” (Conant, 1946) and “Social uses of science” (Pierce, 1954). The many definitions of scientific literacy mean that comparisons between research are not always possible. Feinstein (2011, p.170) went as far as to say that science literacy “has come to mean everything and nothing.” The many concepts of scientific literacy can create confusion as to who is discussing what. This confusion is added to by the fact that some researchers have used the terms science literacy and scientific literacy interchangeably whereas others considered them to be two different things. Roberts (2007, p.730) said that “for some authors the distinction between scientific literacy and science literacy is unimportant for others it is significant.” He chose to refer to them both as “SL”. Feinstein (2011, p.169) agreed that most researchers, though not all, treat the two phrases as synonyms, but Maienschein (1998) described two definitions:

> “The first emphasizes practical results and stresses short-term instrumental good, notably training immediately productive members of society with specific facts and skills. We call this science literacy, with its focus on gaining units of scientific or technical knowledge. Second is scientific literacy, which emphasizes scientific ways of knowing and the process of thinking critically and creatively about the natural world” (Maienschein, 1998. p. 917).

Liu (2009, p.302) also described two definitions saying, “science literacy is related to goals of science education, and scientific literacy is related to approaches to achieving science literacy.” In this analysis the terms are used as they were originally used by the authors of the work being discussed. The terms are used interchangeably where they appear to be meaning the same thing.

In some cases it has been presumed that when authors refer to informal learning, they are discussing learning out of school. Free-choice learning as a relatively new term will not appear in earlier models of scientific literacy. The older term of informal learning will be used here to consider out of school learning.

A review by Laugksch (1999) was used as a starting point for a trail through the literature to find models of scientific literacy. Additional models were found during the literature review of scientific literacy. Work that clearly included a model or distinct definition of scientific literacy was used in the review. The models discussed below are considered to be representative of the range of models that have been developed.

This review of models specifically looked at scientific literacy and not other similar ideas such as public understanding of science or public awareness of science (these ideas, and others, have been discussed in the literature review). This narrowed the focus of the analysis and also allowed for a more straightforward comparison with health literacy models and health literacy research later (Chapter 8). The models are considered chronologically by publication date starting with Pella, O'Hearn and Gale (1966). This shows how the concept of scientific literacy has developed over time, and indicated emerging trends and key themes.

REVIEW OF MODELS

Pella, O'Hearn and Gale (1966, p.199) referred to scientific literacy as "science for effective citizenship" and suggested that this definition has been used by many researchers. In order to determine what they called the "referents" to scientific literacy, Pella, O'Hearn and Gale carried out an extensive review and analysis of consultations and literature published between 1946 and 1964. They concluded that:

> "The scientifically literate individual presently is characterised as one with an understanding of the (a) basic concepts in science, (b) nature of science, (c) ethics that control the scientist in his work, (d) interrelationships of science and society, (e) interrelationships of science and the humanities and (f) differences between science and technology" (Pella, O'Hearn and Gale, 1966, p. 206).

They stated that their analysis shows that knowledge of interrelationships of science and society, ethics of science, and nature of science are more important than the other characteristics.

This work predates the terms free-choice learning and working knowledge by almost 40 years, however, an individual's working knowledge could contain aspects of any of the characteristics of Pella, O'Hearn and Gale's definition of a scientifically literate person. Also, the definition of scientific literacy as "science for effective citizenship" seems to fit with how working knowledge would be expected to be used in everyday life.

In addition, many ideas like science in society and public understanding of science that are covered in the references of Pella, O'Hearn and Gale 1950's article have been reintroduced and discussed in more recent work.

Pella, O'Hearn and Gale's study in itself provides a useful review of literature relating to scientific literacy up until this time. However, most of the ideas and research referred to seem to have concentrated on formal education providing scientific literacy. A review from 1966 to the present time (this chapter) could show increasing reference to the contribution of free-choice learning.

Rubba and Anderson (1978) reported that, like Pella, O'Hearn and Gale, Showalter (1974) took into account years of relevant literature when producing his definition of scientific literacy. Showalter's (1974) definition of scientific literacy was used by Rubba and Anderson (1978) to develop their own model of the nature of scientific knowledge (the first dimension in Showalter's model). They went on to use this model to develop an instrument to measure school student's understanding of the nature of scientific knowledge.

Showalter's original model of scientific literacy consisted of seven dimensions:

> "1. The scientifically literate person understands the nature of scientific knowledge.
> 2. The scientifically literate person accurately applies appropriate science concepts, principles, laws, and theories in interacting with his universe.
> 3. The scientifically literate person uses processes of science in solving problems, making decisions, and furthering his own understanding of the universe.
> 4. The scientifically literate person interacts with the various aspects of his universe in a way that is consistent with the values that underlie science.
> 5. The scientifically literate person understands and appreciates the joint enterprises of science and technology and the interrelationship of these with each and with other aspects of society.
> 6. The scientifically literate person has developed a richer, more satisfying, more exciting view of the universe as a result of his science education and continues to extend this education throughout his life.
> 7. The scientifically literate person has developed numerous manipulative skills associated with science and technology" (Showalter, 1974, p.2).

As with Pella, O'Hearn and Gale's (1966) characteristics, an individual's working knowledge could include the knowledge, values and skills included in Showalter's dimensions. In particular, despite Showalter's model being designed to provide objectives for school (formal) science education, the idea of an individual continuing "to extend this education throughout his life" fits well with free-choice learning.

Shen's (1975) definition of scientific literacy is of more relevance to free-choice learning and working knowledge as it specifically refers to learning outside of school:

> "We may define science literacy as an acquaintance with science, technology, and medicine, popularised to various degrees, on the part of the general public and special sectors of the public through information in the mass media and education in and out of schools" (Shen, 1975, p.45-46).

On a practical level, Shen's model is relatively straightforward compared to others as it consists of three distinct categories: Practical science literacy; civic science literacy; and, cultural science literacy. Shen defined these as follows:

> Practical science literacy - "the possession of the kind of scientific knowledge that can be used to help solve practical problems" (Shen, 1975, p.46).
> Civic science literacy - "The aim of civic science literacy is precisely to enable the citizen to become more aware of science and science-related issues so that he and his representatives would not shy away from bringing their common sense to bear upon such issues and thus participate more fully in the democratic processes of an increasingly technological society" (Shen, 1975, p.48).
> Cultural science literacy - "is motivated by a desire to know something about science as a major human achievement. It is a cultural adventure. It is to science what art appreciation is the art" (Shen, 1975, p.49).

It is clear that Shen's Practical science literacy has a strong link with working knowledge, as it would include the sort of scientific knowledge that individuals would seek out for themselves according to their needs or interests. Shen pointed out that most of practical science literacy is concerned with the "basic human needs" of health and survival. These needs are of significance for the current study with regards to the BodyWorks exhibition and its themes.

Working knowledge could also contribute to Civic science literacy. This would not only include facts and understandings, but also values and opinions. Shen's category of Cultural science literacy could include working knowledge but could also be seen as providing the interest or motivation for free-choice learning. Working knowledge could be gained because of personal interest or appreciation of aspects of science.

Shen also alluded to the importance of free-choice learning by stating that the aim of advancing practical science literacy must not be left to scientists alone:

> "Opportunities to take part in the effort must be provided not just for scientists but also for practitioners of science popularisation, community education, and mass communication" (Shen, 1975, p.47).

This would include free-choice learning providers such as science centres, museums, television and radio.

It is of interest to note that Shen seems to have concentrated on the "delivery" of science literacy to the public. Another perspective would be to recognise those members of the public who actively seek science literacy for themselves and to provide opportunities for this. Equally, consideration could also be given to empowering those who do not currently seek science information for their interest and needs.

In order to develop a theoretical model, **Gabel** (1976) collected data on people's interpretations of the meaning of scientific literacy. A number of the seven dimensions of scientific literacy developed by Gabel appear to suit the idea of working knowledge. In particular, "Personal Application of Science", which Gabel defines as "application of scientific knowledge and methods of science in daily living" (p.240) and "Utilising Factual Knowledge", defined as "knowing and using for various purposes factual knowledge about nature" (p.241). Both of these fit well with working knowledge being gained and used for personal needs. These also correspond with Shen's (1975) idea of Practical Science Literacy. In fact, all seven dimensions could fit (some more clearly than others) into Shen's three categories of science literacy.

In terms of free-choice learning, Gabel hinted at its importance in the dimension of "Maintaining Current Awareness – valuing of people keeping touch with and maintaining an understanding of new developments in science and technology" (p.240). It could be assumed that this would most likely be achieved through free-choice learning.

Branscomb (1981, p.5) defined science literacy as "the ability to read, write, and understand systematised human knowledge." By applying this definition to various contexts she stated eight different types of science literacy:

> "methodological science literacy; professional science literacy; universal science literacy; technological literacy; amateur science literacy; journalistic science literacy; science policy literacy; and, public science policy literacy" (Branscomb, 1981, p.5).

Branscomb acknowledged that:

> "numerous other definitions may be related to particular sciences, such as psychological or biological literacy, but the eight defined here suffice to delineate what is generally called "science literacy" (Branscomb, 1981, p.6).

The definition of Universal science literacy matches with the idea of working knowledge being used in everyday life to meet individual needs:

> "the ability of every average citizen to understand and cope with the natural phenomena of daily life, a phrase that encompasses the child's ability to learn about heat and cold as well as, in a more complicated word, an adult's ability to comprehend and make personal choices about, for example, exposure to carcinogens in food" (Branscomb, 1981. p.5).

Technological literacy also relates to everyday uses of working knowledge being defined as:

> "the ability to understand and select from the vast catalog of technological abundance those tools and toys that best suit our own needs and interests - we need a minimum amount of competence to cope with automobiles, power saws, computer games, electronic typewriters, electric guitars, toasters, air conditioners, and microwave ovens" (Branscomb, 1981. p.5).

Branscomb hinted at the idea of free-choice learning through her definition of Amateur science literacy, saying it "encompasses the tastes of both fans of "Star Wars" and the amateur scientists who subscribe to Popular Mechanics, Scientific American, or Psychology Today" (p.5). In other words, it includes learning science because of a personal interest or hobby.

By including professional, journalistic contexts, this model is not solely focused on the general public's science literacy. Those contexts that do relate to the general public seem to be covered by Shen's (1975) three category model. For example, Universal science literacy and Technological literacy are part of Shen's Practical science literacy, Public science policy literacy fits into Civic science literacy and Amateur science literacy relates to the definition of Cultural science literacy.

Arons' (1983, p.94) confined the discussion of his twelve abilities a scientifically literate person should possess "to efforts being made through instruction in schools, colleges, and universities to upgrade scientific literacy." This would be expected to have little relevance to free-choice learning and working knowledge. Even though the abilities read like the objectives of a school science course, the ability to:

> "Develop enough basic knowledge and understanding in some area (or areas) of interest to allow intelligent reading and subsequent learning without formal instruction" (Arons, 1983, p.93),

is an invaluable skill to have for free-choice learning. Perhaps Arons was hinting at formal education providing skills for lifelong learning. This has been suggested previously by Lucas (1982) who argued that formal education should be providing students with a background for future learning. However, Arons seems to have dismissed the idea of free-choice learning and the importance of working knowledge saying:

> "It is not difficult to see that far and away the most leverage and the greatest potential for improving public understanding of the subject matter, methods, limitations, and social impact of science reside in the elementary and secondary schools" (Arons, 1983, p.112).

For the purpose of finding a single measure of scientific literacy, **Miller** (1983) carried out a review of meanings of scientific literacy and past attempts to measure it. He worked on scientific literacy as being made up of three dimensions: "Understanding the Scientific Approach"; "Understanding Basic Science Constructs"; and, "Understanding of Science Policy Issues."

Although any part of these dimensions could be achieved through free-choice learning and be part of an individual's working knowledge, Miller concentrated on formal education as the route to scientific literacy stating:

> "There are compelling cultural, economic, and political arguments for a major effort to expand scientific literacy in both the general and attentive publics. In my opinion, the most effective place to start is in the elementary and secondary schools" (Miller, 1983, p.46).

Formal education may be an effective place to learn about the norms and methods of science, and basic science constructs learned in schools may help in understanding some policy issues. However, in order to keep conceptual science knowledge up-to-date, and to form opinions on new science and technology, free-choice learning must be utilised. The same follows for understanding current science policy issues.

In a 1998 article, **Miller** focused on Shen's (1975) Civic Scientific Literacy and how to measure it. He outlined civic scientific literacy as:

> "a level of understanding of scientific terms and constructs sufficient to read a daily newspaper or magazine and to understand the essence of competing arguments on a given dispute or controversy" (Miller, 1998, p.204).

This hints at the idea of learning skills (scientific terms and constructs) in formal education that can be used in free-choice learning. Yet Miller again turned to formal education as the key to improving scientific literacy saying:

> "The evidence suggests that the most effective path to a higher proportion of civic scientifically literate citizens is the improvement of pre-university and university education" (Miller, 1998, p. 219).

Although **Maarschalk** (1986) did not propose a model of scientific literacy, the paper was included here because a definition of a scientifically literate person that is based on informal learning was developed. In agreement with the concept of free-choice learning and working knowledge, Maarschalk recognised that informal science teaching is important, if not vital, to scientific literacy. In addition, he emphasised the importance of informal science learning in this description of a scientifically literate person:

> "A scientifically literate person's hierarchy of values as manifested in his cognitive preference will be such that he will frequently partake in informal science teaching. He will not only spontaneously engage in scientific dialogue, thinking and wondering but will also be spontaneously on the look out for scientific endeavours. This will be reflected in what his reading, viewing and listening are and also in his hobbies and social life" (Maarschalk, 1986, p.357).

This description could result in there being two types of scientifically literate individuals. There are some who, as in Maarschalk's description, are always seeking out scientific information and activities. There are others who are perhaps classed as scientifically literate but take notice of science information and activities only, or mostly, as they come into contact with them. These two types of individual could be called actively scientifically literate or passively scientifically literate. As suggested when discussing Shen's (1975) model, it would be important to provide opportunities and resources for those who are actively scientifically literate, but also, those who are passively scientifically literate could be empowered to actively seek out information.

Maarschalk suggested scientific literacy and informal learning are closely related saying:

> “scientific literacy is both the outcome of a condition for informal science teaching and conversely informal science teaching is outcome of and condition for scientific literacy” (Maarschalk, 1986, p.357).

This is clearly in agreement with the current study with regards to the importance of free-choice learning. Maarschalk also seems to have related to the idea of working knowledge as he described how there must be a spectrum of scientific literacy:

> “A logical interpretation of the Oxford definition of literacy would accordingly be that scientific literacy means the ability to 'read nature' and communicate (including 'write') about it. Of course this could be at various levels, from the primitive and naive of children in an informal science teaching setting to the sophisticated scientific literacy of the professional scientist. It can also vary from a 'general' scientific literacy to 'specific' scientific literacies in different subject areas where 'general' scientific literacy comprises one or more 'specific' literacies” (Maarschalk, 1986, p.357-358).

In other words, there is not a level that when reached one can be considered scientifically literate. The individuality of working knowledge means that people are on a spectrum. Specific literacies may correspond with personal interests and needs in the same way as working knowledge.

Hirsch, Kett and Trefil (1987) presented a list of terms that individuals need to know in order to be culturally literate. Commenting on the scientific terms included in Hirsch, Kett and Trefil’s list, Trefil (1987, p.149) described the goals of scientific literacy as “to provide each citizen with the basic framework of knowledge into which public debate can be placed” which is clearly similar to ideas outlined by those discussing civic scientific literacy.

As stated before, any list of concepts, ideas or phrases that are supposedly required for scientific literacy will soon go out of date and be incomplete because of how science advances and develops over time. Trefil (1987, p.150) does seem to have acknowledged this saying, “Lists of facts and concepts just don’t reflect the true character of science” and:

> “Some specialists can be expected to repeat the familiar objection that merely teaching scientific facts and concepts will fail to convey the nature of “scientific method” (Trefil, 1987, p.151).

However, he then goes on to contradict himself by dismissing the idea that scientific literacy should include the nature of science, arguing:

> "To claim that the paramount goal of teaching basic science is to convey the scientific method is to make the same formalistic mistake as to claim that the main goal of reading instruction is to teach reading strategies" (Trefil, 1987, p.151).

Trefil also hinted at Shen's (1975) idea of cultural scientific literacy:

> "the purely instrumental utility of scientific knowledge may be less important than the wider value to be gained from being acquainted with science as one of the great expressions of the human spirit...From a humanistic point of view, its attainments are on a par with great achievements in art, literature, and political institutions, and in this perspective, science should come to be known for the same reasons as these other subjects" (Trefil, 1987, p.151).

A list of facts that everyone should know in order to be scientifically literate does not correspond with the individuality of working knowledge. Facts and terms will of course be a part of working knowledge but some people will know more about particular aspects of science that are of use or interest to them. Also, Trefil seems to have been suggesting that formal education has the sole responsibility for people's scientific literacy saying, "their education should simply have provided them with the general facts and principles needed to understand the terms of the debate" (Trefil, 1987, p.150).

Hazen and Trefil's (1991) book is similar to Hirsch, Kett and Trefil's (1987) list in that they are again providing the information that they believe one needs to know in order to be scientifically literate, "our aim, in short, is to give you the information you need to become scientifically literate" (Hazen and Trefil, 1991, p.xi). Hazen and Trefil's work was specifically aimed at individuals rather than organisations, for example schools, and stressed to readers that "You must be scientifically literate" and that understanding scientific and technological debates "is becoming as important to you as being able to read" (Hazen and Trefil, 1991, p.xi).

They defined scientific literacy as "the knowledge you need to understand public issues" (p.xii). This is similar to the civic science literacy described by others (including, Shen, 1975 and Miller, 1998). They stated that they would consider you to be scientifically literate if you:

> "can understand the news of the day as it relates to science, if you can take articles with headlines about genetic engineering and the ozone hole and put them in a meaningful context - in short, if you can treat news about science in the same way that you treat everything else that comes over your horizon" (Hazen and Trefil, 1991, p.xii).

This contradicts the idea of working knowledge slightly as not all news is relevant and/or interesting to all people. Indeed, it may be possible that an individual is not interested in any of the topics covered by Hazen and Trefil.

This book could be better seen as a resource for free-choice learning. Hazen and Trefil hinted at the importance of free-choice learning when suggesting that formal education does not provide scientific literacy, "Scientists and educators have not provided you with the background knowledge you need to cope with the world of the future" (Hazen and Trefil, 1991, p.xi). However, the knowledge Hazen and Trefil provided may exclude something that becomes relevant and the information is likely to become out-of-date as science develops and advances. Although, Hazen and Trefil didn't agree with this and wrote that their book is comprehensive:

> "since every future scientific advance will grow out of the ideas contained in this book, mastering them allows you to deal with not only today's problems, but tomorrow's as well" (Hazen and Trefil, 1991, p.xix).

Brennan's (1992) Dictionary of scientific literacy could be thought of as a more detailed form of Hirsch, Kett and Trefil's (1987) list of terms and phrases and covers a broader range of subjects than Hazen and Trefil (1991). Brennan provided explanations of scientific terms in his book, which he said aims "to aid you in your quest for scientific literacy by providing a handy, quick-reference guide to the vocabulary. And vocabulary is key to the game" (Brennan, 1992, p.xi). Brennan didn't imply that everyone needs to know all the vocabulary and by providing the dictionary suggested that people wouldn't know the meanings of all the scientific terms they may come across. To look at this dictionary from the point of view of working knowledge, it could be considered a useful tool for free-choice learning, for finding out more about an aspect of science that is of interest or use. However, as mentioned, any list of scientific terms will soon be out-of-date. For example, there is no mention of terms such as Higgs Boson, Large Hadron Collider, H1N1 in Brennan's dictionary. Therefore it seems inappropriate to have claimed, "This Dictionary of Scientific Literacy is intended to help the reader keep up with the dynamic, rapidly changing world of science and technology" (Brennan, 1992, p.xii).

Jenkins (1994) advised that previous literature suggests:

> "that the notion of a general scientific literacy should be abandoned in favour of more specific and functional literacies that are strongly context dependent. It thus becomes possible to acknowledge scientific literacies concerned with health and safety at work, domestic energy management, health care, diet, or waste disposal, for instance" (Jenkins, 1994, p.5346).

This is starting to move towards the idea of working knowledge and people knowing about different aspects of science depending on their interest and use to that individual. Jenkins suggested that Shen's (1975) model of three categories could be extended, "to accommodate a range of functional scientific literacies concerned with health and safety at work, recreation, domestic energy management, and so on" (Jenkins, 1994, p.5346). Working knowledge and the idea of it being different in every individual could be considered to have an infinite number of these "functional scientific literacies."

Jenkins suggested much more work is needed to better understand ideas of scientific literacy, "There is, however, a substantial research agenda to be addressed" (Jenkins, 1994, p.5349). Jenkins seems to have recognised that free-choice learning has a part to play and incorporated it into his discussion about how "such literacy might be fostered by formal or informal means" (Jenkins, 1994, p. 5349).

Research into working knowledge and free-choice learning must be covered by the suggestion that, "More needs to be known about the social contexts in which science is understood and experienced by the public" (Jenkins, 1994, p.5349).

Despite the title of his book *The Myth of Scientific Literacy*, **Shamos** (1995) was not completely dismissing the idea of scientific literacy. However, he did think that:

> "the notion of developing a significant scientific literacy in the general public, as we have come to understand its normal meaning, is little more than a romantic idea" (Shamos, 1995, p.215).

Unlike most other researchers discussing scientific literacy Shamos did not think scientific literacy is a necessity for the general public, “one does not need to be literate in science to be successful in most enterprises or to lead the “good life” generally” (Shamos, 1995, p.98). Shamos presented a model of scientific literacy consisting of three parts (Shamos, 1995, pp.87-88): Cultural scientific literacy; Functional scientific literacy; and, “True” scientific literacy.

He used Hirsch’s (1987) list of terms to define Cultural scientific literacy and being able to use these terms correctly is what he called Functional scientific literacy. “True” scientific literacy is when an individual knows something about “the overall scientific enterprise” and “appreciates the elements of scientific investigation” (Shamos, 1995, p.89). These elements include, “importance of proper questioning, analytical and deductive reasoning, logical thought processes and reliance upon objective evidence” (Shamos, 1995, p.89).

Shamos believed that most individuals are unlikely to reach his “true” scientific literacy. In fact, he estimated that only 4-5% of adult Americans might be true scientific literates according to his definition and that nearly all of these will be professional scientists or engineers (Shamos, 1995, p.90).

In terms of the ideas of working knowledge and free-choice learning, Shamos seems to have concentrated on scientific literacy being a goal of formal education. Yet, he didn’t think that formal education could create scientifically literate adults because students that do well in science may not necessarily become scientifically literate adults. Shamos did not think that informal education could have a great effect on scientific literacy of adults. He suggested that the mass media (editors, publishers, TV executives) does not have a responsibility to include public access to education as well as to news and entertainment. This neglects the idea that education could be entertainment. He believed that science is too difficult to make everyone scientifically literate and proposed that only 20% of the population need to be scientifically literate to make a difference (Shamos, 1995, p.91). His solution was for schools to concentrate on presenting science to students to improve what he called “scientific awareness” and suggested “three guiding principles for presenting science to the general (non science) students" (Shamos, 1995, p.217) in order to achieve this. Interestingly, these three principles relate closely to Shen's (1975) three categories of science literacy.

It is of note that this is only directed towards students and not the general public and that there is not much time spent discussing how informal education (or free-choice learning) can affect this scientific awareness. Especially as Shamos (1995, p.77) went on to say that if the public is to play a part in science issues "other means than reliance upon formal science education will have to be found."

Once again **Bybee** (1997) focused on formal education and, in particular, how it can be improved in order to achieve scientific literacy. However, it should be noted that he later points out that a science education includes "formal, informal, and incidental learning experiences" (Bybee, 1997, p.82). Also, in a subsequent publication Bybee stated that "free-choice learning must be included in any view of achieving scientific literacy" (Bybee, 2001, p.45).

The problem of a lack of a consensus on a definition of scientific literacy was again discussed with Bybee suggesting that the term has become a "slogan, since many use it without bothering to define what they mean by it or to reveal whose definition they are using" (Bybee, 1997, p.68). Despite the lack of one agreed upon definition, Bybee believed that research on scientific literacy does give some conclusions he listed these as follows:

> "Scientific literacy is a metaphor referring to the purpose of science education.
> Scientific literacy emphasises a general education orientation.
> Scientific literacy expresses norms or standards for science education programs, methods, and assessments.
> Scientific literacy illustrates different perspectives in science education.
> Scientific literacy represents a continuum of understandings.
> Scientific literacy incorporates multiple dimensions.
> Scientific literacy includes both science and technology" (Bybee, 1997, p.68).

Bybee (1997, p.86) himself described scientific literacy as being "best defined as a continuum of understanding about the natural and the designed world, from nominal to functional, conceptual and procedural, and multidimensional." He set out his framework for scientific literacy as a "threshold model" and rather than define different types of scientific literacy he produced a continuum of scientific literacy on which individuals can be placed. This continuum runs from "scientifically and technologically illiterate individuals" at one end to "a small number of individuals whose level of scientific literacy is extremely high" at the other.

Bybee seems to have included working knowledge and free-choice learning in his framework saying:

> "The degree of scientific and technological literacy demonstrated by an individual at any one time is a function of a range of factors - age, developmental stage, life experiences, and quality of science education, which includes an individual's formal, informal, and incidental learning experiences" (Bybee, 1997, p. 82).

This framework corresponds with the current study's view that there are no levels of scientific literacy to be measured, that it is not simply a case of being scientifically literate or not being scientifically literate, but that individuals have a personal working knowledge:

> "Some attempts to define scientific literacy assume as either/or perspective: one has it or one does not. A more productive definition recognises that scientific and technological literacy develop over a lifetime" (Bybee, 1997, p. 83).

Also, he seems to have been recognising the individuality of working knowledge saying individuals "may demonstrate several levels of literacy at once depending on the context, the issue, and the topic" (p. 83) and, some people "will develop further than others at all levels or within one, depending on their motivations, interests, and experiences" (p. 85) and "an individual may be at different places within the framework at any time and for any given topic" (Bybee, 1997, p. 85).

Koballa, Kemp and Evans (1997) proposed a complex model of scientific literacy that consists of three dimensions. The first dimension is a continuum of levels of scientific literacy "ranging from illiteracy to the highest levels of science understanding" (p.28). The second dimension is termed "multiple domains" and seems to fit with the idea of working knowledge as it implies "that a person may be literate in biology but not in physics or the history of science" (p.28). In other words an individual may know much more about one aspect of science than another, what Koballa, Kemp and Evans referred to as, "the domain-specific nature of scientific literacy." A student "may reach an extremely high level of scientific literacy in a very specialised area and yet still be at a relatively low level of scientific literacy in the other domains" (Koballa, Kemp and Evans, 1997, p.30).

Their third dimension of "Scientific Literacy as a Value" is even more closely related to working knowledge. This dimension means, "a person may have mild interest in one science area, a positive attitude toward another, and a strong commitment to yet another area" (p. 30). The reason given by Koballa, Kemp and Evans for these differences in interest is as good as a definition of working knowledge:

> "a person will actively seek and attain those science literacy levels that are encouraged or necessary for his or her community affairs, job, family, hobbies, or other individual pursuits" (Koballa, Kemp and Evans, 1997, p.30).

Although Koballa, Kemp and Evans initially appeared to be focusing on scientific literacy as a goal of formal education, they went on to remark that:

> "No matter how good a job we do of educating our students in science, it will all be for naught unless they have the opportunity or motivation to use science once they have graduated" (Koballa, Kemp and Evans, 1997, p.30).

They recognised the importance of free-choice learning stating, "The stimulus for science literacy must come from inside and outside schools" (p.30) and that "Scientific literacy is a lifelong objective" (p.31). They also shared the views of Lucas (1982; 1983) with regard to schools providing skills for lifelong learning saying, "Scientific literacy is a lifelong objective, and it is up to teachers to provide students with the necessary background knowledge and skills for this pursuit" (Koballa, Kemp and Evans, 1997, p. 31).

In 1998 **Hurd** provided a list of skills that an individual may need to use science in their everyday lives, and so perhaps related working knowledge. He listed attributes required by a scientifically literate person that, "enable students to adapt to the changing world of science and technology and its impact on personal, social, and economic affairs" (Hurd, 1998, pp.413-414). Although the majority of skills listed are for using science knowledge gained in school, some are related to free-choice learning, for example, "Recognizes the cumulative nature of science as an "endless frontier" (p.413) hints at the importance of lifelong learning. Also, the attribute of:

> "Recognizing that scientific literacy is a process of acquiring, analyzing, synthesizing, coding, evaluating, and utilizing achievements in science and technology in human social contexts" (Hurd, 1998, p.414),

could be considered a list of skills for free-choice learning. However, Hurd provides his list as a framework to be part of a school curriculum. He seems to concentrate on skills for using knowledge gained in school. These skills are important but from the perspective of this review, more emphasis on skills for free-choice learning would be important.

In a similar way to Koballa, Kemp and Evans (1997), **Graber, Nentwig, Becker, Sumfleth, Pitton, Wollweber, and Jorde (**2001) presented their model of scientific literacy from the perspective of it being a goal of school education but went on to discuss skills that can be taught in formal education to encourage and assist lifelong learning. This was not a new idea as in 1982 Lucas asked, "What can we do in our school science courses to maximise the transfer of skills in learning to out of school sources?" (Lucas, 1982, p.93). Similarly, Graber et al. added that if scientific literacy is to be a goal of scientific education then science classes should "contribute to the general education of emancipated citizens" (Graber et al., 2001. p.64). Included in this are the ideas of "self-determination...makes the learner independent of a teaching person" (p.64) and, "self-responsibility for ones own learning process being the prerequisite for life-long learning" (p.64). Both these ideas hint at the importance of free-choice learning, and the authors recognised that "Science teaching has to have in mind the students' activities in their future adult life" (Graber et al., 2001, p.65).

Their model was presented as "a competency based model of scientific literacy" (Graber et al., 2001, p.62) made up of seven competencies (Subject, Epistemological, Learning, Social, Procedural, Communicative, Ethical Competence). These can be covered by three categories, "What do people know?" "What can people do?" and "What do people value?" (p.63). The only part of this model that seems to directly relate to working knowledge is in the definition of Subject Competence where they referred to "an individual profile of science knowledge and understanding" (p.62). However, all of the competencies could be formed and developed by free-choice learning and therefore be part of an individual's working knowledge.

Although **Pardo and Calvo** (2004) did not propose their own model or definition of scientific literacy they did review and question other ideas. Their work is included here because as part of their questioning of the methods of measuring scientific literacy they discussed what they called the specialisation thesis. This idea seems to be closely related to working knowledge as it proposes that individuals may have an interest in and be knowledgeable about one or two specific areas of science, "a parallel fragmentation of interest and knowledge" (Pardo and Calvo, 2004, p.216). They suggested that this will affect how the public understanding of science and scientific literacy are researched and worked towards:

> "Instead of maintaining the assumption and pursuing the ideal of a citizenry educated in all major branches of knowledge and particularly in science at large, analysts and policy-makers might have to accommodate themselves to a more modest, but perhaps more realistic, model of individuals interested, for reasons to be explored, in just one or two areas of science and technology. In other words, from a universal and comprehensive scientific literacy goal with Enlightenment roots, they might have to shift to a model of discrete scientific literacies that is more attuned to the fragmentation of life and interests at the turn of the twenty-first century" (Pardo and Calvo, 2004. p. 217).

This specialisation thesis is related to context dependent models such as the specific and functional scientific literacies discussed by, for example, Jenkins (1994) and Branscomb (1981), which also suggested narrower types/categories of scientific literacy.

Throughout his valuable review **Roberts** (2007) referred to science literacy and scientific literacy as SL "except where there is reason to distinguish the terms" (Roberts, 2007, p.731) suggesting he saw them as interchangeable. He divided the numerous definitions and models of SL into two types, what he calls, Vision I and Vision II. Vision I is described as looking at the "products and processes of science itself" (p.730). Whereas, Vision II is to do with "the character of situations with a scientific component, situations that students are likely to encounter as citizens" (Roberts, 2007, p.730). This is a helpful distinction to make between models and is similar to the way Maienschein (1998) distinguished science literacy and scientific literacy. In terms of working knowledge, Vision II seems immediately relevant, but of course, working knowledge could include the "products and processes of science" of Vision I. Roberts acknowledged that these visions are "idealised extremes" (Roberts, 2007, p.730) and that in practical terms a mix of the visions is likely, "Assessment programs and curriculum embodiments partake of these two visions in a kind of mating dance wherein they complement one another" (Roberts, 2007, p.730).

As with previously mentioned authors, Roberts also pointed out the lack of agreement on a definition of scientific literacy, "It is well known in the science education community that no consensus exists about the definition of SL" (p.729) and stated the problems associated with this:

> "It is difficult to communicate about research results, such as international student assessments of SL, or to compare programs and teaching approaches that claim to advance SL, in the absence of a common definition" (Roberts, 2007, p.735).

However, he did (like Bybee, 1997) make some conclusions (two) from the literature. His first observation was that "everyone agrees that students can't be scientifically literate if they don't know any science subject matter" (Roberts, 2007, p.735). His second observation was that "the literature can be grasped more easily by considering the approaches, or conceptual methodologies, that authors have used" (Roberts, 2007, p.736). He went on to discuss the literature in terms of five of these "conceptual methodologies." The methodology most relevant to the current study seems to be that described as drawing on "situations or contexts in which aspects of science are presumed and/or demonstrated to be valuable for students' everyday lives" (Roberts, 2007, p.736). This includes the Science for Specific Social Purposes approach of Layton, Davey and Jenkins (1986), who stated that it seems likely "adult learning of science is strongly context-related" (Layton, Davey and Jenkins, 1986, p.39). This appears related to working knowledge but it should be noted that working knowledge could of course contain information that is not useful in everyday life, but has been obtained through an interest.

In their paper presented at the AARE (Australian Association for Research in Education) conference, **Kanasa and Nichols** (2008) proposed a straightforward model of scientific literacy consisting of three domains: affective domain; behavioural domain; and, cognitive domain - The AB&C model of scientific literacy. The affective domain is to do with “attitudes to science” (p.3) and the behavioural domain is concerned with “individuals utilising science” (p.3). The cognitive domain is described as “the traditional concern of science education, i.e., the acquisition of knowledge, mental abilities and cognitive schema used within the sciences” (Kanasa and Nichols, 2008, p.3). Similar categories were identified by Graber et al. (2001) Affective = what do people value? Behavioural = what can people do? and Cognitive = what do people know?

Although their research focused on formal education, Kanasa and Nichols’ paper provides a simple model, which many previously discussed models could be incorporated into. They have achieved this by taking other definitions into account in developing the model:

> “Rather than viewing the various definitions as competitors within a theoretical arena, it has been possible to categorise the aspects of the various definitions into three domains: the affective, behavioural and cognitive domains. This is necessary to address the concerns of authors as they emphasise different aspects of scientific literacy” (Kanasa and Nichols, 2008, p.3).

Although Kanasa and Nichols did not refer to anything similar to working knowledge, the model could be seen to categorise aspects of an individual’s working knowledge. In particular, their definition of the behavioural domain fits with the concept of working knowledge in the way that it recognises the importance of attitudes and behaviours:

> “Narrow conceptions of scientific literacy which only consider the cognitive domain of scientific literacy fail to address the need of citizens to develop attitudes (affective domain) and behaviours (behavioural domain) in relation to these new technologies” (Kanasa and Nichols, 2008, p.3).

Liu (2009) added to the idea of school providing skills for lifelong learning, discussed by others (including Lucas, 1982; 1983; Koballa, Kemp and Evans, 1997; Graber et al., 2001) by proposing that there should be stronger links between formal and informal education, and recognising the significance of free-choice learning:

> “It seems clear that we have expected too much of children to achieve science literacy in school by the time they graduate from high school; we have overlooked much larger learning resources and potentials outside schools and beyond high school” (Liu, 2009, p.307).

Liu suggested the reconceptualisation of scientific literacy as Science and the Public and that this should be recognised to be "both a state and a life-long process, as both a personal choice and an economic necessity, and as both a personal enhancement and civic participation" (Liu, 2009, p.309). Liu believed there are two approaches needed to achieve this. Firstly, he suggested considering formal and informal science education as a continuum, rather than two separate things, thus emphasising the importance of free-choice learning. This seems to be one of the few papers, other than those by Falk, to have stressed the importance (and use the specific term) of free-choice:

> "Current learning theories recognize the importance of both formal and informal education, and effective learning takes place in both formal and informal settings. This view of learning reflects the fact that school children spend far more time outside schools than inside schools" (Liu, 2009, p.307).

Secondly Liu proposed that all science professionals should be involved in promoting science literacy in the public, that "all professionals become both science participants and educators" (p.308). For example:

> "research scientists, although they may be well equipped with current knowledge and skills in sciences, may not know how to communicate science to the general public" (Liu, 2009, p.308).

As well as recognising the importance of free-choice learning, Liu seems to have been supportive of the ideas of working knowledge saying, for example, "different types of science literacy may be appropriate for different people." (p.302). Liu also hinted at the ideas of working knowledge when discussing the deficit model as a flaw in current ideas of science literacy:

> "This deficit model ignores the fact that students and the general public do have a wide variety of informal knowledge and experiences about natural and life phenomena" (Liu, 2009, p.305).

Liu also agreed that science literacy should not be a specific level of knowledge to be achieved:

> "Science literacy should be an evolving state instead of a status to acquire. People constantly learn science in and outside of school, within and outside work, and both formally and informally" (Liu, 2009, p.306).

Murcia (2009) used the metaphor of a rope to describe a framework of scientific literacy. She reviewed previous definitions of scientific literacy and suggests that it is made up of three knowledge dimensions; "Nature of science;"

"Interaction of science and society;" and, "Enduring and important scientific terms and concepts" (p.219). The rope metaphor represents "knowledge, skills and understandings" (p.226) that individuals have in each of the three dimensions. "As individuals develop they construct further 'threads' of understanding that build onto what they know, thickening and strengthening their 'rope'" (Murcia, 2009, p.226).

Murcia's rope metaphor is a useful way of thinking about the individual nature of scientific literacy and, despite this research being based on formal (higher) education, it reflects the idea of working knowledge and how it is unique to an individual. The metaphor is also similar to the idea of working knowledge depending on an individual's experiences and interests, "The depth of development in each knowledge dimension would vary depending on the learning experiences, interests and contexts in which individuals' function" (Murcia, 2009, p.226).

Murcia's statement that "Scientific literacy is clearly about KNOWING but is also about a way of THINKING and ACTING" (Murcia, 2009, p.219) is similar to Kanasa and Nichols' (2008) AB&C model of scientific literacy, as described previously. Murcia also seems to have supported the idea of education providing skills for lifelong learning saying, "The teaching and learning goal should be to develop outcomes that are meaningful and useful to all individuals through out their lives" (Murcia, 2009, p.228).

Feinstein's (2011) definition of "science literate people" is perhaps the idea of scientific literacy that is most comparable to working knowledge. He based his definition on research that:

> "tells us that people selectively integrate scientific ideas with other sources of meaning, connecting those ideas with their lived experience to draw conclusions and make decisions that are personally and socially meaningful" (Feinstein, 2011, p.180).

This led him to describe scientifically literate people as "competent outsiders" as:

> "people who have learned to recognize the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help them achieve their own goals" (Feinstein, 2011, p.180).

Feinstein seems to have supported Liu's (2009) idea of bridging the gap between informal and formal education and suggested a way of doing it:

> "Making science relevant" should not be something that the teacher does alone, but rather something that students learn to do, becoming progressively better at it through concerted practice. This practice would necessarily involve starting with their own questions, firmly embedded within their own social context, and reaching into the social worlds of science in an attempt to connect scientific ideas with lived experience" (Feinstein, 2011, p.180).

Feinstein looked to be proposing a way of connecting free-choice learning (and therefore working knowledge) with formal education. This adds to Lucas' (1983) thoughts that "School science decisions need to take into account how what is taught interacts with informal sources" (Lucas, 1983, p.28) and that school science:

> "needs to help prepare its learners to learn from intentional sources, from unintentional sources, and perhaps how to gain from accidental encounters with either type of source" (Lucas, 1983, p.28).

Although providing a bridge between formal and informal, Feinstein was still focusing on scientific literacy being a goal of formal education. However, he did refer to the idea of formal education providing skills for learning throughout life saying that research does suggest that, "learning about science in a deeply personal context could make students more willing to plunge into unfamiliar, science-tinged waters in the future" (Feinstein, 2011, p.182).

DISCUSSION

As we retraced the path the research has taken, important themes have emerged. The four key themes coming out of this review of models of scientific literacy from the perspective of working knowledge and free-choice learning are: the spectrum of scientific literacy; contexts of scientific literacy; responsibility for scientific literacy; and, future-proofing scientific literacy. These themes provide ideas and direction for future research in free-choice learning and scientific literacy.

THE SPECTRUM OF SCIENTIFIC LITERACY

The most straightforward definition of scientific literacy is that it is some knowledge of science. Some is not a defined quantity; it can be a little knowledge, or a lot of knowledge. The term scientific literacy is confusing as it suggests there are two categories, you are either scientifically literate, or scientifically illiterate or “one has it or one does not” (Bybee, 1997). However, the individuality of working knowledge means that there is a spectrum of scientific literacy. In other words, everyone has some level of scientific literacy, or, as Bybee (1997, p.81) put it, “scientific literacy represents a continuum of understandings and abilities.” Liu (2009, p.306) described the spectrum, or subjective nature, of scientific literacy as “an evolving state instead of a status to acquire” and added: “learning science is indeed a life-long process, rather than the goal to achieve once for all” (Liu, 2009, p.306).

Conversely, models that propose a specific set of skills, or facts, or understandings that are required in order to be classed as scientifically literate are not taking into account the individuality of working knowledge. Suggesting a list of terms a person should know about science implies that if you know the terms you are scientifically literate. If you don’t know the terms you are scientifically illiterate. However, there will be people who know a few of the terms, people who know most of the terms, and people who know more than the terms suggested, as well as everyone in between. Collins and Evans *Periodic table of expertises* applies here too (see also Page 41). Their specialist expertises can be seen to exist on a spectrum from knowing facts, to understanding the meaning of information, to being able to understand and discuss science, right up to the contributory expertise of being able to *do* science (Collins and Evans, 2007, p.14).

This spectrum of scientific literacy provides some evidence for the importance of free-choice learning. If scientific literacy was only determined, or predominantly determined, by formal learning, there would be much less variation in people’s levels of scientific literacy. In formal education settings it could be argued that everyone learns, or is taught, the same topics to a similar level, so there could be little difference between individual’s scientific literacy. Any variation in individual’s scientific literacy would be due to differences in, for example, understanding or ability to recall facts. However, it may be the case that greater differences are in part due to free-choice learning, the development of working knowledge and their interaction with formal education.

Models discussed above that consist of a number of dimensions or categories (including, Shen, 1975; Gabel, 1976; Miller, 1983; Shamos, 1995) could be revised in order to take working knowledge into account by introducing a continuum, or spectrum, within each category. For example, Gabel (1976) wrote about seven dimensions of scientific literacy. Each of these dimensions could be considered to have a continuum within them. Gabel's dimension of "maintaining current awareness" would range from people who only take notice of major science stories in the news to those who actively seek out information on new science issues and developments. Similarly, Gabel's dimension of "utilising factual knowledge", which he described as "knowing and using factual knowledge about nature", would include people with a small amount of factual knowledge, perhaps in one or two topics, to those with a large amount of factual knowledge, in various subjects.

CONTEXTS OF SCIENTIFIC LITERACY

The contexts/dimensions in some models are also of relevance to the idea of working knowledge. There are some models that try to include both contexts and a continuum. For example, Maarschalk (1986) agreed with the idea of a continuum and described a spectrum of various levels of scientific literacy from that of a child to that of a professional scientist. He also hinted at the contextual nature of scientific literacy suggesting it also varies from a general scientific literacy to specific scientific literacies in different subject areas. Koballa, Kemp and Evans (1997) went a step further and developed a model that combines a continuum of scientific literacy with a second dimension of domains or contexts (as well as a dimension for the value of scientific literacy). The contexts represent the fact that a person may be very literate in one aspect or topic of science but less literate in another. Depending on how specifically you define these contexts, there could be an unlimited number of them. This results in a very complicated model but it would recognise the individuality of working knowledge.

Bybee (1997) also recognised a continuum of understandings and contexts stating that "scientific literacy incorporates multiple dimensions" (Bybee, 1997, p.81). The idea of contexts or dimensions is included in other work such as: Branscomb's (1981) types of science literacy; Jenkins' (1994) functional scientific literacies; and Pardo and Calvo's (2004) specialisation thesis. Other work related to contexts in scientific literacy includes Science for Specific Social Purposes (Layton, Davey and Jenkins 1986), mentioned above, and Crowley and Jacobs' (2002) Islands of Expertise, discussed in the literature review. In addition, health literacy, discussed in detail elsewhere, could perhaps be seen as a context, or dimension, of scientific literacy, depending on its definition.

This idea of there being contexts within scientific literacy fits with the idea of working knowledge. An individual's working knowledge will depend on their interests and motivations and therefore it will develop in different contexts, or subjects, more than others. Again, like the continuum of scientific literacy, the fact that a range of contexts or dimensions apply to scientific literacy supports the importance of free-choice learning. If scientific literacy is only influenced by formal education, its contexts would be limited to the contents of formal education curriculums and assessments.

Just as some models can be revised to include a spectrum to take account of working knowledge, they can further include working knowledge if a context is introduced. For example, Shen's (1975) categories of practical, civic and cultural science literacy could each contain a huge (perhaps countless) range of contexts. An individual's cultural science literacy could be confined to an interest in and knowledge of the history of steam engines. An individual's civic science literacy could be specifically related to river pollution from local agriculture and resulting political issues.

A model that could describe the individuality of working knowledge fully would be extremely complicated and almost impossible to imagine. For example, there are seven levels along Koballa, Kemp and Evans' (1997) continuum of scientific literacy, to fully incorporate individuality, there would need to be additional spectrums within each of these levels. So, for example, at level six an individual should be able to understand the nature of a science discipline and know its history. There will be people who know a great deal of history about a science discipline, and people who know only a little of the history. There will also be those who understand more than one discipline.

Working knowledge means that everyone is scientifically literate but on different levels across a continuum, and to complicate this, there is a continuum for all the different aspects of science and all the contexts that science is placed in.

RESPONSIBILITY FOR SCIENTIFIC LITERACY

As discussed in the review above, earlier models of scientific literacy focus on formal education as having sole responsibility for the public's scientific literacy. However, more recent models appear to show that there is increasing recognition of the importance of free-choice learning (or informal education) and a movement away from concentrating on formal education as the key provider of scientific literacy (in particular, Feinstein, 2011; Liu, 2009). Formal education does have a role to play in scientific literacy and a number of researchers see it having a responsibility in providing skills for lifelong learning and therefore free-choice learning.

Views range from focusing completely on formal education, for example:

> "the most leverage and greatest potential for improving public understanding of the subject matter, methods, limitations, and social impact of science reside in the elementary and secondary schools" (Arons, 1983, p.112).

to those recognising the importance of lifelong learning:

> "Scientific literacy is a lifelong objective, and it is up to teachers to provide students with the necessary background knowledge and skills for this pursuit" (Koballa, Kemp and Evans, 1997, p.31).

It could be argued that science is so extensive and so dynamic that it is impossible for schools to be solely responsible for scientific literacy. As put forward under the spectrum of scientific literacy, the spectrum wouldn't exist if formal education had the only input into people's scientific literacy.

Also, for many reasons some people do not develop an interest in science until after their formal school education. Perhaps because only then are they able to follow up on their own areas of interest or concern. Therefore, it would be of great benefit for schools to provide skills that enable the investigation and learning of science beyond formal education. In other words, formal education "should aim at providing a background for future learning" (Lucas, 1982, p.90). This could go some way to future-proofing scientific literacy.

FUTURE-PROOFING SCIENTIFIC LITERACY

Because science is dynamic and scientific knowledge can quickly go out of date it is important to future proof scientific literacy. Also, people's interests, needs and the contexts in which they encounter and use science are always changing. Feinstein, Allen and Jenkins (2013) describe this as:

> "the unpredictable path of scientific progress, shifting social and political demands on scientific knowledge, and the variety of contexts and motives that drive public engagement" (Feinstein, Allen and Jenkins, 2013, p.315).

This suggests that throughout their lives there will be times when they need to seek new understandings, form new opinions or update their knowledge of science. Gabel (1976) is one of few to have included some reference to future-proofing in a model of scientific literacy with the dimension called, "maintaining current awareness." This is to do with keeping up with new developments in science and technology.

So rather than having sole responsibility for providing scientific literacy, it may be a better goal for schools to provide a grounding in science and the skills required to maintain and add to scientific literacy outside of formal education.
Miller (2010, p.200) discussed this in terms of adult science learning in the age of the Internet saying, "formal schooling will play a critical role in science learning as a primary source of basic constructs and as a provider of information seeking skills." More simply, schools should provide the interest, motivation, empowerment and skills for lifelong free-choice learning (Lucas, 1982; 1983; Koballa, Kemp and Evans, 1997; Graber et al., 2001; Roth and Calebrese Barton, 2004; Feinstein, Allen and Jenkins, 2013).

Perhaps the solution needs to be a bridge between free-choice learning and formal education, and skills for lifelong learning of science could be one way of providing this bridge. This could be the answer to whose responsibility it is to provide scientific literacy (i.e. both formal and free-choice). Also, taking working knowledge into account in formal education settings could strengthen the bridge by enabling it to operate in two directions. Feinstein (2011) hinted at this when suggesting that science needs to be made relevant to pupils' lives. Koballa, Kemp and Evans (1997) also implied a similar idea saying, "The stimulus for science literacy must come from inside and outside schools" (Koballa, Kemp and Evans, 1997, p.30).

The idea of bridging between school and out-of-school learning is not entirely new. Scribner and Cole (1973) discussed a two-way movement to bridge school and practical life. This included moving,

> "everyday life into the school so that its subject matter and activities deal with some of the same aspects of social and physical reality that the pupils confront outside of school" (Scribner and Cole, 1973, p.558).

So this is similar to recognising pupil's working knowledge of science in formal education. The other direction of the bridge was described as, "The techniques of the modern school need to be introduced into the context of recognised problems" (Scribner and Cole, 1973, p.558). This could include developing skills in school for free-choice learning. Roth and Calabrese Barton (2004, p.5) suggest science class should be "an empowerment zone where students are valued for their abilities to contribute to, critique, and partake in a just society."

Liu (2009), and to some extent Feinstein (2011), suggested the bridging of free-choice learning and formal education and this study would hope to provide some evidence that free-choice learning, and resulting working knowledge, should somehow be incorporated or at least given recognition in formal education. Aubusson, Griffin and Kearney (2012) agree saying:

> "School science needs to take more account of young people's out-of-school learning experiences and develop greater consistency to synthesise learning across formal and informal domains" (Aubusson, Griffin and Kearney, 2012, p.1130).

This is perhaps a long way off and the idea of formal education providing skills for lifelong learning seems more obtainable. This idea is not a new one, as mentioned, back in 1983 Lucas was even suggesting that formal education is assessed on how effective it is in providing such skills. "School courses could be judged on how well they provide a framework for future informal learning when faced with presently unpredictable future needs" (Lucas, 1983, p.1). Additionally, other researchers have specifically discussed the bridging of formal and informal (for example, Hofstein and Rosenfeld, 1996; Stocklmayer, Rennie and Gilbert, 2010) and provided a model for bridging to be facilitated (Fallik, Rosenfeld and Eylon, 2013). The suggestions made in these papers mostly concentrate on how the informal can add to the learning of the formal curriculum. However, free-choice learning most often takes place because of a need or an interest, not because of a curriculum. So, perhaps part of the bridging should involve taking working knowledge and relating it to the formal curriculum. This is discussed further later (Page 267).

FUTURE RESEARCH

The models and definitions examined here spans forty-five years and yet confusion remains over the definition of scientific literacy. If one model or definition could be agreed on it would be much easier to compare research. Jenkins (1994) seems to have agreed:

> "Lack of clarity about the essential feature of scientific literacy accompanies uncertainty and ignorance about how such literacy might be fostered by formal or informal means" (Jenkins, 1994, p.5349).

The current study will not provide a definitive solution to this problem but it would hope to continue the push towards the recognition of the importance of free-choice learning and working knowledge. No model has been found that focuses only on the contribution of free-choice learning and working knowledge to scientific literacy (or views their contribution as more significant than formal education). It is possible that such a model could bring together ideas and definitions of scientific literacy and provide a framework for future research.

The themes that have resulted from this analysis indicate some important directions for future research relating to scientific literacy. Empirical research on the ideas of the spectrum of scientific literacy and contexts of scientific literacy should contribute to addressing the lack of consensus on a definition of scientific literacy and perhaps provide a model as close to reality as possible that includes the significant contribution of free-choice learning. In order to include working knowledge and free-choice learning, such a model should recognise the spectrum and contexts of scientific literacy and allow for future-proofing of scientific literacy.

In terms of a model providing a framework in which to investigate scientific literacy perhaps the more simple models are the most useful. For example, Shen’s (1975) model is useful for both categorising people’s scientific literacy and also providing aims for activities and projects hoping to improve scientific literacy. Further categorisation could be created by combining Shen’s model with that of Kanasa and Nichols (2008). This would provide for affective, behavioural and cognitive parts to each of Shen’s categories (practical, civic, cultural). So, for example, affective cultural science literacy could mean thinking that science is relevant and important, behavioural cultural science literacy could mean actively seeking science stories in the news, and cognitive cultural science literacy could mean understanding some of the contributions science has made to society.

Further work on where the responsibility lies for scientific literacy and the potential for future-proofing scientific literacy are also required. In particular, the idea for bridging formal education and free-choice learning. The current study’s work on gaining a better understanding of working knowledge and free-choice learning may contribute useful ideas on how this bridging might work (this will be discussed in Chapter 9).

Most importantly, more needs to be done to quantify and recognise the contribution of free-choice learning to an overall science education and scientific literacy. The increasing recognition of the importance of free-choice learning in the research discussed suggests this may be the next step required in the conversation.

IN THE NEXT CHAPTER...

…working knowledge and free-choice learning will be used as a lens through which to revisit models and definitions of health literacy. This will contribute to the third research question of this thesis: of “What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?”

CHAPTER 7 - REVISITING HEALTH LITERACY THROUGH THE LENS OF FREE-CHOICE LEARNING AND WORKING KNOWLEDGE

As discussed in the literature review, there seems to be a comparison between some ideas in scientific literacy and those in the field of health literacy. In addition, the topics covered in the BodyWorks exhibition used in the empirical research mean that the idea of health literacy is of great relevance to the current study. It is therefore relevant to look at models of health literacy and examine these in the same way as models of scientific literacy, i.e., through the lens of free-choice learning and working knowledge. This will show if the research in health literacy is following a similar path, and, as in the previous chapter's review, present key themes and ideas for future research. This contributes to the third research question of this thesis: of "what can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?"

As with scientific literacy there is a wide range of definitions of health literacy in the literature. However, there do seem to be some definitions that are referred to more frequently than others. For example, Ratzan and Parker's (2000) definition for the National Library of Medicine and used in the Department of Health and Human Services' (HHS) Healthy People 2010:

> "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" (Ratzan and Parker, 2000, p.vi).

This definition corresponds with working knowledge to the extent that it includes skills ("obtain, process, and understand") and not just facts. Also knowledge is used in an everyday situation ("to make appropriate health decisions") in the same way working knowledge would be used. Although this definition emphasises the individuality of health literacy (like working knowledge), it suggests that problems with low health literacy are solely down to the individual rather than any organisations (Institute of Medicine, 2004). This makes it difficult to know who would have the responsibility for improving health literacy.

In 1998 Nutbeam redefined health literacy (for the World Health Organisation, 1998), changing its definition to:

> "Health literacy implies the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions. Thus, health literacy means more than being able to read pamphlets and make appointments. By improving people's access to information, and their capacity to use it effectively, health literacy is critical to empowerment. Health literacy is itself dependent upon more general levels of literacy. Poor literacy can affect people's health directly by limiting their personal, social and cultural development as well as hindering the development of health literacy" (Nutbeam, 1998, p.357).

This definition is more comprehensive than Ratzan and Parker's (2000) as it includes motivation and using information rather than simply obtaining and understanding it. So, for example, this would mean not just knowing how and why smoking is harmful to your heath but having the motivation to use the information and to perhaps try to stop smoking.

The following is an examination of models and concepts of health literacy through the lens of working knowledge and free-choice learning. The work of Nutbeam was used as a starting point for a trail through the literature to find models of health literacy. Additional models were found during the literature review. As with the review of models of scientific literacy (Chapter 6) work that clearly included a model or distinct definition of health literacy was used in the review. The models discussed below are considered to be representative of the range of models that have been developed. The models are considered chronologically by publication date, starting with Nutbeam (2000). Models and definitions prior to this were based on functional literacy (reading and writing) and would be difficult to compare with scientific literacy models.

REVIEW OF MODELS

Nutbeam (2000) reviewed previous definitions of health literacy and suggested that they were too narrow and didn't include "much of the deeper meaning and purpose of literacy for people" (p.263). He went on to use work from the field of literacy studies to develop his model to include what literacy actually enables people to do. This led to his model of three levels: Basic/functional literacy; Communicative/interactive literacy; and, Critical literacy.

In his level of communicative/interactive literacy working knowledge seems to become important, in particular when using skills to "actively participate in everyday activities" (pp.263-264) and to "apply new information to changing circumstances" (p.264). But it is Nutbeam's third level, critical literacy, that seems most closely related to working knowledge, Nutbeam described this as using skills to "critically analyse information, and to use this information to exert greater control over life events and situations" (Nutbeam, 2000, p.264).

He added that these three levels fit with the World Health Organisation (WHO) definition of health literacy, (Nutbeam, 1998, quoted above). This in turn corresponds with working knowledge, including the idea that working knowledge is made up of skills and abilities and not just facts.

Throughout the paper Nutbeam discussed the role of health education but it is not made clear if health education includes free-choice learning. Perhaps health education should be considered as taking place in both the formal sector and the informal (free-choice learning) sectors. When a previous definition of Health Education by Nutbeam (1998) was referred to, it is still not clear if free-choice learning is being taken into account:

> "Health education comprises consciously constructed opportunities for learning involving some form of communication designed to improve health literacy, including improving knowledge, and developing life skills which are conducive to individual and community health" (Nutbeam, 1998, p.353).

The fact that the opportunities for learning are "consciously constructed" and "designed" would suggest that free-choice learning is not taken into account. Of course, some free-choice learning resources could be considered to be constructed and designed. The results of the current study (Chapter 5) would suggest that free-choice learning is too important to not take into consideration. The effect of free-choice learning on health literacy (no matter how it is defined) could be considerable.

The opening statement of **St Leger's** (2001) paper could be seen as dismissing the role of free-choice learning in health literacy, "Schools are essential in achieving health literacy" (p.197). Although he did not directly refer to the input of free-choice learning he did emphasise similar ideas to that discussed previously in reference to future-proofing scientific literacy (Page 179). For example, he seems to have supported the idea of schools providing skills for lifelong learning and went as far as to state, “Schools have responsibility for developing lifelong learning skills” (St Leger, 2001, p.198). This idea came from the roles of a health promoting school (St Leger and Nutbeam, 2000).

St Leger (2001) helpfully outlined the importance of schools developing lifelong learning skills in their pupils using the example of the area of nutrition:

> “These educational skills are fundamental in adjusting to, and coping with, dietary changes that may occur because of life events such as parenting, diagnosis with an illness or disease, and understanding the debate about a relevant community issue, e.g. genetically modified foods” (St. Leger, 2001, p.198).

These life events are one of the reasons an individual may add to their working knowledge through free-choice learning because of a personal interest or need.

Zarcadoolas, Pleasant and Greer (2003) defined health literacy as:

> “the evolving skills and competencies needed, to find, comprehend, evaluate, and use health information and concepts to make educated choices, reduce health risks, and improve quality of life” (Zarcadoolas, Pleasant and Greer, 2003, p.119).

This definition corresponds with working knowledge as it includes “skills and competencies” and not just facts. It also takes into account the changing or “evolving” nature of working knowledge. In their 2005 paper they added to this definition saying:

> “Health literacy evolves over one’s life and, like most complex human competencies, is impacted by health status as well as demographic, sociopolitical, psychosocial and cultural factors” (Zarcadoolas, Pleasant and Greer, 2005, p.196).

Zarcadoolas, Pleasant and Greer (2006) also referred to the applied nature of working knowledge in terms of a health literate person being able to apply concepts and information to new situations:

> “Health literacy is much more than understanding a finite list of health facts or vocabulary. Health literacy consists of a dynamic group of productive skills a person calls on when facing new situations” (Zarcadoolas, Pleasant and Greer, 2006, p.48).

Zarcadoolas, Pleasant and Greer (2003; 2005; 2006) proposed a model of health literacy consisting of four domains, which is similar to some of the models of scientific literacy described earlier (for example, Shen, 1975; Shamos, 1995). The four domains are: Fundamental literacy/numeracy; Science and technology literacy; Community/civic literacy; and, Cultural literacy.

Gray (2009) provided a practical example of how Zarcadoolas, Pleasant and Greer's model could be applied to an individual situation in pharmacy practice:

> "Mrs B, considering giving up smoking, has read and heard the messages relating to the risks of smoking and her scientific literacy recognises the potential poor health outcomes. She acknowledges the ban on smoking in public places through her civic literacy. The overriding factor in her eventual decision not to give up is determined by the habits of her family and friends, who are all smokers. Her cultural literacy reminds her that the consequence of giving up would put her in difficult social situations" (Gray, 2009, p.335).

Fundamental literacy was described by Zarcadoolas, Pleasant and Greer (2005, p.197) as referring to "the skills and strategies involved in reading, speaking, writing, and interpreting numbers." These skills are important for developing working knowledge and taking part in free-choice learning and Zarcadoolas, Pleasant and Greer (2003) seem to have recognised this saying, "Fundamental literacy affects a wide range of cognitive, behavioural, and social skills and abilities" (Zarcadoolas, Pleasant and Greer, 2003, p.120).

Zarcadoolas, Pleasant and Greer's description of the Science and technology literacy domain is similar to, and includes aspects of, definitions (and models) of scientific literacy reviewed earlier. For example, they seem to have been referring to knowledge on the nature of science, "an understanding that scientific uncertainty is to be expected and that rapid change in the accepted science is possible" (Zarcadoolas, Pleasant and Greer, 2003, p.120).

Their 2005 description of Civic literacy is similar to the Civic Science literacy described by Shen (1975) as it refers to "abilities that enable citizens to become aware of public issues and to become involved in the decision-making process" (Zarcadoolas, Pleasant and Greer, 2005, p.197).

The domain of Cultural literacy differs slightly from that described by authors in the scientific literacy field (for example Shen, 1975). Here, cultural literacy is very closely related to working knowledge as it includes beliefs and opinions, "recognising and using collective beliefs, customs, world-views, and social identity relationships" (Zarcadoolas, Pleasant and Greer, 2003, p.120).

In their 2005 paper, Zarcadoolas, Pleasant and Greer applied their model of health literacy to communications regarding the anthrax threat in the US during 2001. Successfully applying their model to a real-life situation implies that it is closely related to and includes the idea of working knowledge. In addition, they clearly recognised the importance of free-choice learning describing how times where the public is looking for information, such as the anthrax attacks, can be seen as opportunities to improve health literacy.

Zarcadoolas, Pleasant and Greer (2005, p.196) said that "the benefits of health literacy impact the full range of life's activities - home, work, society and culture" suggesting health literacy is closely related to working knowledge and free-choice learning as these also provide benefits in all aspects of life.

The Institute of Medicine (IOM) (2004) used Ratzan and Parker's (2000) definition of health literacy, described earlier. This definition includes skills such as obtaining and processing information as part of health literacy rather than just facts and so could be considered to be related to working knowledge. The IOM added that health literacy is "a shared function of cultural, social, and individual factors" (IOM, 2004, p.32). Working knowledge could be one of these individual factors and free-choice learning could be one of the links between cultural, social and individual factors.

The IOM went on to list a table (Table 2-1, page 42. IOM, 2004) of examples of "Skills Needed for Health." The skills listed range from understanding food labels to deciding which websites contain accurate health information to finding one's way around a hospital. All of these skills could be part of a person's working knowledge.

The IOM referred to a previous report (Institute of Medicine, 2002), which suggested that health literacy should be assessed in individuals and populations "in terms of the influences on their lives and cultural histories, or "experiential identity" (IOM, 2004, p.21). This idea of experiential identity is similar to working knowledge and the IOM (2004, p.21) went on to say that "people's knowledge and understanding of their health, and their health literacy, are based on a composite of these life experiences." The IOM also recognised how health literacy, like working knowledge, can be influenced and added to by personal events for example, "a new living situation or a change in family member's health or birth of a child" (IOM, 2004, p.24).

The IOM proposed a conceptual framework for health literacy. This framework seems to include ideas similar to working knowledge as they recognised that:

> "individuals bring specific sets of factors to the health context, including cognitive abilities, social skills, emotional state, and physical conditions such as visual and auditory acuity" (IOM, 2004, p.32).

However, they concentrated on literacy providing the "skills that enable individuals to understand and communicate health information and concerns" (IOM, 2004, p.32). Whereas the current study would argue that literacy would be a part of the wider idea of working knowledge, and this working knowledge would enable individuals to understand health information. The IOM seems to have contradicted this emphasis on literacy as the foundation of health literacy in a later chapter saying, "limited health literacy probably affects more than just those with limited literacy" (IOM, 2004, p.66).

Just as in the scientific literacy research analysed previously, the IOM noted that there were a number of definitions of health literacy in use and that "consensus is needed to develop an operationally defined construct of health literacy" (IOM, 2004, p.52). More recent work would suggest that a consensus is yet to be reached (for example, Frisch et al., 2012).

Speros (2005) did not propose a model of health literacy but the paper is included here as a review and analysis of health literacy in "nursing, medical, public health, and social science literature" (p.634) was carried out:

> "in order to clarify its meaning, reduce ambiguities associated with references to it, and promote consistency in using the concept in nursing dialogue and research" (Speros, 2005, p.638).

This analysis took into account how health literacy has been defined by a range of authors and proposes an overall definition. Working knowledge seems to be included in the finding that:

> "Health literacy empowers people to act appropriately in new and changing health-related circumstances through the use of advanced cognitive and social skills" (Speros, 2005, p.633).

Cognitive and social skills could be part of working knowledge and could have been developed through free-choice learning.

The result of Speros' analysis was that:

> "The defining attributes of health literacy are reading and numeracy skills, comprehension, the capacity to use information in health care decision-making, and successful functioning as a healthcare consumer" (Speros, 2005, p.633).

There is no direct link to working knowledge in these defining attributes, however "the capacity to use information" is a skill used in free-choice learning and for developing working knowledge. It would seem that many authors were still focusing on reading, and numeracy skills yet, as stated by the IOM (2004, p.66) "limited health literacy probably affects more than just those with limited literacy."

Speros' work did hint at the importance of free-choice learning when saying that "social and education levels have little relationship to health literacy" (Speros, 2005, p.638). If social and education levels are not involved in health literacy, perhaps it is free-choice learning (and working knowledge) that is important.

Bernhardt, Brownfield and Parker (2005) didn't propose a model of health literacy but are included here because, like Speros (2005) and Mancuso (2008), they did provide a list of attributes required for health literacy. The attributes they suggest are required to "function in the complex and multidimensional health care environment" (Bernhardt, Brownfield and Parker, 2005, p.5) and were listed as:

> "individual-level attributes including abilities in prose, document, and quantitative literacy; ability to engage in two-way communication; skills in media literacy and computer literacy; motivation to receive health information; and freedom from impairments and/or communicative assistance from others" (Bernhardt, Brownfield and Parker, 2005, p.5).

This description clearly includes more than skills in reading and numeracy. For example, Bernhardt, Brownfield and Parker pointed out that media literacy includes the ability to assess information. Importantly, Bernhardt, Brownfield and Parker, similar to Nutbeam's (1998) definition, discussed how individuals need to be motivated to receive and act on health information. They suggested that this motivation can be linked to the "perceived personal relevance of the information being presented" (Bernhardt, Brownfield and Parker, 2005, p.8). This is related to working knowledge that is most likely to be developed because of a perceived personal relevance because of an interest or need.

Schulz and Nakamoto (2005) discussed health literacy in terms of what they called, "literacy and the lived experience of health" (p.6). The phrase "lived experience" immediately seems related to working knowledge. Although Schulz and Nakamoto (2005) agreed that reading and writing (functional literacy) is important to health literacy they went on to explain how these skills are a foundation for health literacy and other factors are of importance. They described how "ontological considerations" or "internalised ideas of good health" (p.6) are important to health literacy. They seem to have been including working knowledge in their concept of health literacy as it is personal and it includes not just facts and knowledge but also opinions, attitudes, beliefs:

> "being health literate therefore is not equal with propositional knowledge; it's not just declarative and it is even more than procedural; it is procedural as it relates to the person. It almost is the person in an existential sense. It's not only "what to do" but what doing something specific means for me "in my world" (Schulz and Nakamoto, 2005, p.6).

In 2009, **Rubinelli, Schulz and Nakamoto** explained this concept of health literacy further, using the idea of Phronesis. This led them to remark that, in their view:

> "critical" health literacy reflects the individual's capacity to contextualise health knowledge for his or her own good health, to decide on a certain action after a full appraisal of what that specific action means for them in "their own world" (Rubinelli, Schulz and Nakamoto, 2009, p.309).

This seems to be similar to working knowledge being formed because of an individual's own needs, interests, and what is relevant to them. Rubinelli, Schulz and Nakamoto (2009, p.309) suggested people "attempt to contextualise this propositional knowledge." This seems to be a way that working knowledge can be formed. It could be of interest to apply ideas of Phronesis to scientific literacy.

Rubinelli, Schulz and Nakamoto were referring to ideas linked to working knowledge in the following description of "self-examination":

> "Self-examination connects health information external to the individual with her own worlds of knowledge, beliefs, and values, and prompts a recognition of potential failures that might and, indeed, often do obstruct the achievement of a goal" (Rubinelli, Schulz and Nakamoto, 2009, p.310).

The idea of taking information and making it relevant to one's own world fits with working knowledge. In fact, an individual's "own worlds of knowledge, beliefs and values" could be their working knowledge.

Once again **Baker** (2006, p.878) pointed out the lack of consensus on a definition of health literacy, "the term "health literacy' itself has come to mean different things to various audiences and has become a source of confusion and debate." He presented a conceptual model of "the domains of health literacy and the relationship of health literacy with health outcomes" (p.878).

The two main domains within Baker's model are individual capacity and health literacy. Within the domain of individual capacity Baker focused on two subdomains, reading fluency and prior knowledge. The term prior knowledge (as used by Roschelle, 1995) has been discussed in the literature review as being similar to working knowledge. Baker described prior knowledge as being:

> "composed of vocabulary (knowing what individual words mean) and conceptual knowledge (understanding aspects of the world, e.g., how different parts of the body work or what cancer is and how it injures the body)" (Baker, 2006, p.879).

This vocabulary and conceptual knowledge is clearly similar to what the current study defines as working knowledge. It would be more closely linked if Baker's description of prior knowledge included an affective aspect, for example, opinions, beliefs or attitudes.

Baker didn't suggest how individual's may acquire their prior knowledge, we could assume that it may be free-choice learning, but Baker (2006, p.879) suggested it is related to reading fluency as "reading fluency allows an individual to expand one's vocabulary and gain conceptual knowledge. The converse is also true."

Baker (2006, p.879) pointed out that the model he proposed "views conceptual knowledge as a resource that a person has that facilitates health literacy but does not in itself constitute health literacy." Working knowledge contains this conceptual knowledge but will also provide the skills, attitudes, opinions and other constituents of health literacy.

The health literacy domain of Baker's model is divided into health-related print literacy and health-related oral literacy. These are related to working knowledge as Baker stated they depend upon health-related vocabulary and familiarity with health concepts. Baker went on to say:

> "Health literacy is one of many factors (e.g., culture and social norms, health care access) that leads to the acquisition of new knowledge, more positive attitudes, greater self-efficacy, positive health behaviours, and better health outcomes" (Baker, 2006, p.880).

Skills for free-choice learning could be another of these factors. Working knowledge could be one of the factors but could also influence or be an element of the acquisition of new knowledge, more positive attitudes, greater self-efficacy, positive health behaviours, and better health outcomes.

Similar to Speros (2005), **Mancuso** (2008) carried out a concept analysis of health literacy. Health literacy research from 1975 to 2008 was examined with the aim being "to analyse, clarify, and synthesise its meaning" (Mancuso, 2008, p.248) and a concept model of attributes and competencies was proposed. Like others, she made the point of there being many definitions of health literacy; "There are many definitions of health literacy, but none that encompass the totality by which the concept is constructed" (Mancuso, 2008, p.248).

Mancuso's analysis resulted in similar attributes to those discussed by Speros, "The attributes of health literacy are capacity, comprehension, and communication" (Mancuso, 2008, p.249). The concept analysis resulted in health literacy being defined as:

> "a process that evolves over one's lifetime and encompasses the attributes of capacity, comprehension, and communication. The attributes of health literacy are integrated within and preceded by the skills, strategies, and abilities embedded within the competencies needed to attain health literacy" (Mancuso, 2008, p.250).

The idea of health literacy evolving over a lifetime is related to working knowledge and how it builds over time with experiences. Similar ideas have been discussed in terms of scientific literacy models (for example, Bybee, 1997; Murcia, 2009: Liu, 2009) and other health literacy concepts (for example, Zarcadoolas, Pleasant and Greer, 2003; 2005; Schultz and Nakamoto, 2005).

When discussing the attribute of comprehension and how it involves logic, language, and experience, Mancuso cited Doak, Doak and Root (1996) saying, "Experience implies associating new information with something one already knows" (Mancuso, 2008, p.250). This is one of the ways we would expect working knowledge to be used and also acquired.

All of the six competencies identified by Mancuso as antecedents to health literacy have aspects that could be a part of working knowledge. For example, autonomous competence includes "A level of knowledge and personal skill to manage and analyse information regarding one's own health" (Mancuso, 2008, p.249).

Within the competencies Mancuso made reference to skills related to free-choice learning. For example, Informational competence:

> "entails the ability needed to recognise a health information need, a strategy to identify likely information sources and use them to retrieve relevant information and its applicability to a specific situation" (Mancuso, 2008, p.249, cited the Medical Library Association, 2003 as the source of this piece of analysis).

When discussing the Joint Committee on National Health Education Standards' (2005:5) definition of health literacy Mancuso made a strong reference to the importance of free-choice learning saying:

> "It is implied that individuals are empowered within the health-care system to develop the competencies needed through self-directed learning and to

> advocate for personal, family, and community health" (Mancuso, 2008, p.250).

Self-directed is one of the main characteristics of free-choice learning.

Nutbeam (2008) built on his earlier work describing two conceptual models of health literacy. One describes health literacy as a clinical "risk" and the other as a personal "asset".

The conceptual model of health literacy as a risk, "places health literacy as a risk factor that needs to be identified and appropriately managed" (Nutbeam, 2008, p.2074). In other words the responsibility of dealing with poor health literacy lies with the organisations providing health care. It is they who will assess health literacy and provide information, communications, interactions that will lead to improved clinical outcomes.

Nutbeam's model of health literacy as an asset sees health literacy "as a means to enabling individuals to exert greater control over their health and the range of personal, social and environmental determinants of health" (Nutbeam, 2008, p.2074). Nutbeam suggested that his (1998) definition of health literacy fits with this concept of health literacy as an asset. This definition describes health literacy as representing:

> "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, 2008, p.2074).

Nutbeam (2008, p.2075) saw this definition as comprising "a set of skills that enable people to participate more fully in society, and to assert a higher degree of control over everyday events." This is closely related to the usefulness that is included in the idea of working knowledge.

Similar to Nutbeam (2008), **Pleasant and Kuruvilla** (2008) also proposed two approaches to health literacy, namely a clinical approach and a public health approach. These seem to correspond to Nutbeam's (2008) risk and asset based models respectively. They described the clinical approach as seeing health literacy as "a problem that patients have and physicians need to overcome" (Pleasant and Kuruvilla, 2008, p.152). Whereas the public health approach:

> "connects health literacy with health promotion and social marketing of public health interventions...and connects health literacy with education and empowerment, often from a Freirian perspective on adult education and literacy" (Pleasant and Kuruvilla, 2008, p.153).

As with Nutbeam's (2008) two concepts, it is the public health approach that is much more closely related to working knowledge and free-choice learning.

Pleasant and Kuruvilla (2008) discuss the role of knowledge in health literacy and their description of its importance seems related to working knowledge, "The diffusion and use of knowledge in society is arguably one of the most important factors in improving health outcomes" (Pleasant and Kuruvilla, 2008, p.153). It could be argued that the knowledge that is being referred to is mostly working knowledge and that its diffusion is mostly via free-choice learning.

In a 2009 editorial **Nutbeam** looked at how work in the area of literacy studies can benefit health literacy research, although Frisch (2012) seemed to do a more thorough investigation of this (discussed later). Nutbeam's (2009) editorial is mentioned here as he seems to have been describing the personal nature of working knowledge when discussing how content and context are important when measuring health literacy:

> "health literacy will be different for a person with diabetes who is receiving patient education, compared with a pregnant woman attending ante-natal classes, or a young person exposed to health education at school" (Nutbeam, 2009, p.304).

This is perhaps the closest reference to the ideas of working knowledge read in health literacy research. Also in the same editorial Nutbeam (2009, p.304) acknowledged that "health literacy can be developed through education" and that health literacy is an outcome of health education. However, as in a previous paper (Nutbeam, 2000) he did not suggest if health education is formal education and there is no mention of free-choice learning.

Freedman et al. (2009) introduced the term public health literacy, which they defined as:

> "the degree to which individuals and groups can obtain, process, understand, evaluate, and act on information needed to make public health decisions that benefit the community" (Freedman et al., 2009, p.448).

This definition could be considered to be similar to the idea of civic scientific literacy as discussed previously (for example, Shen, 1975), or Zarcadoolas, Pleasant and Greer's (2003; 2005) civic/community literacy.

When this term is considered in terms of working knowledge it suggests some interesting ideas and relationships. To look at health literacy through the lens of working knowledge suggests that it is an individual and personal characteristic. However free-choice learning brings together knowledge and skills of groups, families, communities and shares them between individuals. This may suggest that a separate concept of public health literacy is unnecessary.

Freedman et al. (2009, p.448) stated that the primary aims of public health literacy include to "engage more stakeholders in public health efforts." If free-choice learning is acknowledged as having an input on public health literacy, a large number of stakeholders are already engaged. Free-choice learning providers are already engaged in public health literacy efforts and a perfect example of this is the Glasgow Science Centre's BodyWorks exhibition and activities.

Freedman et al. (2009) did mention free-choice learning's input to public health literacy indirectly saying how an increase in public health literacy may occur through the media. They also suggested that public health literacy should be incorporated into "informal education networks" (p.450) but didn't give recognition of where this is already happening. However, they are one of very few papers in health literacy to specifically mention informal learning.

In suggesting further research into public health literacy Freedman et al. (2009, p.450) proposed that work is needed to "explore the relationship between individual-level health literacy and public health literacy." The sharing of working knowledge between individuals and groups that happens as part of free-choice learning may be an interesting way to start investigating this.

The proposal of this distinct concept of public health literacy further complicated a field that has yet to form a consensus on its original concept of health literacy. For this analysis it may be best to consider public health literacy as Berkman, Davis and McCormack (2010) did, as being complementary to individual health literacy. Or to recognise the idea of "collective action" described by Chinn (2011).

Peerson and Saunders (2009) described the difference between what they called Medical Literacy and Health Literacy. This seems similar to how some authors distinguish between science literacy and scientific literacy (for example, Maienschein, 1998; Liu, 2009):

> "A simple way of describing the difference is: "medical literacy" involves the ability to read, understand and act on instructions for taking a cholesterol-lowering drug; "health literacy" involves the ability to access information about cholesterol, to understand it and to apply it to one's own life" (Peerson and Saunders, 2009, p.288).

The difference they were emphasising is that their definition of health literacy includes:

> "the capacity to understand and act on messages that are central to making critical judgements and decisions not only in health-related settings but also about health" (Peerson and Saunders, 2009, p.286).

and:

> "health literacy is relevant to those individuals who may never become patients or deal directly with the health system, whereas medical literacy is not" (Peerson and Saunders, 2009, p.289).

They saw this view of health literacy as relatively new. However, there are other definitions that do not specifically include interaction with a health system (for example, Nutbeam, 1998; 2008; Zarcadoolas, Pleasant and Greer, 2003; 2005).

The ability to access and understand information is clearly linked to free-choice learning and the ability to apply information to one's own life (both in and out of health settings) is linked to working knowledge. Peerson and Saunders seem to have been moving towards ideas of free-choice learning and working knowledge when they described their view of health literacy and how it interacts with everyday life:

> "Our concept of health literacy includes information and decision-making skills occurring in the workplace, in the supermarket, in social and recreational settings, within families and neighbourhoods, and in relation to the various opportunities and decisions that impact upon health everyday" (Peerson and Saunders, 2009, p.289).

Peerson and Saunders raised the important question of how to describe someone who is, according to a definition, health literate but does not use their health literacy in health promoting ways. The example they used was, “how would we describe the health literacy of someone who knows and understands the health risks of ‘binge drinking’ but chooses to ignore them?” (Peerson and Saunders, 2009, p.289). They suggested that it is important to include motivation and activation as aspects of health literacy. This is not entirely new and motivation and use of information were included in Nutbeam’s definition of health literacy in 1998. Motivation is also an important factor in free-choice learning.

In their conclusions, Peerson and Saunders noted another difference between medical literacy and health literacy, that:

> “while the health sector may be able to substantially influence the former, it is less able to influence the latter. An individual’s personal cognitive and social skills play a crucial role in health literacy but are subject to influences well outside the control of health professionals and the health system” (Peerson and Saunders, 2009, p.292).

These “personal and social skills” are a part of working knowledge and are influenced by free-choice learning. Therefore, it would be fair to say that free-choice learning has a significant influence over health literacy and may be a good starting point for those seeking to improve health literacy. The BodyWorks exhibition used in this study is a good example of free-choice learning with the potential to influence health literacy.

Peerson and Saunders (2009, p.292) went on to propose that “health education will need to involve a significant widening of content and methods.” Again, free-choice learning, with its wide range of resources, would be a good starting point for this.

Berkman, Davis and McCormack (2010) carried out a comprehensive review of definitions of health literacy and some of their discussions are relevant to working knowledge and free-choice learning. In particular, they discussed if being health literate is static or dynamic, concluding that “conceptualising health literacy as dynamic is inevitable” (p.17). This corresponds with the idea that working knowledge is continually added to and develops throughout an individual lifetime. This was seen in some models of scientific literacy (including

Bybee, 1997; Murcia, 2009: Liu, 2009) and the idea of health literacy building over time has been included by other authors (including, Mancuso, 2008; Zarcadoolas, Pleasant and Greer, 2003; 2005; Schultz and Nakamoto, 2005). This development over time must be in part due to free-choice learning.

When discussing the influence that the health-care system has on health literacy, Berkman, Davis and McCormack (2010) stated:

> "One could argue that the population's health literacy would be higher if health-related materials and communication more universally integrated principals of clear language, making them easier to understand and a closer match to individuals' skill level" (Berkman, Davis and McCormack, 2010, p.16).

This seems to be hinting at the importance of relating information to individual's working knowledge in health literacy. This argument could also apply to scientific literacy and has been considered in reference to relating museum and science centre exhibits and activities to working knowledge (Chapter 5).

Jordan, Buchbinder and Osborne (2010, p.36) defined health literacy simply as encompassing "an individual's ability to seek, understand and utilise health information." They carried out interviews with the aim of understanding health literacy from the patient perspective. Although they did not propose a model of health literacy as such, they did identify abilities that are important for health literacy (as they define it).

Jordan, Buchbinder and Osborne's results determined seven abilities that patients identified as important in "seeking, understanding and utilising health information within the healthcare setting" (p.38). These abilities are: knowing when to seek health information; knowing where to seek health information; verbal communication skills; assertiveness; literacy skills; capacity to process and retain information; and, application skills. These abilities could all be part of an individual's working knowledge but how these abilities develop has not been looked at. However, in addition to the seven abilities, other factors that influence the abilities were identified including, patient attitudes and experiences, education and cultural differences. Again, these factors could be part of working knowledge and the education could well include free-choice learning.

As part of their study, Jordan, Buchbinder and Osborne (2010) proposed a conceptual model of individual patient journey from identification of health problem through to resolution. The steps in this model are:

> "Identification of health issue"; "Access and navigation of healthcare system"; "Communicating with health professionals"; and, "Factors impacting on resolution of health issue" (Jordan, Buchbinder and Osborne, 2010, p.38).

This model seems to fail to recognise that the healthcare system may not always be the first place individuals go for health information. There is no inclusion of any input from free-choice learning or working knowledge. For example, people may speak to friends and family, or search on the Internet for information, or use their own working knowledge about a health issue before accessing the health care system.

This study is very much concentrating on health literacy in the healthcare setting, what Peerson and Saunders (2009) would call medical literacy. Even though one of the groups interviewed by Jordan, Buchbinder and Osborne (2010) were from the general population (so not currently patients) and not interacting with the healthcare system at the time of interview. It takes a step back from Peerson and Saunders' idea of health literacy in everyday life and it being "relevant to those individuals who may never become patients or deal directly with the health system" (Peerson and Saunders, 2009, p.289). This concentration on interaction with the healthcare system may have been due to the interview schedule being developed in discussion with clinicians and health service researchers.

Concentrating on the interaction and journey through the healthcare system of course produces useful results that provide guidance for health professionals on how to interact with their patients. However, the seeking, understanding and utilising of health information outside the healthcare system seems too significant to ignore. In fact, information obtained outside the healthcare system may even stop an individual from interacting with the healthcare system. Jordan, Buchbinder and Osborne (2010, p.41) did go on to say: "our results show that an individual's health literacy is dependent on the relationship between individual capacities, the healthcare system and broader society." Yet, they didn't seem to have been giving too much credit to the role that broader society, which would include free-choice learning, would play.

Chinn (2011) again pointed out that there is no agreed definition of health literacy but suggested the definition used by the UK National Consumer Council as a starting point: "the capacity of an individual to obtain, interpret and understand basic health information and services in ways that are health-enhancing" (Sihota and Lennard, 2004).

It could be argued that this definition hints at working knowledge as it includes an individual's skills and it could be assumed that health information is being obtained from free-choice learning, but it isn't clear.

Chinn (2011) looked at Nutbeam's (2000) "critical health literacy" and discussed it in terms of three domains: Information appraisal; Understanding the social determinants of health; and, Collective action. It has been pointed out above that "Critical literacy", as described by Nutbeam, seems closely related to working knowledge.

In simple terms, information appraisal cannot take place without an individual using their working knowledge. They will be using their own knowledge, skills, and opinions to evaluate information and make a decision.

Collective action has an important link to working knowledge and free-choice learning. This is similar to public health literacy proposed by Freedman et al. (2009). Many people gain information, opinions, attitudes, behaviours from friends and family (see results of the current study in Chapter 5). So perhaps working knowledge could be considered as a collective commodity. Chinn (2011) used phrases such as "social capital" "civic or citizen health" (Chinn, 2011, p.63) when discussing collective action and these terms seem to relate to the idea of free-choice learning if we consider people (friends, family, acquaintances) as free-choice learning resources. Chinn seems to have been agreeing with this idea saying:

> "seeing the achievement of literacy as a socially contextualised event involving people in networks working together and referencing common

> values and cultural practices in order to make sense of texts in order to achieve social goals" (Chinn, 2011, p.65).

Despite the advancement of models of health literacy away from those based on reading and writing (functional literacy), as recently as March 2012, the lack of agreement on a definition of health literacy was still being reported:

> "current definitions of health literacy show that health literacy is more than functional literacy in the health domain. At the same time, no consensus exists about what to include in the concept of health literacy" (Frisch et al., 2012, p.119).

Frisch et al. (2012) carried out a review of other literacy domains in order to "identify which dimensions are important for the concept of health literacy and how they can be operationalised" (Frisch et al., 2012, p.120).

Of great interest to the current study is the fact that Frisch et al. included science/scientific literacy in their review. Zarcadoolas, Pleasant and Greer (2003; 2005; 2006) are the only other authors to be found to have mentioned science/scientific literacy. The other domains looked at by Frisch et al. were: civic literacy; cultural literacy; information literacy; media literacy; new media literacy; and, political literacy. Interestingly, some of these have appeared as domains in other models of both health literacy (e.g. Zarcadoolas, Pleasant and Greer, 2003; 2005) and scientific literacy (for example; Shen, 1975; Shamos, 1995)

Frisch et al.'s review presented seven dimensions considered important for health literacy: functional literacy, factual and procedural knowledge, awareness, a critical dimension, an affective dimension and attitudes (Frisch et al., 2012, p.122). All of theses dimensions could be a part of an individual's working knowledge and be gained through free-choice learning. The inclusion of an affective dimension and attitudes has not been seen clearly in other models of health literacy. These dimensions are closely related to the individual, personal nature of working knowledge. The inclusion of these dimensions may indicate that health literacy models (like scientific literacy models) are starting to move towards the idea of working knowledge. However, there was no reference to where or how an individual gains the seven stated dimensions, it seems obvious that free-choice learning would fit in here.

It is also interesting to note the inclusion of the awareness and critical dimensions. It could be argued that these are skills that are useful for free-choice learning and may be part of what could be encouraged in formal education as a means of future-proofing both scientific literacy (as discussed earlier) and health literacy.

Of great relevance to this current study is a review of health literacy models and definitions by **Sørensen et al.** (2012). The review included the majority of work discussed above and used a concept analysis to integrate previous work into a new definition and model of health literacy. The resulting definition was:

> "Health literacy is linked to literacy and entails people's knowledge, motivation and competences to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life during the life course" (Sørensen et al., 2012, p. 3)

This "integrated conceptual model of health literacy" (p.8) developed by Sørensen et al. seems to include working knowledge as it focuses on abilities rather than just facts. Free-choice learning may be included in the "societal and environmental determinants" (p.10) and would also be found in "situational determinants" (p.10), which include peer influences and media use.

Sørensen et al. (2012) stated that health literacy is strongly associated with educational attainment as well as with overall literacy. This contradicts the idea of working knowledge and also previous researchers (for example, Gray, 2009; IOM, 2004; Speros, 2005; Zarcadoolas, Pleasant and Greer, 2006).

Sørensen et al. (2012, p.10) suggested that low health literacy can be addressed by "educating persons to become more resourceful" yet there was no suggestion as to where the responsibility for this lies. Also, this seems to be based on a deficit, or risk, perspective, and the problems associated with this are discussed in Chapter 8.

Sørensen et al.'s (2012) definition and model were used in the European Health Literacy Study. The results of this study showed that:

> "almost half of the people have risk of limited health literacy hence having difficulties in accessing, understanding, appraising and applying information to take decisions in terms of health" (The HLS-EU Consortium, 2012, p.4).

The study suggested that this gap needs to be addressed by:

> "ensuring a higher degree of accessibility and readability of systems as well as strengthening the individual's competences, knowledge and motivation to act in terms of their own health to the benefit of themselves, their families and their communities" (The HLS-EU Consortium, 2012, p.3).

The current research indicates that free-choice learning has a significant role to play in this.

DISCUSSION

DEVELOPMENT OF HEALTH LITERACY CONCEPTS

From this review, it would seem that health literacy models and definitions have been moving more and more away from simply involving functional health literacy of basic reading and writing skills. Models have developed from those based on reading and writing to those based on empowerment, and critical appraisal (for example, Chinn, 2011). This development was recognised by Frisch et al.:

> "The concept of health literacy has changed significantly over the last 25 years. Originally defined as reading, writing and numeracy skills in the health domain, health literacy is now considered a multidimensional concept" (Frisch et al., 2012, p.117).

and Sørensen et al.:

> "the concept of health literacy has expanded in meaning to include information-seeking, decision-making, problem-solving, critical thinking, and communication, along with a multitude of social, personal and cognitive skills" (Sørensen et al., 2012, p.11).

Gray (2009, p.334) described the development of health literacy concepts in terms of two watersheds. The first watershed being in 2000 when research started to move away from concentrating on reading and writing skills. This was when Nutbeam (2000) proposed his model of health literacy discussed previously. Gray (2009, p.334) suggested the second watershed occurred when multiple literacies were included in descriptions of health literacy and gave

Zarcadoolas, Pleasant and Greer (2005) as an example of this. Gray (2009, p.336) also pointed out that health literacy as a concept will continue to develop but emphasised that “its value is in sharing skills, not just information.”

More recently de Leeuw (2012) discussed health literacy research as a series of generations. According to de Leeuw (2012) the first generation of health literacy development involved seeing health literacy as a risk factor (as proposed by Nutbeam, 2008). In this generation of research the health system had responsibility for dealing with and/or improving the health literacy of individuals. De Leeuw suggested the second generation of health literacy research is related to the asset-based approach described by Nutbeam (2008). This second generation starts to include “issues of equity, equality and empowerment” (de Leeuw, 2012, p.1). According to de Leeuw (2012) we are approaching a third generation of development in which health literacy is defined as:

> “the skills, capacities and knowledge required to access, understand and interact with social and political determinants of health and their social discourse” (de Leeuw, 2012, p.2).

Frisch et al. (2012) seem to be part of this third generation as they include both civic literacy and political literacy when working on a concept of health literacy. This third generation is in some ways similar to ideas included in descriptions of civic science literacy discussed previously (including Shen, 1975). Even more relevant is the civic/community literacy included in Zarcadoolas, Pleasant and Greer’s (2003; 2005; 2006) model of health literacy.

RESPONSIBILITY FOR HEALTH LITERACY

As with scientific literacy, there is some debate over where the responsibility lies for improving health literacy. In the scientific literacy research discussed previously the issue of responsibility was discussed between the formal and informal education sectors. The research in that field seemed to be giving increasing recognition to the importance of free-choice, or informal, learning with suggestions of formal education providing skills for lifelong learning. In health literacy research the debate is not as developed or clear-cut. There is some reference to the input of formal education (for example; St. Leger, 2001; de Leeuw, 2012) and some discussion of health education. One of the main difficulties being that it is not clear if health education lies in formal education or free-choice learning, or indeed both sectors. To further confuse the issue, there are arguments in other work that suggest that the responsibility lies with the health system (for example, Jordan, Buchbinder and Osborne, 2010). The health system could be considered to be a part of free-choice learning as it is a setting where people gain and use working knowledge. This current study has shown that people gain working knowledge from the health system, in particular from doctors and nurses (see Chapter 5).

The IOM (2004) suggested three key sectors that “should assume responsibility for health literacy, and within which health literacy skills can be built” (IOM, 2004, p.32). These are: culture and society; the education system; and, the health system. It is not made clear if free-choice learning (or informal learning) is included in these sectors. Perhaps free-choice learning overarches the three sectors and brings them all together. Aspects of culture and society would make up part of free-choice learning, as would the health system. Also, IOM included adult education programs as part of the education system, which could be considered free-choice learning.

In terms of culture and society, IOM stated that “Cultural, social, and family influences shape attitudes and beliefs and therefore influence health literacy” (IOM, 2004, p.109). This idea is closely related to working knowledge as it also contains attitudes and beliefs.

When discussing where people obtain health information from IOM quoted a Gallup Organisation poll (2002). This showed that people are getting health information from a range of free-choice learning sources. The proportion of people reporting that they “obtain a great deal of or moderate amount of health information” from the following sources as: Doctor (70%); TV (64%); books (56%); newspapers (52%); magazines (51%); Nurse (49%); and the Internet (37%) (IOM, 2004, p.121).

Despite showing that people are getting health information through free-choice learning sources, the IOM then contradicted its importance by saying, “the US educational systems offer a primary point of intervention to improve the quality of literacy and health literacy" (IOM, 2004, p.142).

Although the IOM didn't specifically name free-choice learning (or informal learning) they do seem to have recognised its importance to health literacy:

> "competing sources of health information (including the national media, the Internet, product marketing, health education, and consumer protection) intensify the need for improved health literacy" (IOM, 2004, p.126).

The current study would consider what the IOM called "health systems" to be a part of free-choice learning about health (and perhaps could be included as part of what the IOM called Culture and society). This is supported by the Gallup poll quoted previously by the IOM where results suggested that 70% of people get health information from a doctor.

A study by Logan (2007) confirmed the lack of consensus on the responsibility for health literacy. His study showed a lack of agreement on where health literacy initiatives should take place. Respondents were divided on whether it should be formal education, clinical settings or "settings where consumers learn more informally about health" (Logan, 2007, p.127), i.e. free-choice learning. Optimistically, Logan saw this lack of agreement and the different attitudes towards health literacy by health professionals as a basis for further research "basis for an evolving, fluid, vigorous dialogue about health literacy issues among health professionals" (Logan, 2007, p.136).

Perhaps health literacy could learn from the development of scientific literacy research as it moves towards increased recognition of free-choice learning and working knowledge. Health education could be described as free-choice learning but it must be recognised that people gain their health knowledge from sources other than health education, health promotion materials and schools. In addition, health literacy researchers could include support for the idea of formal education providing skills for lifelong learning. This has been hinted at by de Leeuw, "schools are the key stepping stone for health competencies through life" (de Leeuw, 2012, p.1) and outlined by St. Leger (2001) who did state that schools are "essential in achieving health literacy" (St Leger, 2001, p.197). However, he importantly went on to suggest that this can only be achieved if schools give more recognition to free-choice learning and working knowledge when saying, “schools need to be more student-centred” (St Leger, 2001, p.203) and teachers need to be “aware of key agencies and organisations in the community that provide the contextualisation of the issue” (St Leger, 2001, p.203) and there needs to be “more recognition of beyond-classroom activities” (St Leger, 2001, p.203).

FUTURE RESEARCH IN HEALTH LITERACY

As with the field of scientific literacy, the lack of consensus on the meaning of health literacy can be seen as a major problem. Berkman, Davis and McCormack (2010) reviewed definitions of health literacy and concluded that a lack of consensus could be detrimental to progress in research. However, they also noted that, “the range of definitions reflects an appreciation for the complexity of the construct, and the possibility that different definitions may be needed depending on one’s goals” (Berkman, Davis and McCormack, 2010, p.18).

The lack of agreement on a definition of health literacy (similar to scientific literacy) mentioned by many researchers (including, Baker, 2006; Mancuso, 2008; Frisch et al., 2012) may be less important than the failure to recognise the input of free-choice learning. An investigation into the current role free-choice learning plays in health literacy may be a useful place to start. Similar studies are underway looking at science learning outside of school in the UK (Holman, 2011). The results of these studies may encourage health literacy researchers to look at the contribution of free-choice learning.

In addition, the interaction between individual’s working knowledge of health and health information or health promotion materials should be investigated. Schulz and Nakamoto (2005) seem to have agreed with this saying:

> “there is a need to explore expanded vision, particularly a vision that highlights the ultimately subjective nature of a person’s interaction with health information” (Schulz and Nakamoto, 2005, p.8).

The IOM (2004) outlined what they believe a health literate America would be but they added that more research needs to be done as:

> "much more needs to be known about the causal pathways between education and health and the more specific role of literacy, as well as the discrete contribution of health literacy" (IOM, 2004, p.241).

The current study proposes that free-choice learning and working knowledge may be a significant part of these "causal pathways" and the "discrete contribution of health literacy."

Further evidence to support the importance of free-choice learning to health literacy is found through those researchers who do not believe education (or literacy) levels correspond to higher health literacy. In these cases it could be argued that it is free-choice learning that contributed the health literacy. For example, Gray (2009) pointed out:

> "A PhD-educated individual might have poor health literacy, despite high general literacy, if they have never needed to engage with the health system. Conversely, a low-income mother who did not complete secondary education might have higher health literacy, despite poor general literacy, because she has learnt to navigate the health system to help her children" (Gray, 2009, p.335).

Zarcadoolas, Pleasant and Greer (2006) add the following examples:

> "A college graduate with a degree in physics does not understand that taking multiple over-the-counter medications at once can be harmful."
> "A single mother with less than a sixth-grade education understands how to manage her four-year-old son's chemotherapy regimens and asks specific questions about his most recent blood counts" (Zarcadoolas, Pleasant and Greer, 2006, p.46).

More recently, Frisch et al. (2012) outlined the importance of gaining a better understanding of health literacy for the purposes of "adapting health-related information and services and designing successful health education programs" (Frisch et al., 2012, p.117). Again the current study would argue that a better understanding of working knowledge and free-choice learning would contribute to this. This is similar to how a better understanding of working knowledge and free-choice learning could help free-choice learning providers in designing and delivering their activities.

The fields of scientific literacy and health literacy have started from different points and developed in different directions. However, the two fields seem to overlap, or at least run closely parallel, in places so that there should be some best practice that can be shared between them. Frisch et al. (2012) and Zarcadoolas, Pleasant and Greer (2003; 2005; 2006) are the only models the current study has found to date that have put some effort into including the ideas of science literacy research into health literacy ideas.

IN THE NEXT CHAPTER...

... a comparison of the scientific literacy and health literacy research reviewed in Chapters 6 and 7 is carried out. This contributes to the fourth research question set out for this thesis: Can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

CHAPTER 8 - WHAT CAN THE AREAS OF SCIENTIFIC LITERACY AND HEALTH LITERACY LEARN FROM EACH OTHER?

The previous two chapters have reviewed the models of scientific literacy and health literacy through the lens of working knowledge and free-choice learning. The reviews produced a series of key points that appear to be developing in the literature, as well as suggestions for future research. Due to the apparent similarities between some concepts in each area, it is beneficial to now compare and apply the key points from the scientific literacy review to the idea of health literacy and vice versa. This can be seen as a sharing of best practice and may provide clearer definitions or models and, most importantly, novel directions for future research. This analysis will provide us with a series of questions that could be answered in future research.

Zarcadoolas, Pleasant and Greer (2006) suggested that important questions regarding the interaction of scientific literacy and health literacy are:

> "What science must a person know to comprehend and decide to act upon a specific health message?" "What assumptions about the listeners' scientific literacy are made by developers of health messages?" Zarcadoolas, Pleasant and Greer, 2006, p.61).

This study contributes towards answering these questions by highlighting the importance of working knowledge and free-choice learning. A person's working knowledge will contribute to the science they use to understand and act on a health message. This working knowledge could come from a range of free-choice learning sources. Developers of health messages must recognise the importance of free-choice learning when making assumptions about their audiences.

It should be reiterated at this point that working knowledge may be a more useful term and concept than scientific literacy or health literacy. However, there is a great deal of research using these terms to be analysed and explored from the perspective of working knowledge. So, we proceed from the perspective that working knowledge makes up part of scientific and health literacy. The health literacy field may also benefit from consideration of the other ideas similar to working knowledge outlined in the literature review. For example, Islands of Expertise (Crowley and Jacobs, 2002) seem particularly relevant (see Page 39).

It is also important to note that this discussion and potential sharing of ideas and best practice has been limited to the analysis of research in scientific literacy and health literacy. There is of course research in the areas of health education, public health, health promotion, risk communication that may provide similar or further ideas.

STARTING POINTS

The two sets of literature set off from somewhat different places. The health literacy models and definitions started from a functional literacy perspective, where reading and writing are of great importance. Whereas the scientific literacy perspective, although starting around twenty years earlier, appears to have skipped the idea of functional literacy, and started from a more knowledge based point of view, generally concerned with the public having some knowledge of science. Shen (1975) suggested that reading and writing are not necessary for practical science literacy as it can be gained without these functional skills. He even went as far as to say that in some cases practical science literacy is more important than reading and writing:

> "It is interesting that alphabetic literacy (reading and writing) is not a prerequisite for science literacy: the latter can be achieved through speech and pictures without writing. In fact, the urgency of practical literacy will in some cases justify its taking precedence over alphabetic literacy in development planning." UN specialised agencies should "redouble their efforts to integrate science literacy with alphabetic literacy and science education projects" (Shen, 1975, p.47).

These different starting points may be the reason that scientific literacy models typically focus on knowledge whereas health literacy seems to concentrate on skills. For example, some scientific literacy researchers have provided lists of facts, concepts and ideas that one needs to know in order to be scientifically literate (for example, Trefil, 1987; Hazen and Trefil, 1991; Brennan, 1992). Whereas in health literacy we are provided with skills one might require in order to be health literate. For example, the Institute of Medicine (2004) listed skills for health including understanding food labels and finding one's way around a hospital.

It is a generalised view that scientific literacy models concentrate on facts/knowledge and there are models that suggest skills required for scientific literacy (e.g., Arons, 1983; Graber, 2002). More recent models in both fields seem to come to similar conclusions and are including skills and knowledge (for example, Kanasa and Nichols, 2008; Chinn, 2011; Frisch et al., 2012). Perhaps the skills required for both health and scientific literacy are included in skills for lifelong learning. This would be similar to what Nutbeam (2008, p.2075) described as “a set of skills that enable people to participate more fully in society, and to assert a higher degree of control over everyday events.”

The previous chapters suggested that skills are more important, especially with regards to future-proofing, as knowledge can go out-of-date as science and medicine continue to develop. However, Jordan, Buchbinder and Osborne (2010) made the important point that other factors influence these abilities including attitudes and experiences, education and cultural differences. Other researchers have added that as well as skills people need motivation and confidence to use them. This is discussed later in terms of motivation and empowerment (Page 232).

DEFINITIONS

A straightforward way to analyse the reviews in the previous two chapters is to take some of the definitions and models from each field and apply them to the other. For example, a useful review and concept analysis by Sørensen et al. (2012) integrated previous models and definitions of health literacy resulting in the definition:

> “Health literacy is linked to literacy and entails people’s knowledge, motivation and competences to access, understand, appraise, and apply health information in order to make judgments and take decisions in everyday life concerning healthcare, disease prevention and health promotion to maintain or improve quality of life during the life course” (Sørensen et al., 2012, p.3).

This can be adapted into a definition of scientific literacy of: Scientific literacy entails people’s knowledge, motivation and competences to access, understand, appraise, and apply scientific information in order to make judgements and take decisions in everyday life.

This adaptation of definitions can also be done in the opposite direction, applying scientific literacy definitions to health literacy. In the review of scientific literacy models it was found that more recent models were increasingly recognising the role of free-choice learning and working knowledge. Feinstein's (2011) definition of science literate people was found to be closely related to the idea of working knowledge, his definition was based on research that:

> "tells us that people selectively integrate scientific ideas with other sources of meaning, connecting those ideas with their lived experience to draw conclusions and make decisions that are personally and socially meaningful" (Feinstein, 2011, p.180).

If we simply replace "scientific ideas" with "health information" in the above quote, Feinstein's idea can be easily applied to health literacy. Similarly, Feinstein's definition of scientifically literate people can be adapted to health literacy by simply replacing science and scientific with health:

> "people who have learned to recognise the moments when science has some bearing on their needs and interests and to interact with sources of scientific expertise in ways that help them achieve their own goals" (Feinstein, 2011, p.180).

So, health literate people are those who have learned to recognise the moments when health has some bearing on their needs and interests and to interact with sources of health expertise in ways that help them achieve their own goals.

However, one problem with this definition is that a person's own goals may not necessarily fit with good health. They may seek expertise from a health professional and not take the advice given. For example, a person with a sore back may be advised to take painkillers and exercise, but choose only to take the painkillers. This is related to the ideas of motivation and empowerment, which are included more often in concepts of health literacy than scientific literacy. Thus, it is not simply having skills and/or knowledge but using them, as well as wanting to gain further skills and/or knowledge.

Nutbeam included motivation in his 1998 definition of health literacy:

> "Health literacy implies the achievement of a level of knowledge, personal skills and confidence to take action to improve personal and community health by changing personal lifestyles and living conditions. Thus, health literacy means more than being able to read pamphlets and make

> appointments. By improving people's access to information, and their capacity to use it effectively, health literacy is critical to empowerment. Health literacy is itself dependent upon more general levels of literacy. Poor literacy can affect people's health directly by limiting their personal, social and cultural development as well as hindering the development of health literacy" (Nutbeam, 1998, p.357).

Further to this, Peerson and Saunders (2009, p.289) gave an example of how a person may not use health literacy in health promoting ways. They questioned how the health literacy of someone who knows and understand the health risks of binge drinking but decides to ignore them could be described. Although motivation is important in free-choice learning (quite simply, you need to be motivated to participate in some free-choice learning) it is not mentioned as often in scientific literacy models. Are there people who choose to ignore their working knowledge of science? For example, a person who understands the benefits to the environment of recycling but chooses not to. Perhaps motivation and empowerment are two of the skills needed for lifelong learning that should be developed in schools? (see responsibility, Page 225).

This is related to a suggestion made when discussing scientific literacy (Page 159), that there could be two types of scientifically literate individuals. There are some who are always seeking out scientific information and activities. There are others who are perhaps classed as scientifically literate but take notice of science information and activities only, or mostly, as they come into contact with them. These two types of individual could be called "actively scientifically literate" or "passively scientifically literate." Perhaps the passively scientifically literate are lacking motivation and empowerment.

This can easily be applied to health literacy. It would be important to provide opportunities and resources for those who are actively health literate, but, also, those who are passively health literate need to be empowered or motivated to actively seek out information, possibly by making the information personally relevant. This relevance may be linked to empowerment. A goal could be to have more actively health literate (and actively scientifically literate) individuals.

Bernhardt, Brownfield and Parker (2005, p.8) suggested that the motivation to receive and act on health information is related to a “perceived personal relevance of the information being presented.” This is related to the idea of working knowledge being gained because of a need or interest, i.e. a relevance. This can be applied to scientific literacy, both in terms of making school science more relevant (as suggested by Feinstein, 2011) and also encouraging people to be interested in, and get involved in, decision making about scientific issues. This was excellently described in terms of health literacy by Schulz and Nakamoto (2005):

> “being health literate therefore is not equal with propositional knowledge; it’s not just declarative and it is even more than procedural; it is procedural as it relates to the person. It almost is the person in an existential sense. It’s not only “what to do” but what doing something specific means for me “in my world” (Schulz and Nakamoto, 2005, p.6).

MODELS

As with definitions, it is possible to apply models from each field to the other. This is probably easier to do with the more uncomplicated models. For example, Shen’s (1975) model of scientific literature is relatively simple with three sections. It was suggested previously (Page 124) health literacy might fit into the category of practical science literacy. However, if the three separate categories are applied to health literacy, the following types of health literacy can be described:

Practical health literacy would involve practical skills and knowledge. For example, knowing when to visit a doctor, knowing where to look for information, understanding and following instructions on a prescription.

Civic health literacy would include being more aware of health issues in society and being able and willing to form an educated opinion on these issues. It would also cover personal responsibility in society with regards to health for example with regards to vaccination programs or the spread of colds and flu. Civic health literacy may also take in being able to understand the debate over privatisation in the NHS and what it means to individuals.

Finally Cultural health literacy would involve wanting to know more about health and advances in medicine from a personal interest rather than a need.

Kanasa and Nichols' A, B and C model of scientific literacy (2008) can also be applied to health literacy. The Affective domain would be concerned with things like attitudes to health, opinions, or what people value about health due to culture or social influences. The Behavioural domain would be about what people do in terms of their health, for example, to make decisions about their own wellbeing, like choosing to stop smoking. Finally, the Cognitive domain is a person's knowledge and skills about health, what they know. For example, knowing that they should eat five portions of fruit and vegetable each day, deciding what is better to eat, being able to know and understand health information.

In terms of models of health literacy being applied to scientific literacy, Nutbeam's (2000) model seems the most appropriate. His three levels seem to provide detail on skills that could be utilised for scientific literacy:

> "Basic/functional literacy—sufficient basic skills in reading and writing to be able to function effectively in everyday situations"
> "Communicative/interactive literacy—more advanced cognitive and literacy skills which, together with social skills, can be used to actively participate in everyday activities, to extract information and derive meaning from different forms of communication, and to apply new information to changing circumstances."
> "Critical literacy—more advanced cognitive skills which, together with social skills, can be applied to critically analyse information, and to use this information to exert greater control over life events and situations" (Nutbeam, 2000, p.264).

SPECTRUM AND CONTEXTS

There are fewer mentions of the ideas of a spectrum or contexts in health literacy research than in scientific literacy research. It may be useful to apply these ideas to some models/definitions of health literacy. It seems fair to assume that individuals will have different levels of health literacy and that their knowledge and skills will be in contexts of interest to them.

Zarcadoolas, Pleasant and Greer (2003; 2005; 2006) are among the few in health literacy research to recognise spectrums and contexts, they stated, "Health literacy like any other competency is on a continuum" (2006, p.55). If we take Zarcadoolas, Pleasant and Greer's (2003; 2005; 2006) model of health literacy and its four domains: fundamental literacy/numeracy; science and technology literacy; community/civic literacy; and, cultural literacy, each of these domains could be seen as having both a spectrum and contexts. For example, community/civic literacy includes "knowledge about sources of information". There will be individuals with a great deal of knowledge about where to find health information and those with little knowledge of information sources. There will be those who have knowledge of sources in one context but no knowledge in another context. For example, an individual may know reliable sources for information and advice about diabetes but not know where to seek information on back pain. Zarcadoolas, Pleasant and Greer (2006) seem to have been acknowledging spectrums and contexts in their model saying:

> "Literacy skill in one domain can contribute to developing literacy skill in another domain, and competencies in one area can compensate for a lack of competencies in another" (Zarcadoolas, Pleasant and Greer, 2006, p.55).

If health professionals were aware of the contexts that individuals have, they may be able to apply new information to these contexts. This awareness would fit with an asset-based approach (see below, Page 227). Just by recognising or being aware of the spectrum of health literacy and the contextual nature of people's knowledge could make a significant difference, especially in introducing new information to people. In other words, being aware of people's working knowledge and taking it into consideration. This is closely related to ideas discussed in terms of exhibit design (see Chapter 5, Page 147) and Roschelle's work on prior knowledge. In particular:

> "Educators should treat prior knowledge as a store of generative metaphors, not a collection of wrong theories. Prior knowledge is like a set of building blocks, and not an enemy fortress" (Roschelle, 1995, p.42).

As well as working knowledge, individuals' motivations are important when facing new information. Falk and Storksdieck (2010) found that science learning outcomes at a science centre were influenced by individuals' "identity-related visit motivation goals." In other words, what people learned at a science centre depended on their reason for visiting. For example, learning outcomes were different for someone who visited as, what Falk and Storksdieck called, a Facilitator (to help with the learning of others in their social group) and someone who visits as a Recharger (to relax and have a contemplative experience). When applied to a health setting it may be that people interpret health messages differently depending on their motivation for seeking the information. For example, someone recently diagnosed with an illness will have a different motivation to someone worried that they may develop an illness.

Working knowledge means that everyone is health/scientifically literate but on different levels across a continuum, and to complicate this, there is a continuum for all the different aspects of health/science and all the contexts that health/science is placed in. If everyone has a different level of knowledge and skills in different contexts, combining these skills and knowledge seems a powerful thing to do. The result being a community, or a public, that is high on the spectrum in many different contexts. The practical usefulness of this was described by Sihota and Lennard (2004, p.20), “People with the same condition can be a critical source of information, advice and support.”

This idea is discussed by some in the health literacy arena. For example, Pleasant and Kuruvilla (2008, p.153) mentioned “the diffusion and use of knowledge in society”, Freedman et al. (2009, p.448) stated one of the aims of their public health literacy is to “engage more stakeholders in public health efforts” and Chinn (2011, p.63) used phrases including, “collective action” and “social capital.” Sykes (2013, p.154) suggested that even empowerment “may exist at an individual level but may also demonstrate collective understanding and exist at a population or community level.” These ideas are not often seen in scientific literacy models but Graber et al. (2002) incorporated social competence in their model. This was defined as including “the ability to cooperate in teams in order to collect, produce, process or interpret – in short, to make use of - scientific information” (Graber et al., 2001, p.63).

This sharing of health/scientific literacy seems closely related to working knowledge and free-choice learning. A part of free-choice learning is the sharing of knowledge, ideas, beliefs, attitudes, opinions between friends and family, between doctor and patient. These ideas are not widely discussed in the scientific literacy arena and perhaps are an area of future research. A related idea comes from Shamos (1995) who, as previously discussed (Page 164) did not think being scientifically literate is necessary for the general public, that science is too difficult for everyone to be scientifically literate and that only 20% of the population need to be scientifically literate to make a difference. This could be seen as a proposal for a kind of collective action with the scientifically literate 20% sharing their knowledge and skills with the other 80%. Of course from the point of view of working knowledge everyone would have some part to play in a collective action, or sharing of knowledge. The basic definition of working knowledge tells us that everyone has some working knowledge of science:

> “each individual in a community is likely to have a different science knowledge repertoire; a level of science understanding determined by his or her specific needs, abilities and socio-historical context” (Falk, Storksdieck and Dierking, 2007, p.458).

In practical terms it might be difficult to imagine how a scientifically literate community, or health literate community, would work. It is difficult to suggest what kind of infrastructure would be required for the successful sharing of working knowledge. The increasing use of social media could provide a ready-made infrastructure. However, although it may appear so, the use of social media is by no means ubiquitous, especially in places where we may expect to find low health/scientific literacy. Another infrastructure would need to be applied otherwise inequalities would become apparent. In terms of health literacy especially, it is inequalities that we are trying to avoid.

Alternative mechanisms for sharing working knowledge may already exist in the area of Public Engagement with Science (PES). There are many models of engaging with the public already in use, Rowe and Frewer (2005) list over 100 but state “there are undoubtedly more” (p.256). These include, for example: focus groups; citizens' juries; consensus conferences; stakeholder dialogues; and, community forums. In an attempt to classify these mechanisms of engagement Rowe and Frewer (2005, Fig.1, p.255) described three types of public engagement based on the direction of the flow of information. This classification doesn’t include a type of engagement in which the information flow is directly from public to public, as seen in the sharing of working knowledge between friends and family in this current study (see Chapter 5). This disregard of public to public communication is hinted at by Stilgoe, Lock and Wilsdon:

> "in trying to institutionalise or 'tame' public engagement activity we risk ignoring or discounting places outside of the formally mandated engagement processes where publics do, or wish to, engage with science, technology and innovation" (Stilgoe, Lock and Wilsdon, 2004, p.10).

Perhaps engagement mechanisms need to be widened to include those that do not involve a sponsor or institution, unless in a more facilitatory role, for example by providing space for people to meet. This type of engagement may fall into what Davies et al. (2009) call "non-policy dialogue events." If these events meet their objectives they are "spaces enabling diverse cultures to come together, articulate positions and views, and interact in a context of genuine equality" (Davies et al., 2009, p.347). This sounds like the successful sharing of working knowledge.

A more recent development in PES has been the increasing use of the idea of responsible innovation (Stilgoe, Lock and Wilsdon, 2014). Responsible Innovation, RI (or Responsible Research and Innovation, RRI) has been simply defined as: "Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present" (Stilgoe, Owen and Macnaghten, 2013, p.1570).

The approach of RI has similarities to PES and has been described as being how,

> "science and innovation are envisaged as being directed at, and undertaken towards, socially desirable and socially acceptable ends, through an inclusive and deliberative process" (Owen, Macnaghten and Stilgoe, 2012, 753).

RI is a relatively new and still developing concept with "ambiguity as to motivation, theoretical conceptualisation and translation into practice" (Owen, Macnaghten and Stilgoe, 2012, p.754). Perhaps in practice its processes will allow for the sharing of working knowledge among the public as well as to and from policy makers and scientists. Indeed this is included in the development of a framework for RI by Stilgoe, Owen and Macnaghten (2013). They suggest their framework as "a way to guide governance developments in order to enable social learning and empower social agency" (Stilgoe, Owen and Macnaghten, 2013, p.1577). Social learning could include the sharing of working knowledge and social agency could encourage free-choice learning.

FREIRE

It is relevant to mention that the work of educational philosopher Paulo Freire has been written about in both fields. However, the application of his work seems to have a different emphasis when discussed in scientific literacy and then in health education.

In scientific literacy, Santos (2009) applied Freire's ideas to look at political and social sides of science that lead to inequalities. He said, "For Freire, it is not enough to show students how science is present in daily life; it is necessary to show the contradiction of this presence in society" (Santos, 2009, p.370). He argued that scientific literacy should not just be about equipping students with the knowledge and skills to cope with new technologies, it should also include the sociopolitical side that is to do with the inequalities due to new technologies. For example:

> "beyond identifying chemical products in garbage, or the separation methods adopted in the recycling plant, it is necessary to discuss why there are people in our society living in landfills" (Santos, 2009, p.370).

Somehow the idea of inequality in society seems to fit more readily to health literacy. This is probably due to the fact that inequalities because of health literacy have been discussed in the literature (for example, American Medical Association, 1999; Institute of Medicine, 2004; Weiss, 2005; Zarcadoolas, Pleasant and Greer, 2006) and health inequalities are discussed in politics and in the news.

In comparison, in health education, Wallerstein and Bernstein (1998) took Freire's work and looked at the perspective of Empowerment Education. Empowerment and motivation have been discussed in other health literacy research (for example, Nutbeam, 1998 and Tones, 2002). Wallerstein and Bernstein discussed Freire's empowerment education as involving:

> "people in group efforts to identify their problems, to critically assess social and historical roots of problems, to envision a healthier society, and to develop strategies to overcome obstacles in achieving their goals. Through community participation, people develop new beliefs in their ability to influence their personal and social spheres" (Wallerstein and Bernstein, 1998, p.380).

This fits with collective action and social capital discussed above (Page 220-2). Additionally, both Santos (2009) and Wallerstein and Bernstein (1998) discussed Freire's work in ways that are closely related to working knowledge. Wallerstein and Bernstein (1998, p.381) talked about context, "Freire's central premise is that education is not neutral and takes place in the context of people's lives." They also alluded to asset-based ideas suggesting that education should "invite people to believe they have the knowledge" (Wallerstein and Bernstein, 1998, p.380). Also, Santos (2008) could have been referring to how working knowledge can be formed because of an interest or a need when he wrote, "For Freire, human interest comes before knowledge" (Santos, 2008, p.367).

Freire himself (1974) provided ideas that fit with working knowledge and free-choice learning. For example, "Transcending a single dimension, they reach back to yesterday, recognise today, and come upon tomorrow" (Freire, 1974, p.3) is similar to how working knowledge is developed over time through new experiences and learning, as is the following description:

> "Inheriting acquired experience, creating and recreating, integrating themselves into their context, responding to its challenges, objectifying themselves, discerning, transcending, men enter into the domain which is theirs exclusively - that of History and Culture" (Freire, 1974, p.4).

Freire's ideas could also be seen as suggesting skills for lifelong learning, especially when he proposed: "An education of "I wonder", instead of "I do" (Freire, 1974, p.32), and the following description of what an education should provide:

> "The education our situation demanded would enable men to discuss courageously the problems of their context; it would arm men of the dangers of the time and offer them the confidence and the strength to confront those dangers instead of surrendering their sense of self through submission to the decisions of others. By predisposing men to reevaluate constantly, to analyse "finding," to adopt scientific methods and processes, and to perceive themselves in dialectical relationship with their social reality, that education could help men to assume an increasingly critical attitude toward the world and so transform it" (Freire, 1974, p.30).

Notably, Santos also suggested a role for the Freirean perspective that may be one way of bridging formal and free-choice learning. It is similar to the suggestion by Feinstein (2011) (see Page 174) of making science in school more relevant. Santos suggested:

> "Freirean science education ought to take SSI (socioscientific issues) as the goal of attaching social meaning to science contents, and of helping students understand the oppressive context of modern society" (Santos, 1998, p.374).

He later added that a Freirean perspective would use inequalities in access to technology as a way to reinforce science education:

> "if teachers could reinforce the role of science education in discussing inequitable access to the technological benefits around the world, they may start to introduce a Freirean view to science education" (Santos, 1998, p.378).

Perhaps inequalities in health, and access to medicine could be used as a bridge in this way. To both reinforce science education but also to affect scientific and health literacy.

RESPONSIBILITY

The models in the scientific literacy field are seen to increasingly recognise the importance of free-choice learning, yet heath literacy seems to be lagging behind in this. This is despite how the importance of free-choice learning to health literacy is underlined by the fact that "social and education levels have little relationship to health literacy" (Speros, 2005, p.638). There is mention of formal education and mention of health education in the health literacy arena, but it is not clear where exactly health education lies, is it in formal or free-choice or both? The situation is complicated further when it is suggested that the responsibility for health literacy lies with the health system. It could easily be argued that the health system is part of the free-choice learning arena, as it is a place where working knowledge is gained. Generally, the health literacy research is not clear as to where the responsibility for health literacy lies. It was suggested that formal education is not enough:

> "many, if not most, students who graduate from high school do not have a sound understanding of the anatomy, physiology, and etiology of the diseases that they are likely to encounter..." (Weiss, 2005, p.38).

Some gave the responsibility to public health education: "The ultimate goal of public health communication and education is to advance the public's health literacy" (Zarcadoolas, Pleasant and Greer, 2003, p.120). Yet, others suggested health education itself needs to change:

> "If achieving health literacy as defined by WHO is to be a goal, some rediscovery of the importance of health education needs to occur, together with a significant widening of the content and methods used" (Nutbeam, 2000, p.267).

Perhaps the starting point is to recognise that the responsibility must be shared:

> "efforts should be made to promote the incorporation of public health literacy into health literacy programs, formal education systems, and informal educational networks" (Freedman et al, 2009, p.450).

This is supported by the recommendations resulting from the European Health Literacy Study that include: "health literacy is strengthened at personal levels through focus on enhancing life competencies at school, at work, at the market place and in the political arena" (The HLS-EU Consortium, 2012, p.4) and "relevant stakeholders such as governments, the private sector, and the civil society make collaborative efforts to advance health literacy in Europe" (The HLS-EU Consortium, 2012, p.4).

The Institute of Medicine (2004) came closest to including free-choice learning when they suggested three key sectors that should have responsibility for health literacy: culture and society; the education system; and, the health system. Culture and society is where free-choice learning lies, it should also be included in the education system and the health system could be included in free-choice learning. In scientific literacy, the work that could compare to this is that of Liu (2009). He saw formal and informal education as a continuum and also suggested that science professionals have a part to play in scientific literacy.

For both science literacy and health literacy, it could be suggested that there are three sectors involved: formal; free-choice learning; and, professionals. Having three inputs into scientific or health literacy may seem better than placing the responsibility on one, as it means there are more resources and more opportunities. However, it may be better to view the three sectors as one and to try to provide bridging between them. An individual's working knowledge is not in isolation and is gained from all three sectors.

It is an important point to make that the sole responsibility for health literacy cannot lie with health professionals. Many of us spend very little time interacting with the health sector and so it has very little influence over personal skills. If health literacy was to be the sole responsibility of the health sector, then only those who have been ill and needed to interact with the health professionals will have any health literacy. It may not be possible to quantify but it would be interesting to make an attempt at discovering who is currently doing the most to improve/affect health literacy and scientific literacy.

RISK V ASSET

Nutbeam (2008) introduced an interesting perspective to the question of who is responsible for health literacy. He suggested two models of health literacy, one as a risk and one as an asset. As a risk, poor health literacy is seen as a problem that needs to be dealt with by health providers. As an asset, health literacy is seen as a set of skills that allow people to make better decisions about their health, and to have more control over their health. Yet it is not clear where the responsibility lies for providing these skills.

Similar terminology, “deficit”/”asset”, has been used by researchers in the public understanding of science area, but with slightly different meaning. From one perspective the public’s understanding of science (scientific literacy) is seen as a deficit, a risk. The scientific community see the public as not knowing what they need to know about science. Jenkins (1994) described the deficit model of scientific literacy as:

> “a research methodology that relates scientific literacy to what the scientific community believes should be widely known and appreciated, rather than to the scientific knowledge and understanding that lay citizens regard as significant in addressing their everyday concerns” (Jenkins, 1994, p. 5348).

Liu (2009, p.305) described the deficit model as ignoring “the fact that students and the general public do have a wide variety of informal knowledge and experiences about natural and life phenomena.” The alternative perspective is to see the public as having some level of scientific literacy (understanding of science) and to view this as an asset, to be built on. This “asset” perspective fits with the idea of working knowledge. Turner’s (2008) description of the asset-based approach as the contextualist paradigm is almost a definition of working knowledge:

> "it considers attitudes toward and understandings of science to be shaped primarily by individual's local experiences, real-life experiences with technology and with experts, and particular needs, expectations and culture" (Turner, 2008, p.57).

The asset perspective is also closely related to Pardo and Calvo's Specialisation thesis (discussed in Chapter 6, Page 169) and the ideas of spectrum and contexts in scientific and health literacy (see above) as well as prior knowledge, for example:

> "Almost all data begin from identifying learning failure. If we start, on the other hand, by identifying success and then investigating the concepts that enable success, we find an equally strong role for prior knowledge. Prior knowledge is properly understood not as a cause of errors or success but rather as the raw material that conditions all learning" (Roschelle, 1995, p.41).

For both research areas, the importance of working knowledge, as supported by the results in this thesis, suggests that an asset-based approach could be more appropriate. So not only trying to improve health and scientific literacy but improving the communication of information and activities from providers.

FUTURE-PROOFING

As discussed previously, science and health/medicine are dynamic fields. Ongoing research and development mean that any factual or conceptual knowledge gained through formal education can go out of date. Indeed, part of scientific and health literacy should be recognising that these changes occur. As Zarcadoolas, Pleasant and Greer (2003, p.120) pointed out, "an understanding that scientific uncertainty is to be expected and that rapid change in the accepted science is possible."

Furthermore, the interests and needs of individuals change throughout their lifetime and so skills for acquiring knowledge may be more important than the knowledge itself. Roth and Calabrese Barton (2004, p.10) described this clearly in terms of scientific literacy: "Scientific literacy in everyday community life means to be competent in finding whatever one needs to know at the moment one needs to know it." This corresponds with Miller's (2010, p.204) description of how adults are increasingly seeking information "in a just-in-time mode in response to a perceived need."

As well as skills for acquiring knowledge, skills for applying, or adapting, existing knowledge could be important. Collins and Evans (2007) included this in their concept of expertise as “referred expertise.” They described this as “the use of an expertise learned in one domain within another domain” (p.15). However they do say that this idea needs further consideration, “What exactly is referred expertise and how does it work? (p.141).

Many health literacy models and definitions seem to have allowed for this as they tend to include skills more than knowing facts and concepts. For example, Ratzan and Parker (2000) included the skills “to obtain, process, and understand basic health information.” Or, Nutbeam (1998) included skills “to gain access to, understand, and use information.” These are the sorts of skills that would be useful for lifelong learning (and free-choice learning) in any area, and it has been suggested, particularly in the scientific literacy field, that schools should have the responsibility for providing these skills.

There are fewer mentions of lifelong learning, or future-proofing, within health literacy research, but there are some examples. St. Leger (2001) talked about lifelong learning skills being provided in schools in order to cope with changes due to life events.

Zarcadoolas, Pleasant and Greer importantly suggested that when people are actively seeking out health information, because of an interest or a need, the opportunity should be taken to improve health literacy: “Moments such as the anthrax attacks are when the public actively seeks information, creating real opportunities to improve health literacy” (Zarcadoolas, Pleasant and Greer, 2005, p.195), and again: “Advancing an individual’s or public’s health literacy should be a central function of health promotions, education and communication” (Zarcadoolas, Pleasant and Greer 2006, p.287).

The same should of course apply to scientific literacy. When a science story is headline news, a recent example would be the work being done at the Large Hadron Collider, efforts should be made to improve scientific literacy. It makes sense to build on people’s interest in a subject when this interest is at a peak, when they are likely to build on their working knowledge through free-choice learning. The question is, how would this be done and who would be responsible?

In relation to adult learning Miller (2010) describes these opportunities as “teachable moments” and describes how informal science educators should go beyond simply providing answers to a problem:

> “the problem being answered is an opportunity to provide understanding of the broader scientific constructs that are needed to make the individual more self-sufficient in the future” (Miller, 2010, p.202).

In terms of health literacy, there is an effort being made to do this by an NHS website called “Behind the Headlines”. The health and medicine stories making the news are explained alongside the scientific articles behind them with the aim of giving “a better understanding of the science that makes the news” (NHS Choices, 2014). Perhaps the most similar organisations in terms of scientific literacy are “Sense about Science” and the “Science Media Centre”. Sense about Science is “a charitable trust that equips people to make sense of scientific and medical claims in public discussion” (Sense about Science, 2015). The Science Media Centre describes itself as:

> “an independent press office helping to ensure that the public have access to the best scientific evidence and expertise through the news media when science hits the headlines” (Science Media Centre, 2014).

However it is not aimed directly at the public and instead acts as an intermediary between the public and journalists, scientists and press officers.

MEASUREMENT

Although not reviewed here, there are numerous proposed ways in which to measure both health and scientific literacy. From the discussion in the previous chapters of the spectrum and contexts of these literacies it may be conceded that they are immeasurable. However, health literacy perhaps provides an interesting idea in measurement in that it could be assumed that those with better health literacy would be in better health. Or, to include the idea of contexts, those who are health literate in a particular context are healthier in that aspect. Of course, this is much too simple a measurement as many other factors are involved, and just because a person is health literate, does not mean they will have good health. Being health literate will not prevent you from having an illness, but it will help in making decisions that will affect how you deal with the illness and how you deal with advice given to you, or where you take information from.

This concept does present some interesting ideas for research though, and also could be applied to scientific literacy: Would a person who is more scientifically literate about energy use and the environment use less energy than someone who isn't? Would an individual who is scientifically literate in physiology and/or nutrition be more physically fit than someone who isn't?

There is also the argument put forward that although health literacy is difficult to measure, and low health literacy difficult to identify, the problem should be tackled with "universal precautions" (Lurie and Parker, 2007, p.S6). In other words, forget about trying to measure something that may be immeasurable and concentrate on overcoming the problems. Of course, this applies to scientific literacy as well.

OUTCOMES

The benefits and outcomes of being a scientifically literate individual, and of a scientifically literate society have been discussed in the literature review (Page 46) as having economic, political, cultural and personal aspects. In the health literacy field, it is the personal aspects that are highlighted more often. For example:

> "findings from various studies demonstrate that individuals with limited health literacy have less health knowledge, lower health status, higher utilisation of health services, and higher health costs than their more literate counterparts" (Weiss, 2005, p.23-24).

However, it is clear that if people are more health literate, there would be both economic and social benefits to society.

SUGGESTIONS FOR FUTURE RESEARCH

The above analysis of the previous two chapters has provided some ideas for future research and questions to be answered. These are now summarised below under key headings.

SKILLS VERSUS FACTS

In this and previous chapters it has been discussed how a list of facts or concepts that an individual needs to know in order to be health or scientifically literate is inappropriate. As medicine and science are dynamic fields and continually developing, concepts change and knowledge grows. In addition, the spectrum and contexts caused by the individual nature of working knowledge mean that everyone will have different conceptual knowledge anyway. So it is suggested that skills are more important than facts. However, what are the most important skills? Is there a spectrum of these skills and can they overarch all contexts? Can these skills be investigated empirically? These are questions for future research. Also, can these skills be used as a way to measure or quantify scientific or health literacy? It has been suggested that (Page 230-231) scientific and health literacy may be immeasurable, but could skills be measured, and individuals placed on a spectrum?

MOTIVATION AND EMPOWERMENT

There are more references to motivation and empowerment in health literacy models and research than in scientific literacy. In fact, Tones (2002) suggested that health literacy has now moved so far away from its original idea that “the term has become almost synonymous with the concept of empowerment” (Tones, 2002, p.289). It would be of interest to add the elements of motivation and empowerment to more models and definitions of scientific literacy to see how they adjust.

The idea of there being active and passive health and scientific literacy could be looked at further. Do these two distinct categories exist? If so, how can they be accommodated by those supplying science/health information, including free-choice learning providers? Are people more active in seeking health information and more passive with regards to science information?

In both areas of research work could be done to investigate where motivation and empowerment come from. For example, are they skills that could be taught in formal education? Also, it would be useful to understand the relationship between working knowledge, free-choice learning and empowerment and motivation. Not just the motivation to gain knowledge through free-choice learning but the empowerment to use it.

SPECTRUM AND CONTEXTS

The scientific literacy field has started to include spectrum and contexts in models and definitions. However, there seems to be a need for increased recognition of this in the health literacy arena. In other words, more awareness of the fact that every individual has a different level of knowledge and skills relevant to health literacy and these are placed in different contexts. As suggested above, this would fit with an asset-based approach and could make a difference when people are being introduced to new health or medical information, whether in treatment or prevention. The addition of spectrum and contexts to definitions and models of health literacy could assist this.

Significantly, the existence of spectrum and contexts provide evidence for the importance of free-choice learning and working knowledge. Any further work on spectrum and contexts would benefit free-choice learning providers.

COLLECTIVE ACTION

The existence of spectrum and contexts and everyone having different working knowledge fits with ideas such as collective action and social capital. These are discussed more in the health literacy arena but both areas could benefit from more work on this. As Zarcadoolas, Pleasant and Greer (2003) explained:

> "investigating how health communication and education, individual capacities, and social processes interact to create health literate citizens is exciting and important. Broadening the lens through which we investigate these complex abilities is the next step in learning how health literacy develops and can be fostered" (Zarcadoolas, Pleasant and Greer, 2003, p.120).

Research from other areas in community learning, including Freire's Empowerment Education, could provide ideas on how sharing of health and scientific literacy would work. For example, Minkler and Cox (1980) applied Freire's philosophy to a health care setting and suggested that common interest groups or communities could be the units that could bring about social change in the health field. It may be of interest to look at how working knowledge is shared in a waiting room, or in other settings where people with similar health issues come together. More specifically, Tardy and Hale (1998) looked at a mothers' and toddlers' group as a "informal, interpersonal network" and found that informal networks do shape people's perceptions of how and when to access health services. They importantly suggested ways for health service organisations to utilise these informal networks to provide health information, guidance and support. The suggestions include: providing representatives to visit groups; providing training or education for "opinion leaders" within the networks; providing facilities for the groups; obtaining feedback on services from the networks.

It seems clear that these suggestions could be applied to the area of science communication. Individual researchers, organisations or free-choice learning providers could make use informal networks through these suggestions. That is not to say that this does not already taking place in both health and science areas. Indeed, the BodyWorks exhibition used in this study is taken out to community groups and events. However, some newer, less obvious networks could be made use of, for example, mums and toddlers groups, or home educators.

The importance of collective action and the contexts in which people's working knowledge exists has been recognised in parts of the science communication literature. The value of sharing working knowledge seems to have been noted by Wynne (1991):

> "Organisation allows more comparison of experiences and expert accounts, more accumulation of alternative perspectives and questions, and more confidence to negotiate with or challenge imposed frameworks" (Wynne, 1991, p.15).

Wynne and Irwin (1996) describe a "citizen-oriented" perspective on the Public Understanding of Science which "requires considerable sensitivity to the knowledges and understandings possessed by citizens within specific situations and contexts" (Wynne and Irwin, 1996, p.11). They go on to describe how successful the building of social capital and use of collective action can be saying:

> "public groups effectively renegotiate the boundary between science and the public as they come to take responsibility for aspects of knowledge previously taken for granted as the domain of science or medicine" (Wynne and Irwin, 1996, p.13).

The strength of social capital is reiterated by Irwin, Dale and Smith (1996) whose "local knowledge" or "local understandings" seem equivalent to shared working knowledge being built into social capital. They state that local understandings

> "may well represent a more robust and well-tested body of advice, information, and practical assistance than any new or externally generated piece of technical advice" (Irwin, Dale and Smith, 1996, p.55).

Indeed, science communication research provides us with powerful examples of groups and networks utilising social capital for collective action. This includes Wynne's work with Welsh sheep farmers (e.g. Wynne, 1989) and also Epstein's work with AIDS activist groups (e.g. Epstein, 1995; 1996).

Free-choice learning itself could be seen as a collective action or sharing of knowledge. Much working knowledge is gained from other people, especially friends and family. What is the exact role of free-choice learning in social capital? Does the free-choice learning infrastructure (including, museums, libraries, science centres, community groups) provide a starting point for an infrastructure for collective action in science and/or health? How would we create a scientifically literate (or health literate) community?

An interesting argument for looking at health literacy on a community scale, which could easily be applied to scientific literacy, was put forward by Lurie and Parker (2007). They suggested that resources for health literacy could be allocated to communities most in need, in a similar way to how "rates of crime are used to allocate law-enforcement resources" (Lurie and Parker, 2007, p.S6). Although they suggested health literacy is based on education and income, perhaps the resources could be focused simply in areas of poor health.

RESPONSIBILITY

In both areas is not clear where the responsibility for providing the specific literacy lies. From the perspective of this thesis, the importance of free-choice learning cannot be ignored. It has been seen that scientific literacy research is increasingly recognising the importance of free-choice learning and this should also be considered in health literacy. As discussed (Page 226), future work should look at how formal education and free-choice learning can be bridged. Ideas for this have been provided by Santos (2009) and Feinstein (2011) based on making science education more relevant to everyday lives of pupils. Further practical solutions to bridging the gap between free-choice learning and formal education need to be found. In particular, ways of giving more recognition to free-choice learning and working knowledge in formal education.

Schools may not only have the responsibility in terms of scientific and health literacy to provide skills for the future, they are also producing students with the ability to become communicators of health and science. This was described in terms of health literacy by Lurie and Parker (2007, p.S7) who said, “equipping students to serve as an intergenerational resource to parents and grandparents.” This could also apply to scientific literacy.

FUTURE-PROOFING

The idea of schools (formal education) providing skills for lifelong learning (free-choice learning) has been considered as a possible bridge between formal education and free-choice learning. This is mainly from the scientific literacy perspective but is included in health literacy in the form of health promoting schools. Perhaps the health literacy arena should consider this further. For both areas though it is important to work out exactly what skills are required for lifelong learning and how these can be developed at the same time as providing a grounding in science and health.

Paasche-Orlow and Wolf (2007, p.S21) provided some clues as to what skills might be needed for health literacy in their attempt to map causal pathways between limited health literacy and health outcomes. Skills that they have included as “Patient factors” could include skills for health literacy (or indeed scientific literacy) these are: navigations skills; self-efficacy; knowledge/skills; beliefs; participation in decision-making; motivation; and, problem solving.

More recently, Sykes et al. (2013) carried out a systematic review of Nutbeam's (2000) concept of critical health literacy, which revealed what some of the skills required may be. The skills included:

> "advanced personal and social skills, self efficacy and interpersonal skills." "the ability to access, manage, assess the credibility, understand and critically appraise information on health related issues" and also, "being able to contextualise information, apply it to one's own situation, judge risk, act on information and thus share the decision making with health professionals" (Sykes et al., 2013, p.154).

Work on how to make use of people's interest in science and health to improve scientific/health literacy would also be beneficial. Again, it is unclear how this would work and, perhaps more importantly, who would have responsibility. Although, if people had developed skills for free-choice learning from their time in formal education, they may be empowered to make use of their own interests and needs to improve their health/scientific literacy.

Combining the empirical research on free-choice learning and working knowledge with the theoretical reviews of scientific and health literacy may provide answers to some of the questions raised above, or at least point us in the direction of where to find the answers.

IN THE NEXT CHAPTER...

... the findings of the empirical and theoretical research carried out are discussed together in terms of their implications for various groups.

CHAPTER 9 – WHAT DOES THE WORK PRESENTED HERE MEAN FOR RELEVANT GROUPS?

INTRODUCTION

This thesis set out from Falk, Storksdieck and Dierking's (2007) paper, titled "Investigating public science interest and understanding: evidence for the importance of free-choice learning" to look at the ideas of working knowledge and free-choice learning. A literature review led to the formation of four research questions. Two of these questions involved using Glasgow Science Centre's BodyWorks exhibits to investigate working knowledge and free-choice learning of science. The further two questions were determined in order to explore two closely related terms contributed by the literature review. One of these terms, scientific literacy, has an established body of research, which could be revisited with regards to working knowledge and free-choice learning. In addition, scientific literacy connected with the idea of health literacy, which was relevant to the content of the BodyWorks exhibits, as well as free-choice learning and working knowledge. Therefore, the research questions of the study were set out as follows, the first two being empirical in nature, the second two theoretical:

1. can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?
2. can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?
3. what can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?
4. can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

Before the findings from these questions are reviewed and discussed in terms of the implications they may have for various groups, it is important to describe some limitations of this work. The limitations of the methods used in this study, and the steps taken to overcome them have been discussed in Chapter 4. In particular, the use of staff diaries as an additional data collection method was intended to go some way to overcoming limitations including: the difficulty participants may have in articulating their thoughts in interview; any interviewer bias; pressure to say the “right thing”; and, to allow some data to be collected from schoolchildren. The diaries were also intended to contribute to triangulation of results. Unfortunately, due to changes in staff during the data collection period, the diaries were not as useful to the study as they could have been. Nevertheless, some rich data were obtained and analysed as part of the results and, as such, this data collection method would be recommended for use in further work. In addition, the staff members found the diary keeping useful in supporting their communication with users, and the management saw them as a helpful staff development tool.

There are two other issues that have arisen during the completion of this thesis that should be considered. These relate to the content of the BodyWorks exhibition and the problems associated with the terms used throughout the thesis.

A note with regard to the use of the BodyWorks exhibition

It should be reiterated at this point that the BodyWorks exhibits were not chosen by the researcher for this work. The funding for this PhD work was part of the overall funding for the development and delivery of the BodyWorks exhibits which was provided by GlaxoSmithKline. Therefore the research questions were developed around, and made use of, the BodyWorks exhibits. The potential problems with the funding of the research has been discussed previously (see Page 74).

The use of the BodyWorks exhibits for this research has had advantages and disadvantages. These have mainly been due to the content of the exhibits focusing on the theme of health but have also been related to the aims of the exhibition and the fact that the exhibits were intended for outreach activities in the community and in schools. The issue with the aims of the exhibits is discussed in detail in Chapter 5 (Page 145). In brief, the exhibits were designed to meet aims which were to do with schools and their curriculum, yet the exhibits were often used in the community for a varied audience of adults and children. This allowed this research to investigate adults’ free-choice learning and working knowledge as well as collecting some data from children. However, it must be noted that the exhibits were aimed at school-aged children (see Appendix 8).

The fact that the exhibits were used for outreach activities provided the advantage that those interviewed were from a general public with varied interest and knowledge. When the exhibits were used in the science centre those interviewed were from a self-selecting group. They had chosen to visit the science centre, and to pay to visit, so it may be argued that they were showing an interest in science (see Page 90).

The fact that the BodyWorks exhibition was based around health topics was both a benefit and a limitation to this research. One benefit was that it provided a clear advantage in providing data as most people have some knowledge of, or interest in, an aspect of health, in particular of their own, friends or relatives health. Therefore the majority of people interviewed were able to relate to the content of the exhibits on a personal level.

A further benefit of the content is that it has introduced the idea of health literacy to the thesis. This has allowed comparisons to be made with scientific literacy and for best practice to be shared between the two areas. It has also meant that the results can be applied to a health setting and discussed as implications for health education or promotion (see Page 275).

The main limitation of the content of BodyWorks is that other topics may produce different patterns of results. For example, if the data had been collected following interactions with an exhibition on astronomy, it may be presumed that fewer people would have a working knowledge of this topic. However, it could be argued that a well designed and developed exhibition would offer connections to people's working knowledge no matter what the topic being communicated. The connections made with other topics and exhibits could be investigated using the same data collection techniques as this study. This is the most obvious next step in this research and the topics investigated need not be limited to those in science. As suggested (Page 149) this type of data collection could form part of a formative evaluation of an exhibition in order to refine its content (this is discussed again later, Page 258).

A note with regard to terms

Throughout this thesis we have repeatedly come across the problem of a lack of consensus. This included a lack of consensus on: terms regarding learning in and outside of school (Chapter 2); definitions and models of scientific literacy (Chapter 6) and health literacy (Chapter 7); definitions of learning (Chapter 3); and, theoretical frameworks for studying out of school learning (Chapter 3). At this point it is necessary to again address any confusion concerning the terms investigated in this thesis: free-choice learning and working knowledge.

This thesis took as its starting point an article by Falk, Storksdieck and Dierking (2007) where the researcher first found the terms free-choice learning and working knowledge ("Investigating public science interest and understanding: evidence for the importance of free-choice learning.") Falk's original definition of free-choice learning being:

> "the type of learning that occurs most frequently outside of school; in particular, free-choice learning refers to the type of learning typically facilitated by museums, science centers, a wide range of community-based organizations, and print and electronic media including the Internet" (Falk, 2001, p.6).

Working knowledge being the knowledge gained as a result of free-choice learning.

As free-choice learning is a new term, without much previous work to review, this thesis has looked at work in similar areas. As free-choice learning typically takes place outside of school or work in an informal setting, in an informal way, research on informal learning has been included. However, it is not always clear if this work has been referring to the setting or the process of the learning.

As discussed in the literature review, the term free-choice learning appeared more appropriate, perhaps more up-to-date than the more established informal (or nonformal) learning. The most significant problem with the term informal learning is that it is often not clear if the learning is taking place in an informal setting or by an informal process, or both. Free-choice learning has less ambiguity; it can take place formally or informally in an informal or formal setting; although, it is expected that the vast majority of free-choice learning takes place away from formal education settings such as schools and colleges. There are of course exceptions, for example, a student may choose to read beyond a subject in school, a person may take an Open University course out of interest. The key factors for free-choice learning are therefore not where or how the learning is taking place, but why and what learning is taking place. Why learning is taking place will always be because of personal reasons, because of an interest or a need. What learning is taking place will always be free of curriculum or external goals, it will be because of a person's own personal agenda. The key element of free-choice learning is that the learner is in control. So perhaps the term is useful because free-choice learning can occur through informal or formal processes in an informal or formal setting. In other words, it can cross the barriers of informal and formal, in some cases even connecting the two.

If we consider there to be a continuum for where the learning is taking place running from formal to informal, we expect most free-choice learning to take place toward the informal end of the spectrum. If we also add a continuum for how the learning is taking place from formal to informal, again we expect free-choice to be mostly towards the informal end. Looking at this visually (Figure 9.1), and including where we would expect most of formal, or school, education to be, we can see a small overlap. It may be that by increasing this overlap bridging can occur and connections between free-choice and formal can be made and strengthened, and learning can be seen as a whole.

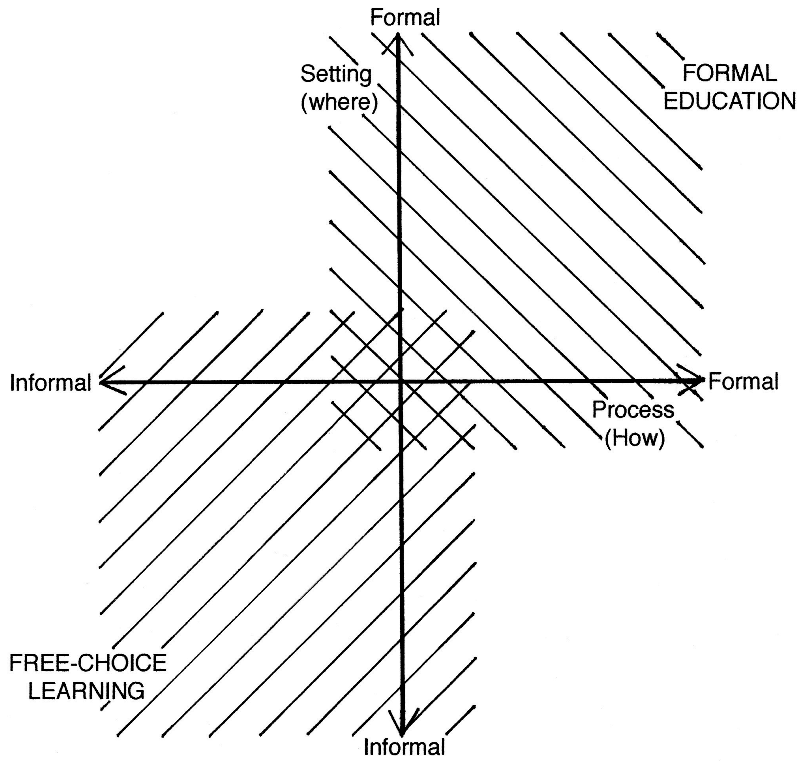


Figure 9.1 - Visual representation of informal, formal and free-choice learning.

Despite setting out to investigate the ideas of working knowledge and free-choice learning, throughout the writing of this thesis the suitability of these terms has played on my mind. Even with initial interest in these new terms, there are a few reasons that make them less than ideal and perhaps unnecessary.

Working knowledge has been a useful term for this work as it provided a term to specify aspects of knowledge that were gained through free-choice learning. However, there are many overlaps between an individual's working knowledge and knowledge gained in formal education. Separating these is useful for investigation but it may also be a barrier to the bridging of free-choice and formal. If the aim is to connect free-choice and formal, separating the knowledge gained by the two takes them further apart. Also, thinking literally, the term working knowledge could be thought of as knowledge gained through work or while working something out, or knowledge that can be applied to a certain problem or situation. This adds to confusion in an already confusing field.

With regards to free-choice learning, throughout the course of this research, both empirical and theoretical, a point has repeatedly returned to mind. If we take the literal meaning, what learning is actually *free*-choice? The term itself suggests a learner chooses what and where to learn to suit their needs and their interests; they are free to learn as they choose. Despite free-choice learning emphasising that the learner has control over the learning, there will almost always be an external control over what they learn. However, from the interpretivist position of this research the *free*-choice comes from the individual's own personal interpretation of the information presented.

For example, in this study participants used the BodyWorks exhibits and it can be said that they took part in a free-choice learning activity. They chose to use the exhibits and chose how to interact with the exhibit and its written material. However, it was a team of developers and science centre staff that chose the content and aim of that exhibit and what message to try to put across. So can this really be considered free-choice of the participant? Perhaps learning can be considered more free-choice when, for example, an individual chooses to find out more about a topic by reading a book, searching the Internet, or watching a TV programme. But, the content of the book was decided by the author, the message from the webpages decided by a writer and designer, and the aim and narrative of the TV programme has been put across by writers, producers, presenters. Even by attempting to frame a communication to make it more relevant to individuals could be seen as influencing the free-choice nature of this learning. Yet, Nisbet and Scheufele (2009, p.1771) think that "it is a mistake to believe that there can be "unframed" information."

So maybe this learning is not free-choice. Perhaps it becomes free-choice when the learner is equipped with skills to not just take in the content and the message but to analyse, criticise, and form their own opinions of the content. It could be these skills, and their application, which give the individual ownership of that knowledge. Of course, the skills to do this are controlled by where we learn these skills and, more importantly, by our culture, our social network and even politics. So, again, maybe this learning cannot be described as truly free-choice.

The results of this study suggest that when a reason for learning was alluded to (Table 5.8, Page 124) it was mostly for leisure. This immediately suggests free-choice, but those mentioning computer games are not likely to have played the computer game for the purpose of learning, and those mentioning learning at a gym did not go to the gym with the aim of learning.

From the analysis of why free-choice learning was taking place (Page 124) there are potentially three types of free-choice learning. In one type, learning occurs almost as a by-product of an activity, the individual has not set out to deliberately learn or gain information. As Falk, Storksdieck and Dierking (2007, p.459) described as “some of what we learn we learn rather incidentally, without consciously wanting to learn.” In the second type of free-choice learning, individuals actively aim to gain information, or learn, because of an interest in something. The third type of free-choice learning involves actively seeking out information because of a need. That need could be to solve a problem, or to understand an issue. Only in the second type is the learning carried out as a completely free-choice.

Most importantly, there has been little take up of the term free-choice and most research continues with the older term informal learning. I cannot suggest a better term than free-choice or informal. However, the empirical research here shows that, whatever you wish to name it, learning outside of school is important, and the theoretical research on scientific literacy suggests the need for better bridging or links between out of school and in school learning. The confusing nomenclature can only be a barrier to the bridging. Perhaps the most direct step is to remove this barrier and simply describe everything as learning. Of course, this would not be a straightforward step. The simple solution would be for researchers to always be clear on which term they are using and their definition of that term. So for this thesis free-choice learning is:

> “the type of learning that occurs most frequently outside of school; in particular, free-choice learning refers to the type of learning typically facilitated by museums, science centers, a wide range of community-based organizations, and print and electronic media including the Internet” (Falk, 2001, p.6).

Working knowledge is the knowledge gained as a result of free-choice learning.

Reflecting on this thesis the main benefit from using the term free-choice learning has been to provide a different perspective and to bring together research that is usually located in separate fields. When informal learning is discussed it is often in reference to learning that has occurred as a result of an interaction with an organisation, including museums, the media, or community groups. Free-choice learning includes this but also takes in places and organisations not usually associated with learning. This was seen in the results of this study; for example, free-choice learning in the gym, at the doctor's or playing games. This type of learning is not often included in informal learning research. In addition, free-choice learning includes aspects of research in the areas of the public understanding of science and public engagement with science. Generally, public understanding of science and/or public engagement with science research is about what people know about science, how they engage with science and their attitude toward, or awareness of, science and scientists. Informal education research concentrates on research provided by organisations. Free-choice learning includes all of this as well as learning of science by individuals incidentally, or because of an interest or a need. The overarching of these areas may be the appealing advantage of free-choice learning as a term. This advantage suggests its use should be increased and taken forward in future research.

Despite the confusion and lack of consensus over terms, it remains clear that out of school learning is important and requires much further research and exploration. This thesis is part of this research and provides direction for further discussion.

The findings resulting from the research questions of the thesis are now discussed in terms of the implications that they have for: free-choice learning providers; the health system and health educators/promoters; formal education; and, society. Remembering that this study was based in the area of free-choice learning and because of this, and the researcher's background, implications for free-choice learning are the main focus and discussed in more detail.

REVIEW OF FINDINGS

Before discussing the findings in terms of their implications for associated groups, it is useful to summarise the key findings produced by each of the research questions during the development of the thesis.

1. Can the BodyWorks exhibits be used as a tool to provide of evidence of free-choice learning and working knowledge?

The data collection using the BodyWorks exhibits and the subsequent analysis of this data provided evidence for free-choice learning and working knowledge. It was found that the majority of participants (93%) showed evidence of taking part in free-choice learning when discussing the exhibits they had used during interview. 16% of participants mentioned work, 3% mentioned college, and 10% mentioned school. It was found that the majority of participants (98%) showed evidence of working knowledge when discussing the exhibits during interview.

In addition, although not setting out to look at people's self-perceived interest and knowledge in science, some useful data on this were obtained. As part of some structured questions, which had the purpose of easing participants into the interview, it was found that the majority of participants reported a higher level of interest in science than they did in being knowledgeable about science. When each participant was looked at individually, it was found that 78% of participants reported their interest in science as higher than their knowledge, only 3% reported a higher knowledge than interest, and 19% gave the same score for knowledge and interest. The fact that most participants (98%) showed evidence of working knowledge of science contradicts the self reported knowledge. In other words, people in this study may be more knowledgeable about science than they think they are, or report that they are.

2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?

The data analysis provided us with a better understanding of free-choice learning. In particular, data suggested where, how, when, with whom free-choice learning took place.

The results showed free-choice learning to be taking place in a range of places. Some of these places are clearly recognised as free-choice learning providers whereas others are not. This adds more confusion to the debate over terms. For example, should a science centre, that sets itself out as a free-choice learning provider and has learning amongst its aims, be seen in the same way as a games arcade, which most likely does not see itself as a free-choice learning provider? Similarly, how many doctors would see themselves as providing free-choice learning? So do we need more terms to recognise these differences? We could divide free-choice learning into coincidental and intentional free-choice learning. However, there will be cases where coincidental free-choice learning occurs in an intentional free-choice learning provider! This may add to the case for removing additional terms and seeing everything as simply “learning”.

This study did not provide clear results as to how the learning reported by participants was taking place. This is partly because of the range of sources of free-choice learning, from listening to a doctor, to playing a video game, to watching television. We should accept that there are many ways that people learn, partly due to where the learning takes place but also because of how the individual prefers to learn.

When a reason for learning was alluded to in this study it was mostly for leisure and secondly due to an interest in their own health or someone else’s. The interest in health is clearly due to the content of the BodyWorks exhibition, but the amount of learning taking place because of, or as a result of, leisure is notable. This suggests that people are gaining working knowledge through leisure activities. They may do an activity with the intention of learning or learning may be an aside to the activity. What is important is that people are learning during their leisure time, away from work or school.

The interest in health could lead to individuals actively seeking out information from the Internet, television or books; it is in these situations when skills for free-choice learning become most important. These skills include judging sources, analysing and evaluating information and making decisions.

Limited data were obtained with regard to with whom free-choice learning was taking place and further work may tie down more information on this. However, it seems reasonable to assume that just as there are a range of places and ways to learn, there will be people learning in a range of groups, with family or friends, and people learning alone.

A better understanding of working knowledge was gained using the BodyWorks exhibits. It was shown that working knowledge is not just what we know but also what we think and feel. Importantly, using the Annapolis proposal as a structure (described on Page 94), and considering how the exhibits increased the complexity of working knowledge, a better understanding of how people's working knowledge interacted with the exhibits was gained. The majority of participants (91%) showed evidence of increasing the complexity of their working knowledge by reinforcement when interacting with the exhibits. Fewer participants (28%) added to their working knowledge and fewer still (10%) showed evidence of change.

The study found that, when discussing the BodyWorks exhibits, understandings were mentioned most often, followed by perceptions, then facts and finally values. This pattern is likely to be different for other exhibits and activities and may depend on the aims set out in the design. This study looked at facts, understandings, perceptions and values, but working knowledge could also include skills, opinions, attitudes and behaviours.

3. What can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?

The results of the empirical research showed the importance of free-choice learning and working knowledge. Therefore it was useful to revisit the literature on concepts of scientific and health literacy to try to understand how working knowledge and free-choice learning are incorporated into these fields. One way of looking at how these terms fit together is that free-choice learning produces working knowledge, which makes up part of scientific literacy and health literacy. Or, alternatively, working knowledge is a big part of scientific and health literacy and it is provided by free-choice learning.

Reviews of models and definitions of both scientific literacy and health literacy were undertaken, looking at the research specifically in terms of free-choice learning and working knowledge. In particular, the reviews looked at where free-choice learning and working knowledge were recognised in the literature, and where there was potential for them to be included. Although these reviews were theoretical in nature, they have provided some ideas and implications for various groups.

Revisiting models of scientific literacy provided us with evidence that in general, free-choice learning and working knowledge are being increasingly recognised as important for scientific literacy. Four key themes emerged from the review of scientific literacy models: (i) the spectrum of scientific literacy; (ii) contexts of scientific literacy; (iii) responsibility for scientific literacy; and, (iv) future-proofing scientific literacy. These themes provide a focus for further research as well as suggesting how we should apply the empirical results of this thesis to the emerging problems.

Revisiting health literacy research showed that the literature in this field has taken a different path to that of scientific literacy. Again, this review from the perspective of free-choice learning and working knowledge provided direction and ideas for future research.

(i) Spectrums and (ii) Contexts

The review of the concepts of both scientific and health literacy provided information on how they exist on a spectrum which, depending on the definition of scientific or health literacy, can include knowledge, skills and/or understanding. In addition, the spectrum exists in a range of contexts. It was suggested that working knowledge could be partly responsible for the existence of the spectrum and contexts. Furthermore, the empirical work provided some instances of these. For example, with regard to an understanding of balance, a spectrum was seen from those who knew the ear was involved in balance up to those who were able to describe proprioception and the vestibular system. An example of contexts was shown where some people knew about hardening of the arteries with regard to watching their diet, and others knew about hardening of the arteries from experience of a medical intervention.

The empirical work has also made it clear that a context here has two meanings. In the theoretical work it was taken to mean something similar to topics. However, the interviews showed that it can also mean being aware of a topic in different situations or settings. So, people know about different topics, but also people are aware of topics in different settings. For example, the reaction timer exhibit showed that people were aware of the topic of reactions in the context of games, in sports people and in driving. Perhaps being aware of a topic in more contexts moves your knowledge of that topic towards the higher end of the spectrum of scientific or health literacy.

The data collected in this study gave information on people's knowledge and interest of science (Page 108). It was found that 78% of participants reported their interest in science as higher than their knowledge; only 3% reported a higher knowledge than interest; and, 19% gave the same score for knowledge and interest. This was in response to a question regarding science in general; it would be interesting to see if a different pattern was established when asking about more specific topics. This may provide further information on the spectrum and the contexts of scientific literacy. For example, we may find an individual who is very interested in astronomy as a hobby but reports that they are not very knowledgeable about it. The same person may be highly knowledgeable about renewable energy, perhaps because of work, but report a low interest in this context.

The existence of the spectrum and contexts in scientific and health literacy fits with everyone having different working knowledge. This is also connected to ideas such as collective action and social capital. These would involve sharing a group or community's working knowledge (or scientific or health literacy) so that it is one resource. Everyone's working knowledge is different and everyone is scientifically literate but on a spectrum and in different contexts. So perhaps it is more appropriate to talk about scientifically/health literate communities or groups rather than it being a concept relating to individuals.

(iii) Responsibility

Reviewing the concepts of scientific and health literacy raised the issue of where the responsibility for providing these lies. In scientific literacy, the models reviewed were moving towards a shared responsibility between formal and free-choice. For example, Liu (2009) suggested:

> "Current learning theories recognize the importance of both formal and informal education, and effective learning takes place in both formal and informal settings. This view of learning reflects the fact that school children spend far more time outside schools than inside schools" (Liu, 2009, p.307).

In health literacy, the situation was less clear, with responsibility involving: the health system; formal education; and, health educators. The results from the empirical study show that people are gaining knowledge from a range of free-choice learning sources, from games, to medical professionals, to television, and so the situation is even more complicated than the models suggest. What is clear from the results is that free-choice learning is important. Therefore, it must have some responsibility in contributing to scientific and health literacy.

(iv) Future-proofing

During the theoretical work it was discussed how facts and understandings about science (and health) can become out of date as science is dynamic and continually being added to. Also, people's interest and need for information change, so they need to be able to source information and assess it. They also need to be motivated to seek out information and empowered to be confident in what they know. It was reasoned that because of this a way of future-proofing knowledge would be required. It was suggested that skills for free-choice learning might be the answer to this. It must be noted that these skills themselves will require future-proofing as where we gain information from is changing. At present, skills are required to search the Internet and to use social media and forums to gain information. As technology develops new skills may be required. So although skills are required for free-choice learning, free-choice learning must also provide the skills for future free-choice learning.

4. Can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?

The reviews of scientific and health literacy models and definitions were used to look at the different directions the two areas have taken and to compare key themes and overlapping ideas. This provided ideas where best practice could be shared between the two areas. For example, some models and definitions from one field could easily be adapted and used for research by the other. In addition, novel ideas for research were suggested, which may have been overlooked within the fields. Importantly, the analysis and comparison of the two reviews provided some ideas for future research and questions to be answered. The research questions were suggested and discussed in the following areas (Page 231): skills versus facts; motivation and empowerment; spectrum and contexts; collective action; responsibility; and, future-proofing.

IMPLICATIONS FOR FREE-CHOICE LEARNING PROVIDERS

The starting point for this thesis was a paper on free-choice learning. The empirical research was carried out in a free-choice learning setting and the theoretical research was undertaken through the lens of free-choice learning. So it follows that the results will be more easily applied to this group than others. The results have implications for free-choice learning providers in terms of their: (i) justification; (ii) the design and development of exhibits and activities and (iii) the measurement of the impact of those activities. Other implications (iv) and the Wellcome Trust Review of Informal Science Learning (v) are also considered.

(i) Justification

It was found during interviews that the majority of participants (93%) showed evidence of taking part in free-choice learning when discussing the BodyWorks exhibits they had used. The fact that only 7% of participants did not mention any free-choice learning (and only 29% mentioned formal learning environments) suggests that a lot of knowledge comes from free-choice learning (and is therefore working knowledge, according to our definitions). This importance of free-choice learning is unquestionably of benefit to free-choice learning providers. Quite simply, the importance shown provides justification for the existence of providers of free-choice learning including: museums; science centres; aquariums; botanical gardens; art galleries; libraries; etc. These results, showing the importance of free-choice learning, could be used as evidence to provide support for funding applications to public and private bodies.

In return, free-choice learning providers should realise how important the activities, exhibits and programmes that they provide are in developing individuals' working knowledge. Responsibility lies not only in reinforcing knowledge from formal education but, as discussed above, to place that knowledge in new contexts and to provide opportunities to follow interests and to develop skills for further free-choice learning.

It was also found that people are learning from places that may not usually be recognised as free-choice learning providers; examples here included: games arcades; hospitals; and, gyms. This lends support for the outreach activities that some providers take part in, by suggesting that learning doesn't need to happen in a setting that is thought of as educational. For example, this supports how the BodyWorks exhibition is taken to places like scout groups and shopping centres, as well as science festivals and schools.

If the importance of this kind of learning can be communicated to and shared with the public, perhaps new visitors will be attracted and people may visit more often. This is related to the idea of people being "in on" their learning (as mentioned on Page 111). If people are aware that they are learning in free-choice environments, they may become more confident in their knowledge and report themselves not just as having an interest in science but as being knowledgeable too. This belief or confidence in their knowledge may encourage them to become involved in debate about controversial science issues or take a job with a scientific or technological component. Their confidence could transfer to their children and encourage them to take up science subjects at school and beyond. This would fulfil many of the economic, political, cultural and personal reasons for the public understanding of science and also for scientific literacy as discussed in the literature review (Pages 22 and 46).

As discussed in Chapter 5 it is possible that many people consider their knowledge about science to be mostly made up of what they have been taught in formal education, and so they don't include any working knowledge when thinking about their science knowledge. People may assume that you are taught everything you need to know about science at school. If you can't remember it, or you weren't interested in it, then you aren't knowledgeable about science. Sharing the importance of free-choice learning may change this perception.

The importance of free-choice learning shown in the data collected underlines the finding of the theoretical research (Chapter 6) that free-choice learning providers have a responsibility in providing scientific literacy. Reciprocally, the increasing acknowledgement of free-choice learning in models of scientific literacy provides justification for the existence and funding of free-choice learning providers.

This importance also reinforces the need for bridging between free-choice learning and formal education. As discussed in Chapter 6, one aspect of this bridging could be in formal education providing of skills for free-choice learning, to allow for the future-proofing of scientific literacy. However, the importance of free-choice learning suggests that it must also play a role in providing skills for future-proofing. This is discussed further below (Page 256) in terms of the design and development of free-choice learning activities and exhibits.

The importance of working knowledge was also seen in this research. Ninety eight percent (98%) of participants showed evidence of working knowledge when discussing the exhibits. This has implications for free-choice learning providers in relation to designing exhibits and activities, and measuring their impact.

(ii) Design and Development

Information gained from addressing the question "Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?" contributes ideas for the design and development of free-choice learning exhibits and activities. This is supported by the key themes emerging from the theoretical questions of "what can be gained from revisiting scientific and health literacy concepts from the perspective of free-choice learning and working knowledge?" and "can best practice with regards to free-choice learning and working knowledge be shared between the fields of scientific and health literacy?"

(a) Taking into account the better understanding of free-choice learning

It was found that as well as learning from sources normally recognised as free-choice learning providers, including museums, science centres or from television programmes, people were also learning from more unconventional places, for example, games arcades, doctor's surgery, hospital and gyms. This can provide ideas for new places for outreach activities to take place or for new collaborations. For example, the content of the BodyWorks exhibits suggests the potential for them to be used as outreach in gyms.

In the results, examples were seen of people learning in different ways, from playing video games to listening to doctors to watching television. Many free-choice learning providers already take into account that people learn in different ways and so provide activities and exhibits that reflect this. They may provide hands-on exhibits for people to do things, exhibits for visitors to watch films, exhibits to see things, or exhibits with information to read and reflect. The results of this study underline this and support the development and provision of a variety of activities to allow for different learning styles in places like science centres, museums and libraries.

However, the theoretical results suggest that free-choice learning providers should not only allow for and support different learning styles but also have a responsibility to play in future-proofing skills for learning. They have a role to play in developing skills for free-choice learning throughout life. This should involve introducing new skills, such as skills for new social media, but also keeping skills that have been developed in formal education practiced, such as researching and decision-making. For example, providing activities that involve debate or present both sides of a situation could contribute to people's decision-making skills.

Further justification for free-choice learning providers was found in the reasons why people were taking part. When a reason for learning was alluded to in this study it was mostly for leisure. Free-choice learning providers, including science centres, are often regarded as a leisure activity, something to do in leisure time.

Here again the question is raised as to whether people are “in on” the learning. Are people going to science centres with the intention of learning, the intention of entertainment, or is it a bit of both? This leads to the idea of there being “subgroups” of free-choice learning. For example, intentional free-choice learning as compared to coincidental free-choice learning. Whatever the case, it is clear that learning is taking place in leisure time, should it be intentional or not. Connecting this learning to learning taking place in formal education could be powerful way of supporting learning in both locations.

As mentioned in the analysis, Page 125) it has been suggested (Afonso and Gilbert, 2006, p.1540) that when interacting with an exhibit people may retrieve information that they coded when in a similar mood. So if they see the activity as leisure, they will relate it to information gained during other leisure activities. This reveals a conflict in how some free-choice learning providers present activities. If free-choice learning providers wanted people to relate an activity to something they learnt in school, they may be less likely to do this if it presented in a free-choice manner. Likewise, information learnt in school may be coded in a way that it is difficult to recall and use outside of school. Providing real world links and examples to science learning in school could help with this. This would also contribute to bridging between free-choice and formal education.

Free-choice learning providers should also take note of the other reasons found for taking part in free-choice learning, and perhaps take advantage of them. In this study, the second most common reason was due to an interest in their own health, or someone else’s. As discussed, this is mostly due to the content of the exhibition. However, this learning can be seen as taking place because of a personal interest or need. Free-choice learning providers could take advantage of this interest or need by providing activities to fulfil them. Health is an obvious topic for this, but as another topical example, increasing energy bills mean that people are becoming more interested in energy, including how it is generated and how it can be saved. Out of this interest and/or need people are likely to seek more opportunities to take part in free-choice learning about these issues. In addition, providing new, topical activities and exhibits based on current research or breakthroughs contributes to the future-proofing of scientific literacy, by keeping knowledge up-to-date and relevant. Currently, it is unlikely that an individual would visit a science centre or museum to seek out information on a specific subject, because of an interest or a need. By providing more topical and relevant activities, this may change.

The variety in the free-choice learning that people are taking part in should not be seen as a negative for free-choice learning providers. It may seem like a daunting task to cover all the possible links people might be making between activities and their working knowledge. It should not be seen as an overwhelming task to take into account all the possible links people may make with activities or exhibits. Similar to the paradox of continuity (see Page 135), people's knowledge should be seen as resource to build on and link with. There are practical ways of encouraging these links, for example, asking questions as part of an activity to allow people to think about the activity or give their opinions and by providing frames to make content more personally relevant (see also Pages 42 and 140).

One of the most straightforward ways for providers to take advantage of the range of free-choice learning, is to carry out formative evaluation as part of the development of an activity or exhibit. It is important not to assume what links people may make: "it is important to carry out careful audience research to determine which frames work across intended audiences" (Bubela et al., 2009, p.515). Formative evaluation can give information on the sources of free-choice learning being used by people which can be used to develop frames for communication. For example, the balance board exhibit in BodyWorks often caused people to mention the Nintendo Wii games console. A formative evaluation could have revealed this link and would have allowed this connection to be made in the exhibit text, or by staff, thus reinforcing some people's connection to the exhibit or providing a connection for others. Another example became apparent during an interview with a member of staff discussing comments written in their diary about the MindBall exhibit. This exhibit is popular but can be difficult to explain or provide connections to it. However, a schoolgirl, in conversation with a member of staff, related the concentration required for the exhibit to difficulties in concentrating associated with types of dyslexia. This seems like a link other people could relate to and be interested in. It has been missed in the development of the exhibit, and may also have been missed in a formative evaluation. However, a continual summative evaluation of exhibits, involving feedback from staff (perhaps through staff diaries), would allow relevant and up-to-date connections to be added to text or simply shared among staff. Up-to-date connections would also contribute to future-proofing exhibit content and allowing for the spectrums and contexts of people's scientific literacy to be catered for.

(b) Spectrums and contexts

It is important that free-choice learning providers recognise the roles they have to play in the concept of scientific literacy: they contribute working knowledge to an individual's scientific literacy; they reinforce scientific literacy gained during formal education; and, provide new contexts for parts of scientific literacy. Providing these contexts is an essential role, as such diverse contexts may never be realised within the constraints of time and other resources available to formal education. These contexts are similar to how Bubela et al. (2009) propose framing can benefit in science communication:

> "drawing upon research to explore alternative storylines, metaphors and examples that more effectively communicate both the nature and the relevance of a scientific topic" (Bubela et al., 2009, p. 517).

So, free-choice learning providers must continue to provide novel ways of presenting science to provide new contexts and build on the learning from formal education. In fact, in the Scottish education system's Curriculum for Excellence, formal education is actively looking for opportunities to increase the width and depth of learning (this is discussed further later, see Page 273). These types of opportunities are what free-choice learning can contribute and this must form part of a bridge between the two areas. The bridging is added to by the reinforcement of learning from formal education. However, the conflict is that free-choice learning providers must also allow for people to explore interests and to build on their working knowledge and so provide content not related to curriculums. Indeed, the importance of free-choice learning would suggest that more attention should be paid to interacting with people's working knowledge rather than knowledge gained in schools. So bridging must also happen between free-choice learning providers.

Some providers overcome the problem of providing for free-choice and formal this by offering separate programmes of activities for school groups and for public audiences. So, school group activities would concentrate on providing new contexts for learning and reinforcing learning from formal education. Whereas public programmes would focus on connecting with working knowledge, and allowing people to follow interests.

By taking the school curriculum into account, free-choice learning providers are taking a step towards bridging with formal education but does this work in the opposite direction? Are schools taking working knowledge and free-choice learning into account? Or, more practically, how can schools take more advantage of free-choice learning and working knowledge? (This is discussed further on Page 267). Bridging will be stronger between formal and free-choice if it works in both directions.

So it follows that the responsibility for providing people with scientific literacy falls not only on formal education but also free-choice learning. Its role varies from reinforcing ideas learned elsewhere, to providing a new context for some knowledge, to adding to a spectrum of knowledge.

(c) Taking into account a better understanding of working knowledge

As working knowledge is important (98% of participants in this study showed evidence of working knowledge related to the BodyWorks exhibits), it can be considered logical to design an activity or exhibit to interact with people's working knowledge in some way. For example, the aims of the activity could be set out in terms of increasing the complexity of that working knowledge, by reinforcing, adding to or changing. As part of a formative evaluation, using similar methods to those used in this study, details of the working knowledge people are using when interacting with the new activity/exhibit could be ascertained. In addition, details of the free-choice learning that took place when gaining the working knowledge could be collected.

This study found that the majority of participants (91%) showed evidence of increasing the complexity of their working knowledge by reinforcement when interacting with the BodyWorks exhibits. Fewer participants added to their working knowledge (28%) and fewer still changed their working knowledge (10%). Reinforcement may not be seen as a significant aim for an activity but it is still of great importance and, according to the operational definition for this study (Page 70), it is learning. However, reinforcement should not be thought of as simply learning the same thing over again. It is the same idea but it is being enriched with new connections, being thought of in a new context, experienced in a new way. For example, when talking about the Reaction Timer exhibit, participant K5 (Female 40-49) stated: “Em you sort of see people in sports like if it’s the 100 metres the reaction time after the gun going off.” Although it seems, and has been noted, that participant K5 has reinforced knowledge she has about reaction times in sports, she has also measured her own reaction time and felt what it is like trying to react as quickly as possible. She has made a connection between measuring her own reaction time and hearing about athletes’ reaction times. It is fair to assume that next time she hears about reaction times she will connect to her experience with the exhibit. So encouraging and providing connections is important for free-choice learning providers. This can be done by sharing the connections others have made, through exhibit text or by staff.

It is important to note again at this point that people may come to a free-choice learning resource with incorrect or flawed knowledge, or misconceptions. As discussed in Chapter 5 (Page 135), in terms of the paradox of continuity, the key approach to this is to carry out front-end and/or formative evaluation. To be aware of these misconceptions means they can be used as the basis for building new knowledge or adjusting old.

It may be easier to design activities or exhibits that reinforce rather than add to or change, but that doesn’t mean it is impossible and should be avoided. If increasing the complexity of working knowledge by adding to or changing is less common because it requires more cognitive effort, then free-choice learning providers need to find ways of making this easier. This could be achieved by giving the information in different forms, so people can watch, read, discuss, or interact or framing information to make it more relevant (see also Pages 42 and 140). As discussed above (Page 256) this also allows for different learning styles and can also build new skills for learning, thus contributing to the future-proofing of scientific literacy.

It requires further research, but it may be that adding to or changing only occurs after a part of working knowledge has been sufficiently reinforced. This adds to the idea that learning may happen in the long term. Of course, one of the effects of free-choice learning may be to empower the learner to learn in the future. This empowerment could be considered to be contributing to the future-proofing of scientific literacy.

This study also found evidence that it may be easier to add to or change understandings rather than facts, perceptions or values. However, this is a small study on one topic, and only looked at four aspects of working knowledge. The adding or changing of working knowledge depends on the aims and the content of the exhibits as well as the participants. Further work would be worthwhile to obtain more data on this.

Perhaps more useful is the finding that those who reported being more interested in science were more likely to increase the complexity of their working knowledge. It makes sense that if you are more interested in science you are more likely to pay attention to the exhibits and to increase the complexity of your working knowledge in some way. This leaves free-choice learning providers with the problem of how to attract and engage with those who do not feel they are interested in science. Remember that despite some participants reporting a low interest in science, the majority had a working knowledge of the topics in the exhibition. As discussed earlier (Page 111) the answer may lie in making people more aware of the importance of free-choice learning and working knowledge. It was also found that those reporting to be less knowledgeable are more likely to add to their working knowledge, or perhaps those that know more, have less to add.

The most important point to take from this is that working knowledge is made up of more than simply facts and understandings and working knowledge can be reinforced, added to or changed. So activities and exhibits should be designed with aims to interact with, and increase the complexity of, all facets of working knowledge. If interacting with working knowledge is set out in the aims, then it should also be considered when evaluating the activity, or measuring its impact.

(iii) Measuring Impact

Measuring the impact of activities is of great importance to free-choice learning providers. They must show that they are meeting their aims, to account for funding and even to justify their existence. As stated previously, as working knowledge is important, it is reasonable to design an activity or exhibit, and set its aims, to interact with people's working knowledge. A measure or indication of how the activity interacts with working knowledge, or increases the complexity of working knowledge, can be a measure of the impact of the activity. In other words, if working knowledge is as important as this study suggests, then increasing its complexity (by reinforcement, adding to, or changing) is an appropriate impact to measure.

Some free-choice learning providers currently evaluate and measure impact by taking before and after measures of people's knowledge on a particular topic. However, this study has provided some evidence that everyone has different working knowledge and that there is a spectrum of scientific literacy and this exists in different contexts. So, everyone is starting from a different place. Plus, some people will be reinforcing, some adding and some changing working knowledge, and some of this may be easier to do, for example, in this study it was easier to reinforce. By using interactions with working knowledge as a measure of impact, the spectrums and contexts of scientific literacy are accommodated.

By considering the results obtained from the aim of gaining a better understanding of working knowledge, a structure for setting goals for activities and measuring their impact can be produced. This would be based on the activity or exhibit interacting with working knowledge and increasing the complexity of that working knowledge. So, for example, instead of setting an aim that through using a particular exhibit “people will learn the reasons why smoking is bad for them”, the aim would be that the exhibit will increase the complexity of people’s working knowledge on why smoking is bad for health. Or, the exhibit will reinforce/add/change people’s working knowledge on smoking and health.

The results of this study are based on the use of one set of exhibits on one theme. Further work using other types of activity, for example, workshops, live shows, online activities, and other themes, are essential to confirm the suitability of increasing the complexity of working knowledge as a measure of impact. However, based on the current findings, we can suggest some points. For a start, the way in which working knowledge can be divided into facts, understandings, perceptions and values should be taken into consideration when developing exhibits and activities. Dividing working knowledge up like this allows for more specific aims for activities, for example, the exhibit aims to reinforce/add to/change people’s understanding of the effect of smoking on health, or the exhibit will reinforce/add to/change people’s working knowledge of facts regarding smoking and health. Setting out aims in this way means that data collections similar to those used in this study can be used as a way to evaluate the activities to see if aims are being met.

(iv) Other implications

It has been mentioned above (Chapter 8) how the fact that every individual has a different working knowledge could be connected to ideas such as collective action and social capital. In other words, considering everyone’s working knowledge as one resource. Free-choice learning providers could form part of a network or infrastructure that encourages a pooling of people’s working knowledge. So perhaps when talking about the public understanding of science, or public engagement with science, it should refer to the overall understanding, or engagement, of all the individuals added together. This could help to meet the goals of the public understanding of science in particular, having a public more ready and willing to engage in debate about scientific issues, a public better equipped to make decisions regarding scientific issues. However, this depends on the pooled working knowledge being accessible to all.

In some ways free-choice learning itself is a collective action, or a form of social capital. This is seen in how people themselves are free-choice learning providers, sharing and debating working knowledge between each other.

(v) The Wellcome Trust Review of Informal Science Learning

During the completion of this thesis the Wellcome Trust published two reports it had commissioned on informal science learning in the UK. One report was completed by GHK Consulting and titled Review of Informal Science Learning (Lloyd, Neilson, King and Dyball, 2012) and the other completed by Stanford and Oregon State Universities and titled Analysing the UK Science Education Community: The contribution of informal providers (Falk, Osborne, Dierking, Dawson, Wenger and Wong, 2012). Some of the recommendations of these reports are linked to findings from the current thesis. In particular, Lloyd et al.'s (2012) second recommendation concerns, "how the links between informal and formal learning can be enhanced for mutual benefit" (Lloyd et al., 2012, p.51). This recommendation is similar to Falk et al.'s (2012) first recommendation, "need to build a stronger sense of a common identity among all providers of science education or educational experiences that support science learning and engagement" (Falk et al., 2012, p.61). This study has highlighted the importance of bridging and in this discussion chapter practical suggestions to contribute to this bridging by utilising working knowledge are given. Overcoming the lack of consensus on terms, discussed above (Page 241-2), may also contribute to a common identity.

Lloyd et al.'s (2012) third recommendation focuses on evaluating informal science learning. This includes:

> "establishing, as far as possible, common performance management and evaluation requirements, indicators and metrics across different funding streams and services." (Lloyd et al., 2012, p.52) and "the development of a common set of indicators and measures that can be used in evaluating informal learning activities" (Lloyd et al., 2012, p.53).

Falk et al.'s (2012) fourth recommendation adds to this saying:

> "The science learning and engagement system needs support to build its knowledge base of which outcomes to measure and the ways in which they might be measured" (Falk et al., 2012, p.65).

As discussed here, increasing the complexity of working knowledge has the potential to be used as a measure of impact of activities. However, more work is needed on other topics and types of activity. Indeed, this further work would fit with Lloyd et al.'s (2012, p.53) suggestion for "a programme of evaluation research to provide an evidence base on the medium- to long-term impacts of informal learning in the UK."

IMPLICATIONS FOR FORMAL EDUCATION

Although the focus and setting of this thesis is in free-choice learning, the results do provide some connections to formal education. However, it is essential to note that the support provided for free-choice learning by the work in this thesis does not in anyway mean that formal education has less of a role to play in science education and providing scientific literacy. Free-choice learning should be regarded as providing additional contexts for learning, contributing to the spectrum of scientific literacy and so providing a classroom of students with a rich and varied working knowledge to be utilised. Perhaps most significantly, free-choice learning is where learning continues beyond formal education. So formal education provides the foundations of knowledge and skills that all free-choice learning is built on. It is advantageous for both to improve the bridging between them.

There is a vast body of research on pedagogies and learning in formal education, which has formed teaching techniques, strategies, assessments and curriculums. What this study has suggested in terms of design and development and measuring impact in free-choice learning cannot replace research in formal education and never set out to. However, the importance of working knowledge and free-choice learning that has been shown in this study does suggest that they should have some recognition in formal education, not least to reinforce the bridge between formal and free-choice. The results are now discussed in terms of how formal education can take advantage of free-choice learning and working knowledge, in particular, how to form and/or strengthen a bridge between free-choice learning and formal education, (i) utilising free-choice learning and working knowledge. The discussion then provides some justification for current practice in formal education in terms of the Curriculum for Excellence in Scotland, (ii) A note on the Curriculum for Excellence.

(i) Utilising free-choice learning and working knowledge

Many formal education providers already take advantage of the educational opportunities provided by places like museums and science centres. As well as visits to free-choice learning providers and outreach visits from the providers into schools, free-choice learning also contributes to continual professional development activities for teachers and online teaching materials. However, in addition to these activities, students are likely to be taking part in free-choice learning that is more *free* choice and hasn't been organised or encouraged by the school. The importance of free-choice learning suggests that formal education should do more to add to the bridge between the two. It could be reasoned that as free-choice learning providers include school curriculums in the aims of their activities, schools should include inputs from free-choice learning in their curriculums.

Previous researchers have discussed the bridging of formal and informal learning of science (for example, Hofstein and Rosenfeld, 1996; Stocklmayer, Rennie and Gilbert, 2010) and suggested a model for how this can be achieved (Fallik, Rosenfeld and Eylon, 2013). However, the discussion of bridging has mostly concentrated on how informal science education providers can contribute to formal school curriculums. The importance of free-choice learning hints that integrating working knowledge into school curriculums may form part of the bridge. In other words, instead of free-choice learning providing for the curriculum, the curriculum should provide for free-choice learning. Free-choice learning takes place because of an interest or a need, not because of a curriculum. Rather than considering bridging to have the aim of improving school learning, an alternative view is to consider it as a way of making use of free-choice learning that has already taken place. In addition, perhaps recognising, or giving credit for, free-choice learning will encourage more free-choice learning. The clear problem with this is that free-choice learning is wide and varied and everyone's working knowledge is unique to them, it would be difficult for formal education to take this all into account. However, from the perspective of Personal Construct Theory this could be very effective:

> "When young people engage directly with their school curriculum, and bring their own personal issues and positions into relation with its ways of framing the world, there can be radical learning breakthroughs" (Salmon, 2003, pp.313-314).

The range of places in which free-choice learning is taking place underlines how varied the working knowledge of students will be. For example, in this study working knowledge was being gained at home, in gyms and at doctors' surgeries. This is clearly a challenge but should also be considered beneficial and positive. A classroom of students is a diverse pool of working knowledge to share and build on. The first step may simply be to recognise the input from free-choice learning, to recognise that students have their own working knowledge, to see this as something to build formal learning onto. Then the working knowledge can be taken advantage of to strengthen the bridge between formal and free-choice. The findings of this study are now discussed in terms of practical ways of utilising pupils' working knowledge and contributing to the bridge between formal and free-choice.

By recognising the input from free-choice learning, formal education could help individuals be more aware of their learning. It has been discussed here previously (Page 111 and 254) that people may not recognise free-choice learning activities as educational or as learning. Thus, not being aware of the importance of free-choice learning and not being confident in what they know. This was seen in the results of this study where, despite reporting low knowledge of science, people had a high interest in science and also showed evidence of working knowledge in relation to the BodyWorks exhibits. By acknowledging the input from free-choice learning, formal education could contribute to people feeling more knowledgeable about science. This confidence may lead to people being more likely to contribute their knowledge and opinions to debates and to take part in further free-choice learning. Thus, playing a part in the future-proofing of scientific literacy.

Formal education is already aware of the spectrum of scientific literacy, of pupils' differing levels of interest and knowledge in topics. It should be recognised that working knowledge from free-choice learning is partly responsible for this spectrum. This working knowledge should be utilised as a resource to be shared and built on in the classroom, thus adding to the bridge between formal and free-choice. For example, working knowledge of one topic can be used to introduce a new topic; working knowledge of a particular health condition could be utilised to introduce aspects of physics through diagnostic technology. Again this would contribute to the bridge between formal and free-choice. This fits with how Novak thought Personal Construct Theory could be concerned with formal education:

> "Applying Kelly's notions to teaching would mean that educational strategies aim at enabling students to examine, clarify, and extend their personal system of constructs" (Novak, 1983, p.318).

Also, people themselves are free-choice learning providers, sharing working knowledge and learning from each other. Students can learn from each other in formal education, again utilising working knowledge as a resource to be shared and built on. In terms of the Personal Construct Theory framework, Pope discussed students sharing ideas as relating to Kelly's model of man as a scientist (see also Pages 78-79):

> "There should be a supportive climate for students as they try to articulate their construing by being encouraged to talk about their ideas. Talking about ideas and listening to the conflicting opinions of others and the putting of these ideas to the test is an approach to teaching which is consistent with Kelly's model of 'man the scientist'" (Pope, 2003, p.305).

Formal education might think of free-choice learning as a provider of contexts to give depth to learning and to reinforce knowledge. Free-choice learning can be exploited in this way via field trips, or online resources, or simply referring students to a television programme or a website. In addition, the working knowledge of individuals can be further utilised to provide contexts for others. For example, a pupil's experience of having an MRI scan can provide an interesting context for teaching some topics in physics. Equally, formal education could provide new contexts for free-choice learning. Fromm relates this to Personal Construct Theory saying:

> "Furthermore it is always possible to place the same (learning) item in numerous contexts and construe it in many different ways, because events 'hold no institutional loyalties'. The differences between teachers and pupils may involve the construing of items as separate units, the terms used to phrase such a unit, or the contexts of construction to which these units belong" (Fromm, 2003, p.321).

The importance of free-choice learning may suggest that some of its qualities might be applied to parts of formal education. For example, voluntary, self-paced and non-sequential. This would not only allow individuals to use skills from free-choice learning in formal education but would also allow formal to be involved in developing free-choice learning skills for the future. This would help in the future-proofing of scientific literacy.

If formal education settings realise the importance of free-choice learning, perhaps they will begin to offer more free-choice learning opportunities themselves. Many colleges and universities offer adult education and evening classes but could they open up their facilities and staff to a wider range of people? Universities are increasingly becoming involved in outreach and engagement activities. The importance of free-choice learning provides backing for these types of activities and support for their significance. Schools, colleges, universities should be seen as learning facilities for their communities, not just their pupils, students, attendees.

As well as making use of working knowledge, potentially the most effective way for formal education to contribute to the bridge is to provide individuals with skills for taking part in free-choice learning; thereby future-proofing scientific literacy. The majority of participants in this study (93%) showed evidence of taking part in free-choice learning. The opportunity should be taken to make this learning as effective as possible by improving skills for free-choice learning. The importance of this has been relates to theoretical framework set out for this thesis and, in particular, Kelly's idea of man as a scientist:

> "It is our opinion that a general tendency towards teaching people how to be taught as opposed to encouraging them to learn how to learn continues to reproduce many of the problems that arise from society's inability to cope creatively with personal, technical, and social change" (Thomas and Harri-Augstein, 1983, pp.332-333).

Equipping people with these skills is the most straightforward way of future-proofing scientific literacy and would contribute to the bridge between formal education and free-choice learning. The bridge could be formed by formal education providing the skills for free-choice learning, and free-choice learning providers contributing the resources.

Developing these skills in schools could be used as a neat way of recognising working knowledge and free-choice learning. Pupils could be encouraged to build on their own personal working knowledge of their own interests while developing skills in evaluation and analysis of information and use of free-choice learning sources. For example, if a student was interested in astronomy, the teacher could apply skills in researching and evaluating to this topic. The pupil could be given the task of researching a news story on astronomy with the teacher providing guidance on the reliability of sources and search techniques. Being given time to follow their own interest could provide students with motivation for future learning. By giving an individual's free-choice learning recognition in the formal environment, the bridging is strengthened further.

The idea of recognising students' interests has also been suggested as an implication of the ROSE (Relevance of Science Education project) survey. Here it is proposed that,

> "Students experiences as well as their interest should be attended to in the construction of curricula, in the production of textbooks and other teaching material as well as in the classroom activities" (Sjørberg and Schreiner, 2010, p.29).

Without this acknowledgement of interests it is suggested that students may develop negative attitudes about science and may turn their back on science in future life "be it as students or citizens" (p.29).

Some of the ideas outlined above are already recognised in formal education, this study merely provides support for them. The overall message is to recognise the importance of free-choice learning (and working knowledge) in order to strengthen and/or build the bridge between it and formal education and to contribute to the future-proofing of scientific literacy. Most importantly, formal education should empower people to take part in free-choice learning. It should instil a confidence in, and a love for, learning so that individuals are likely to continue learning throughout their lives.

(ii) A note on the Curriculum for Excellence

Just as the results of this study provided some justification for current practices by free-choice learning providers, the results also provide support for some aspects of formal education. The data collection in this present thesis was carried out in Glasgow, Scotland. In Scotland in 2010-11 a new curriculum, named The Curriculum for Excellence was implemented in schools. This is noted here as parts of the curriculum suggest ideas linked to bridging between formal education and free-choice learning, and so this study provides some support for the curriculum.

Looking at the original documentation for the Curriculum for Excellence (Scottish Executive, 2004), which set out the values, purposes and principles of curriculum design, there is no specific link to or mention of free-choice learning's contribution to education. However, there are some indications of recognising the importance of free-choice learning and working knowledge and, more importantly, outcomes that free-choice learning could support. In terms of the key themes in scientific literacy, discussed in this study (Chapter 6), there are suggestions related to: a) responsibility; b) the importance of free-choice learning and working knowledge; c) spectrum and contexts; and, d) future-proofing. These are now discussed.

(a) Responsibility

There are strong suggestions that the importance of free-choice learning is being recognised, despite it not being specifically referred to. Statements such as:

> "Taken as a whole, children's learning activities should combine to form a coherent experience. There should be clear links between the different aspects of young people's learning, including opportunities for extended activities which draw different strands of learning together" (Scottish Executive, 2004, p.14).

and:

> "To enhance opportunities and allow greater personalisation of learning, schools will need to look beyond their own expertise and resources so that their students can have access to suitable provision" (Scottish Executive, 2004, p.14).

support the idea that areas other than formal education should be included and that bridging between the areas is necessary. It should also be noted that the Curriculum for Excellence appears to be taking up a responsibility in health literacy. The strand of health and wellbeing is set out to be taught and integrated across all subject areas of the curriculum.

(b) The importance of free-choice learning and working knowledge

The relevance and personal nature of working knowledge is connected to the curriculum, in that:

> "Young people should understand the purposes of their activities. They should see the value of what they are learning and its relevance to their lives, present and future" (Scottish Executive, 2004, p.14).

The individual nature of working knowledge is related to the statement that, "Each child has an enormous capacity for learning and the potential to achieve in different ways" (Scottish Executive, 2004, p.9). This also connects with the spectrum of scientific literacy as does the statement that:

> "At all stages, learners of all aptitudes and abilities should experience an appropriate level of challenge, to enable each individual to achieve his or her potential" (Scottish Executive, 2004, p.14).

(c) Spectrum and contexts

There is mention of contexts in terms of breadth of curriculum design:

> "The curriculum should be organised so that they will learn and develop through a variety of contexts within both the classroom and other aspects of school life" (Scottish Executive, 2004, p.14).

Although, this researcher would argue that it is not just in school life where these contexts are found and that free-choice learning can provide a greater variety of contexts.

Perhaps the clearest place where free-choice learning could play a part is in the depth of curriculum design, described as:

> "There should be opportunities for young people to develop their full capacity for different types of thinking and learning. As they progress, they should develop and apply increasing intellectual rigour, drawing different strands of learning together and exploring and achieving more advanced levels of understanding" (Scottish Executive, 2004, p.14).

Free-choice learning is one of the different types of thinking and learning and bridging with formal education would draw these strands together. The advanced levels of understanding could be achieved through providing new contexts and reinforcing knowledge gained in schools. And also, vice versa, school provides new contexts for working knowledge and more advanced understanding of what is learnt through free-choice learning.

(d) Future-proofing

Future-proofing of knowledge is alluded to by way of skills for future learning in the curriculum, which “should give young people the confidence, attributes and capabilities to make valuable contributions to society” (Scottish Executive, 2004, p.11). It is clearly set out in the implication that the curriculum should provide “better preparation for further study and work through improved skills, greater confidence and improved attitudes to enterprise, work and lifelong learning” (Scottish Executive, 2004, p.17). This would contribute to bridging between free-choice and formal as well as future-proofing scientific literacy.

Most strongly related to future-proofing is how the curriculum set out its purpose as building four capacities that aim for all children to become “successful learners, confident individuals, responsible citizens and effective contributors to society and at work.” Some detail in these capacities is supported by findings from this thesis. In fact, the capacities could be considered as a list of the skills required for future-proofing scientific literacy and thus contributing to a bridge between free-choice learning and formal education. For example, the capacities include:

> “enthusiasm and motivation for learning;” “openness to new thinking and ideas;” “use technology for learning;” “think creatively and independently;” “make reasoned evaluations;” “link and apply different kinds of learning in new situations;” “develop and communicate their own beliefs and view of the world;” “assess risk and take informed decisions;” “commitment to participate responsibly in political, economic, social and cultural life;” “make informed choices and decisions;” “evaluate environmental, scientific and technological issues;” “develop informed, ethical views of complex issues;” “apply critical thinking in new contexts;” “create and develop;” and, “solve problems”(Scottish Executive, 2004, p.12).

Despite being set in, and carried out in, a free-choice learning setting, this study has provided some new ideas and suggestions for how formal education can contribute to the bridge with free-choice learning. Equally important is how aspects of this study provided support for current practices, in particular the Curriculum for Excellence.

IMPLICATIONS FOR THE HEALTH SECTOR

The introduction of the concept of health literacy to this thesis has provided an interesting juxtaposition of two research areas. Chapter 8 showed how models and definitions could be applied to the other field and importantly, the comparison provided useful ideas for future research (see Pages 231-237).

As discussed previously, (Page 239) the topic of health has been both beneficial and a hindrance to this study. Some of the main benefits of the topic being that: it must bridge both formal and free-choice; it is a topic we interact with throughout our lives; and, it is personal and relevant. Therefore, it must have strong links with the idea of working knowledge.

The fact that this study is not based in the health sector, but in free-choice learning, also has negative and positive aspects. The researcher is based outside the health area and has little experience of health promotion or health education research. For example, there is limited background knowledge of research on how materials and activities are designed in health education or ways in how their impact is measured. Therefore, there may be similarities, or overlaps, between some of the ideas suggested here and current practices. Conversely, being outside the area means there are fewer barriers to suggesting novel ideas or directions for research.

The findings are now discussed in terms of how they can be applied to, and utilised by, the health sector in terms of: (i) Recognising the importance of free-choice learning and working knowledge; (ii) Utilising a better understanding of free-choice learning and working knowledge; (iii) Recognising responsibility as a provider of free-choice learning; (iv) Spectrums and contexts; and, (v) Future-proofing.

(i) Recognising the importance of free-choice learning and working knowledge.

As with free-choice learning and formal education, the importance of free-choice learning and working knowledge should be recognised in the areas of health education and health promotion. This should not just be in terms of health promotion and education materials or campaigns but also in the day-to-day business of providing healthcare. The first step is to be aware that working knowledge exists and is important. Frontline healthcare workers including: general practitioners; nurses; specialists; pharmacists; and, allied healthcare professionals, need to be aware of working knowledge, how it develops and how people use it to interact with new knowledge. Perhaps the importance of free-choice learning and working knowledge could be introduced by explaining how they play a part in health literacy. However, health literacy is a relatively new concept and this would depend on its recognition by professionals.

(ii) Utilising a better understanding of free-choice learning and working knowledge.

Those providing health information in the health arena include doctors, nurses and all others communicating with the public, including those in health promotion and health education. These groups need to be aware that people gain working knowledge from a variety of sources, not just from formal education. This study has shown that free-choice learning takes place in a range of places and, for this particular topic, these places include doctor's surgeries and hospitals. There may be an opportunity for health promotion or education to take advantage of the fact that people are learning in a range of places, for example, from games, and from each other.

The main problem with the range of sources used by people is that not all free-choice learning may provide accurate or impartial information. This again highlights the importance of people being equipped with skills for free-choice learning including, research skills, decision-making, and evaluation (see future-proofing). Perhaps the health sector should have a role to play in providing these skills. The NHS Choices "Behind the Headlines" website is one example of the health sector starting to build skills in decision-making and evaluation. This kind of resource is something that could be utilised by free-choice learning providers and formal education.

Just as the better understanding of working knowledge can be used in the design of free-choice learning activities, and the measuring of their impact, it can also be used by health promotion and education. This use of working knowledge in design and measuring impact is discussed in detail in terms of free-choice learning providers (Page 255-264). In summary, working knowledge is made up of more than simply facts and understandings and working knowledge can be reinforced, added to or changed. So health promotion and/or education activities and materials could be designed with aims to interact with, and increase the complexity of, all facets of working knowledge. In addition, if interacting with working knowledge is set out in the aims, then it should also be considered when evaluating the activity, or measuring its impact.

Many health promotion materials aim to change people's perceptions or values. Unfortunately, the data from this study have shown very few examples of adding to or changing perceptions or values. This suggests that it is easier to add or change understandings rather than facts, perceptions or values. This seems to make sense in health related situations. For example, it would be easier to change someone's understanding of how their diet affects their health but to change their values with regards to what they actually eat would be more difficult. Further work may show that changing or adding to understandings can lead to changes in perceptions and values.

(iii) Recognising responsibility as a provider of free-choice learning

As well as recognising and utilising working knowledge and free-choice learning, healthcare providers and health educators need to be aware of their position as free-choice learning providers. Every health education and health promotion activity is a free-choice learning activity. Perhaps even more importantly, every interaction an individual has with a healthcare worker is a free-choice learning opportunity and has the potential to interact with that person's working knowledge. It should be recognised that people approach the health arena seeking information as well as the health arena putting information out to the public. All healthcare professionals, including: pharmacists; community health workers; doctors; nurses; physiotherapists; surgeons; and dentists, should see every interaction as an opportunity to reinforce, change or add to working knowledge. Evidence of this is seen in this study where the second most mentioned place as to where free-choice learning was taking place was at a doctor's or a hospital. Additionally, working knowledge is often passed on to family and friends. Therefore, it is important that health care workers are aware of the role they play in the development of working knowledge, and that they are a free-choice learning resource. Of course, these professionals will require support to achieve this, in particular, the time to spend with patients.

In the data collected, when a reason for taking part in free-choice learning was alluded to, the second and third most popular reasons were concerning own health and concerning someone else's health. So people are actively looking for free-choice learning opportunities with regards to health. This interest, or need, for free-choice learning can be used to the advantage of the health arena when planning health promotion and/or health education materials and activities. For example, ensuring materials are easy to access and relevant to people's working knowledge, being aware, and making use of spectrums and contexts in health literacy. It is important that on these occasions when people are actively seeking free-choice learning opportunities, opportunities to add to their working knowledge, that they have the skills and the resources to do this effectively.

It is also important to note at this point that just as free-choice learning providers and formal education must share the responsibility for scientific literacy and its future-proofing, they must also be involved in health literacy alongside health professionals and educators. Freedman et al. (2009) suggested that this may be a starting point for improving health literacy and that:

> "efforts should be made to promote the incorporation of public health literacy into health literacy programs, formal education systems, and informal educational networks" (Freedman et al., 2009, p.450).

This is backed up by the recommendations resulting from the European Health literacy Study, which included:

> "health literacy is strengthened at personal levels through focus on enhancing life competencies at school, at work, at the market place and in the political arena" (The HLS-EU Consortium, 2012, p.4).

and:

> "relevant stakeholders such as governments, the private sector, and the civil society make collaborative efforts to advance health literacy in Europe" (The HLS-EU Consortium, 2012, p.4).

(iv) Spectrum and contexts

There is less recognition of spectrum and contexts in health literacy research than scientific literacy. However, they can also be applied to health literacy and utilised in the areas of health education and promotion. It is easy to see these as a challenge to be overcome (as seen in the deficit based models of health literacy) but they should be utilised in this area just as they can be by free-choice learning providers and by formal education. Those producing health information for the public, and medical practitioners interacting with patients, need firstly to be aware of working knowledge and how it contributes to a spectrum of health literacy and contexts of health literacy. They should be aware that although some individuals know little about a certain topic, others will know a lot. That although some people may not know much about a topic, they may know more about another related topic.

It could also be useful to be aware of the fact that people may have an interest in a topic but play down their knowledge. This was seen in this study as individuals reporting themselves as having an interest in science but not being knowledgeable about science. As discussed, this may be because they are not recognising knowledge gained from free-choice learning. More importantly to the health sector, it may be due to a lack of confidence in their knowledge; this is perhaps something the health sector can contribute to.

Working knowledge's contribution to health literacy should be seen as an asset to be built on. In addition, people's working knowledge should be seen as a resource to be shared with others. Importantly, the empirical results in this thesis showed that people were gaining working knowledge with friends/relatives, or because of friends/relatives health. In the staff diaries there were examples of children knowing about a particular condition because of a relative's health. For example, "Is that the pancreas? My Granny's diabetic and her pancreas doesn't make insulin so she needs injections" (P5 child - Staff C, Diary Page 4). This hints at how people can be free-choice learning providers to other people. This is important in health where someone who has experienced a particular medical condition would have developed working knowledge of that condition. This person could be viewed as a free-choice learning resource for other people experiencing the condition for the first time. In a way, this is similar to how science communicators share science knowledge with the public.

(v) Future-proofing

Health provides us with an excellent example of when people will require skills in order to future-proof their knowledge. Health messages change over time and as people experience new health conditions throughout their lifetimes they find a need to reinforce, change or add to their working knowledge. Skills are required: to understand the information given to them by health professionals; to know what questions to ask; to know where and how to look for further information; to assess this information; and, to use information to make decisions. An important part of this future-proofing would involve having the motivation to seek out information and the empowerment to do this and to act on the working knowledge gained.

Again, health educators and health professionals should be aware of their role as free-choice learning providers. Every interaction between a health professional and an individual should be seen as an opportunity for free-choice learning to take place, not just learning of facts or understandings but also skills. Skills for the present and skills for future-proofing.

IMPLICATIONS FOR SOCIETY AND ITS INDIVIDUALS

Education, whether labelled as formal, informal, or free-choice is an integral part of society. The range of sources of free-choice learning suggests that education and learning are a part of many aspects of society, including: leisure; entertainment; family; community; and, culture. So, the implications discussed already apply to society. However there are some points discussed previously that can be applied specifically to society and its individuals. These are now discussed in terms of: (i) recognising the importance of free-choice learning and working knowledge; (ii) spectrums and contexts; (iii) responsibility; and also, (iv) a note on the current economic climate in the UK.

(i) Recognising the importance of free-choice learning and working knowledge.

Firstly, society as a whole should recognise that learning takes place in a wide range of places. Learning of all kinds should be supported and encouraged. In particular, increased support for free-choice learning providers, such as: museums; galleries; libraries; and, community groups, should be provided. Over thirty years ago Falk (1982, p.85) suggested, “Science education, or any kind of education for that matter, should become a community responsibility.”

If society were to recognise the importance of free-choice learning and of working knowledge, then individuals would be more aware of the learning that is taking place in this way. It follows that people would have more confidence in their knowledge, and would be encouraged to take part in more free-choice learning. One of the implications of the Aspires survey (2013, p.30) was that families should be supported “to feel more comfortable and knowledgeable about science.” In this study it was suggested that people were interested in science but did not think themselves to be knowledgeable about science. When each participant was looked at individually, it was found that 78% of participants stated a higher interest in science than how knowledgeable they were, only 3% reported a higher knowledge than interest, and 19% gave the same score for knowledge and interest. The fact that most participants (98%) are showing working knowledge of science contradicts the self-reported knowledge. In other words, people may be more knowledgeable about science than they think they are, or report that they are. If more aware of free-choice learning, working knowledge and their importance, people may realise that they know more than they think. They may have more confidence in the knowledge that they gain through free-choice learning and be more likely to take part in further free-choice learning. This, in turn, could provide further support for free-choice learning providers, but also support the recognition of working knowledge in formal education. This is related to findings by Thomas and Harri-Augstein (1983, p.334) when looking at Kelly’s idea of people as scientists. They found that when people were more aware of the process of their learning they showed increases in subsequent learning performance.

Greater awareness of free-choice learning may simply be realised through recognition and support for providers. Not only those providing learning opportunities but also encouraging and supporting the building of free-choice learning skills. This includes support for free-choice providers like libraries and community centres, but also formal education providers like schools, colleges and universities. In addition, more open access to scientific and technical research would recognise the importance of free-choice learning. Back in 1991, Wynne was suggesting that more “flexible social access to diverse sources of scientific information” should be provided (Wynne, 1991, p.118).

If people can recognise that they are learning about science from a range of sources and that they have their own working knowledge of science, and if the importance of these is recognised, it may follow that the objectives stated for the public understanding of science and for scientific literacy (as outlined in the literature review, Pages 22 and 46) are answered. For example, if an individual has more confidence in their working knowledge of science they may be more likely to take a technical job, they will see themselves as more informed with regards to political arguments about science, be more likely to be involved in debate, be more supportive of science, be interested in science as a cultural endeavour and take part in more free-choice learning about science and other subjects. This understanding and appreciation of our own learning has been neatly described in terms of Personal Construct Theory:

> “If we accept the invitation to explore our tendencies to objectify our beliefs and to gain greater awareness of our active role in creating our understanding, we may more effectively maintain contact with the eternal existence of the unknown and approach each new moment with greater freshness” (McWilliams, 2003, p.82).

(ii) Spectrums and Contexts

As well as recognising the importance of free-choice learning and working knowledge, it is also beneficial for society to appreciate that everyone has their own individual working knowledge of science. As discussed in Chapter 6 working knowledge means that everyone is health/scientifically literate but on different levels across a continuum, and to complicate this, there is a continuum for all the different aspects of health/science and all the contexts that health/science is placed in. If everyone has a different level of knowledge and skills in different contexts, combining these skills and knowledge seems a powerful thing to do. Considered from the theoretical perspective of this thesis sharing of working knowledge ties with Kelly's Sociality Corollary. This includes not just sharing knowledge but understanding and sharing how that knowledge has been construed, "To the extent that one person construes the construction processes of another, he may play a role in a social process involving the other person" (Kelly, 1970, p.14).

In addition, if everyone knew the same topics in the same detail, where would new ways of thinking come from? Where would new ideas and solutions to problems come from? Working knowledge and free-choice learning must have an involvement in innovation, even if it is as simple as individuals following their different interests.

Spectrum and contexts should be considered as assets and utilised. For example, some individuals may almost be lay experts (or "experience-based experts" Collins and Evans, 2007, p.142) in certain areas; they could be invaluable as trusted experts in debates. Also, opportunities should be provided for sharing of working knowledge to produce social capital or collective action. Ideally providing places where people can share their working knowledge. The result being a community, or a public, that is high on the spectrum in many different contexts. This correlates with Personal Construct Theory and Kelly's idea of man as a scientist with their own personal theories and constructs. It is the sharing of these personal theories (working knowledge) that is powerful. Bannister emphasised the importance of this saying: "for Kelly the central question for psychology becomes how do people share and use their personal theories?" (Bannister, 2003, p.34). The current thesis suggests that free-choice learning has a significant role to play in the sharing of personal theories.

(iii) Responsibility

Overall, if society were aware of the importance of free-choice learning, and how it has a responsibility to play in scientific literacy, it would be expected that there would be more support, including financial support, for providers of all kinds, from libraries, to aquariums. This support would hopefully include resources in the health arena to enable medial practitioners to utilise working knowledge and for people's working knowledge of health to be shared.

If society can support formal education and free-choice learning providers to work together to future-proof scientific literacy by equipping people with skills for researching, assessing, decision-making, we may find ourselves in a well-informed, learning-rich society. This links back to Personal Construct Theory and a Kellyian perspective of learning as described by Salmon: "Learning, in this philosophy, is synonymous with living itself. As human beings we are all lifelong learners" (Salmon, 2003, p.312).

(iv) A note on the current economic climate in the UK.

At the time of writing this thesis Britain is currently coming out of a recession. Public service funding is being cut and prices of fuel and food are rising. In addition, resources in the National Health Service are under pressure and it seems inevitable that the service will become increasingly privatised. This economic climate highlights the importance of scientific and health literacy. People need to know how to make best use of the resources available to them, and to be confident in doing so.

If we find ourselves in a position where some medical services will need to be paid for the evaluation and decision-making skills in health literacy become even more important. Paying for medical care immediately underlines inequalities in health between rich and poor but also inequalities in health literacy. The same may follow for scientific literacy, where those with better scientific literacy are better placed to make decisions, for example, regarding energy use and energy saving. Education, both formal and free-choice (including the health sector) have an important role to play in ensuring these inequalities do not arise or, at least, are minimised. This is despite the fact that funding to all groups is reducing. So perhaps the most cost effective way of reducing any potential inequalities is the sharing of individuals' knowledge and skills through society. If we can build a strong bridge between formal and free-choice, education can provide an initial network for doing this. This collective action and utilisation of social capital (also discussed in Chapter 8) could lead to a scientifically and health literate community that shares skills and knowledge to face and overcome current and future challenges. From the personal construct perspective of this thesis, “The human quest, in Kellyian philosophy, is ongoing and lifelong” (Salmon, 2003, p.313).

SUMMARY OF RECOMMENDATIONS

FOR FREE-CHOICE LEARNING PROVIDERS

- Use the importance of free-choice learning as evidence to support funding.
- Recognise the importance of own free-choice learning activities.
- Share and increase the awareness of the importance of free-choice learning.
- Consider new outreach locations and collaborations.
- Reconsider ideas for bridging with formal education.
- Provide activities to build skills for future-proofing scientific literacy.
- Provide activities that allow for different learning styles, e.g. to do, to watch/see, to reflect on.
- Take advantage of people’s existing interests and needs to provide topical or relevant activities.
- Recognise importance of formative evaluation and summative evaluation in providing contexts and helping to future-proof activities.
- Consider setting out aims of activities in terms of increasing the complexity of working knowledge.
- Consider using increases in the complexity of working knowledge as a measure of impact.
- Be part of a free-choice learning infrastructure that encourages pooling of people’s working knowledge.

FOR FORMAL EDUCATION

- Utilise working knowledge by integrating it into formal curriculums in order to contribute to the bridge between formal and free-choice learning.
- Consider giving credit for free-choice learning in some way, with the aim of encouraging further free-choice learning.

- Encourage individuals to be more aware of their own free-choice learning.
- Utilise working knowledge as a resource to be shared and built on in the classroom.
- Consider free-choice learning as a provider of contexts to give depth to knowledge and to reinforce knowledge.
- Utilise individuals' working knowledge to provide contexts for others.
- Develop individuals' free-choice learning skills and confidence in learning for the future.
- Consider themselves as a free-choice learning provider.
- Recognise how free-choice learning can contribute to the Curriculum for Excellence.

FOR THE HEALTH SECTOR

- Recognise the importance of free-choice learning and working knowledge in health education and promotion as well as in the day-to-day business of providing healthcare.
- Consider using working knowledge in design and measuring impact of activities.
- Recognise responsibility as a provider of free-choice learning.
- Be aware of how working knowledge contributes to a spectrum of health literacy and contexts of health literacy.
- Recognise that people are free-choice learning resources.

FOR SOCIETY AND ITS INDIVIDUALS

- Recognise that learning takes place in a wide range of places.
- Support and encourage all kinds of learning.
- Appreciate that everyone has their own working knowledge. Everyone is health/scientifically literate on different levels and in different contexts.
- Consider providing opportunities for sharing of working knowledge to produce social capital or collective action.

CONCLUSION

1. Can the BodyWorks exhibits be used as a tool to provide evidence of free-choice learning and working knowledge?

This research has contributed further evidence for the importance of free-choice learning and working knowledge in science learning. This has been achieved by using the BodyWorks exhibits as a tool to stimulate individuals to talk freely about their working knowledge and free-choice learning experiences. The main limitations of this evidence are the small-scale of the study and narrow context of the BodyWorks exhibit content. This immediately suggests that the next step is to carry out the research using sets of exhibits and activities that have different themes. This would aim to strengthen and widen the context of the evidence.

2. Can the BodyWorks exhibits be used as a tool to gain a better understanding of free-choice learning and working knowledge?

A better understanding of free-choice learning was gained in terms of where, why and with whom it is taking place. A better understanding of working knowledge content was achieved as well as how its complexity is increased following use of the exhibits. Again, this evidence is limited by the narrow context of the BodyWorks exhibits and suggests future work using different exhibits and/or activities. Also, the content of working knowledge investigated was limited to facts, understandings, perceptions and values. Working knowledge is likely to be made up of many facets including skills, opinions, attitudes and behaviours. Further research could aim to explore other aspects of working knowledge.

3. What can be gained from revisiting scientific literacy and health literacy concepts from the perspective of free-choice learning and working knowledge?

Revisiting scientific and health literacy from the perspective of free-choice learning and working knowledge has provided key themes to be considered when thinking about scientific and health literacy and how to improve these. The themes are moderately supported by the data collected and analysed under the previous two research questions. The main limitation of this is that these themes are somewhat theoretical in nature. Therefore future work should aim to provide and empirically test practical ideas for learning providers to include these themes in their activities.

4. Can best practice with regards to free-choice learning and working knowledge be shared between the fields of health literacy and scientific literacy?

Sharing best practice between the fields of scientific and health literacy has proved valuable for creating ideas and direction for future work in these areas. These ideas are limited in that they are theoretical and do not provide practical answers for research design and empirical study. Therefore the next step in this work is to take the proposed ideas and build them into further pieces of research, for example by piloting suggestions.

The results from this study provide both support for current practices as well as ideas for the future for various groups. For free-choice learning providers, the evidence for the importance of free-choice learning and working knowledge provide support for their existence and for some of their current activities. In the future, they may consider using working knowledge to lay down aims and objectives and to measure the impact of their activities and exhibits. There is also some support provided for the long-term impact of such activities through the importance of reinforcement of working knowledge seen in this study.

For formal education, the findings provide support for aspects of the Curriculum for Excellence in operation in Scotland. In the future formal education may recognise working knowledge as a resource that can be utilised in the classroom. In addition, the fact that people seem to have a great interest in health related information could be exploited and health and medical themes used to introduce other science topics.

Those in health education and promotion could also see working knowledge as a resource to build on. It is important that the heath sector is aware of its role as a free-choice learning provider. As with free-choice learning providers, they could consider working knowledge in the design of their materials and campaigns.

The first step for all is to acknowledge the importance of free-choice learning and working knowledge and then to work towards exploiting these so that every individual can benefit.

Appendices

Appendix 1a - Photographs of example BodyWorks Exhibits

Balance Board

Reaction Timer

Grip Test

Mind Ball

Appendix 1b - Descriptions of BodyWorks Exhibits mentioned (from Glasgow Science Centre BodyWorks explainer document).

Arm endurance
To do
The visitor must hold onto the handles and with their arm straight out in front of them, they should lift the weight and see how long they can hold it for. As soon as the visitor lifts the weight a timer will start. There are 2 weights and 2 timers for visitors' to compete with their friends. When the visitor can hold the weight no longer they can drop it and the timer stops.
What is it all about?
The visitor will test out their arm endurance with this exhibit. They will have a weight to pick up and see how long they can hold it for. There will be a timer on the exhibit telling them how long they held the weight for. They can then compare their result with their friends. Visitors could improve their score by training but what is likely to happen is muscle fatigue and if they don't rest the time they can hold the weight for will be reduced. To improve they would need to keep practising over time.

Balance board
To do
Visitors have to try to balance on this board for as long as possible. They can then compare their score with their friends. The balance board is pivoted in the centre, so when visitors stand on it they must try to use their core muscles to keep balanced and not tip the board. To start visitors will put their hand on a strip on the table top part of the exhibit. When they remove their hands from this, the time will start. They must then remain balanced for as long as they can.
What is it all about?
Your core muscles (those in your stomach and lower back) and your balance apparatus in your inner ear determine how well you will be able to balance. To become better at balancing you can train your core muscles to be stronger.

Blocked and normal arteries
To do
The visitor has to pump the handles up and down to force blood through the arteries. The artery on the left is harder to pump blood through than the one on the right. The exhibit has 2 arteries, one blocked and one normal. There are 2 pumps for pumping blood through each of the arteries. The blocked artery is smaller in diameter to represent furring inside the artery. This makes it more difficult to pump the blood through the artery.
What is it all about?
This exhibit demonstrates how blocked arteries can cause health problems. The visitor has to pump blood through a blocked and a normal artery. It will be more difficult to pump the blood through the blocked artery as the artery is smaller and therefore restricts flow. Eating too much fat and salt in your diet and smoking can lead to blocked arteries.

Grip test
To do
Visitors hold onto the handle and grip as tightly as they can to see how strong their grip is. There is a digital readout telling them how strong they were. The visitor can then compare their grip strength with their friends.
What is it all about?
Grip strength is determined by many factors, such as age, fitness (strength of forearm muscles) and sex. You can build up your grip strength by doing physical activity to train

the muscles in your hand.

Heart beat drum

To do

The heart beat drum has two handles for the visitor to hold. There are sensors on the handles that pick up the visitor's pulse rate. The pulse rate is then beat out on a bass drum. Visitors can test their resting heart rate, do some form of exercise and then test their heart rate again to compare the difference.

What is it all about?

This exhibit allows visitors to hear their heart beat being beat out on a bass drum. Visitor's hold onto the handles and the drum then beats out their heartbeat. Your heart is a muscle that pumps blood around your body. Your heart has four chambers and the muscles of your heart squeeze the blood through these chambers. There are 2 valves in your heart to make sure that the blood only pumps in one direction. The beating sound of your heart is made when the valves snap shut.

How high can you jump?

To do

This exhibit consists of a board that the visitor stands on. There is a display in the middle of the board. The visitor should stand with their feet on either side of the display. The will do a standing jump and the display records how long they were off the ground for in milliseconds. The longer the visitor is off the ground, the higher they have jumped.

What is it all about?

Visitors can find out how high they can jump and compete against their friends.
This exhibit demonstrates the abilities of our muscles and skeletal system. We can jump much higher when we gather speed before we jump, however, from a standing jump it is much trickier to jump high. Visitors may find it easier to jump higher by bending their knees and using their legs like a spring. Our bodies have amazing strength because of the way our bones and muscles act together as levers.

How much water?

To do

The exhibit is a set of scales with an altered dial so that it reads in litres. The visitor can step on the scales and find out approximately how many litres of water they have in them.

What is it all about?

Your body is about 60% water. You need to drink lots of water, milk or fruit juice everyday to keep these levels up. You lose water through sweat, so when you're active you need to drink more water.

Mindball

To do

Visitors strap the contacts onto their head and then relax. The Mindball detects alpha waves that the brain produces when you are in a relaxed state. When a certain level of these waves is reached, the Mindball starts moving the ball away from the visitor. The Mindball works by detecting the wavelengths of the electrical impulses of the brain through the contacts on the headband. The programme run by the Mindball then mechanically moves the ball when the level of brain wave production reaches a threshold level. The threshold level required depends on the level that the game is set at.

What is it all about?

The Mindball can be used to train your brain so you can tell when you are relaxed. Research has shown that by making yourself more aware of the state of your brain i.e. relaxed, then you are able to train yourself to get into that same state again more quickly. This would be ideal for athletes who need to remain focused before a competition. Using the brain trainer would allow them to get better at getting into a completely relaxed and focused state just before an important race.

Reaction timer
To do
There a number of lights on the board and next to each is a button. When a light goes on the visitor must press the button next to it as fast as possible. As soon as a light goes on a timer starts, which only stops when the corresponding button has been pressed. The average reaction time is calculated based on the reaction time taken to react to each of the lights appearing in the sequence.
What is it all about?
Training (practice) can reduce your reaction time. Visitors can use the exhibit to hone their reaction times to get better at reacting to specific stimuli.

Smoker's lungs
To do
The lungs are attached to a pump. The visitor can pump air into each of the lungs to inflate them.
What is it all about?
There are two lungs in a box; one healthy and the other are the lungs of a smoker. The visitor must pump air into each of them and notice the difference in how they inflate. The smoker's lungs look very dark in colour and do not inflate as much as the healthy lungs. There is a very obvious difference in the way the smoker's lungs and the healthy lungs inflate - the smoker's lung does not inflate as fully as the healthy lung. This demonstrates the effect of smoking on lungs.

Torso
To do
Visitors can take the organs out of this torso and then try to put them back into the correct places.
What is it all about?
The torso is a standard plastic torso used for teaching anatomy. The organs are anatomically correct and in proportion to the size of the torso.

Appendix 2 – Interview Schedule

Age(s)

16-19	20-29	30-39	40-49	50-59	60+

Age if under 16 ________________________

Level of science education (if over 16)
School - GCSE/Standard Grade/A-level/Higher

How interested are you in science?

Not at all				Very
1	2	3	4	5

How knowledgeable would you say you are about science?

Not at all				Very
1	2	3	4	5

Appendix 3 – Plain Language Statement

University of Glasgow | School of Education

VIA VERITAS VITA

The University of Glasgow, charity number SC004401

Plain Language Statement

Study title and Researcher Details

Previous experiences and the BodyWorks exhibition.

University of Glasgow, Department of Curriculum Studies

Researcher: Elaine Malcolmson

Supervisor: Professor V Lally. Department of Curriculum Studies

Invitation

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask if there is anything that is not clear or if you would like more information. Take time to decide whether or not you (and anyone in your care under the age of 16) wish to take part. Thank you for reading this.

What is the purpose of the study?

This study is looking at the things people already know about the topics covered in the BodyWorks exhibition from Glasgow Science Centre. The study is also interested in where people gain information about health and science. This can be things like books, newspapers, television, friends medical staff etc.

The results of this study will help to improve future activities at the science centre.

Why have I been chosen?

You have been chosen to take part in the study because you have used the BodyWorks exhibits. Throughout the day other people will be asked to take part in the study.

Do I have to take part?

It is up to you to decide whether or not to take part. If you decide to take part you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

The researcher will spend around 15 minutes talking to you about the BodyWorks exhibits you have used. This conversation will be audio-taped and the researcher will make a note of your answers and any comments that you have.

Will my taking part in this study be kept confidential?

All information, which is collected about you during the course of the research will be kept strictly confidential. You will be identified by an ID number and any information about you will have your name and address removed so that you cannot be recognised from it.

What will happen to the results of the research study?

The results from this research will be published as part of a PhD study in the School of Education at the University of Glasgow. You will not be identified in any publication.

Who is organising and funding the research?

This is a joint research project between the University of Glasgow and Glasgow Science Centre. It is funded by GlaxoSmithKline, who have also sponsored the BodyWorks exhibition.

Who has reviewed the study?

This project has been reviewed by the School of Education Ethics Committee.

Contact for Further Information

For further information please contact Elaine Malcolmson, email e.malcolmson.1@research.gla.ac.uk

If you have any concerns regarding the conduct of this research project, contact the School of Education Ethics Officer, Dr Georgina Wardle at g.wardle@educ.gla.ac.uk

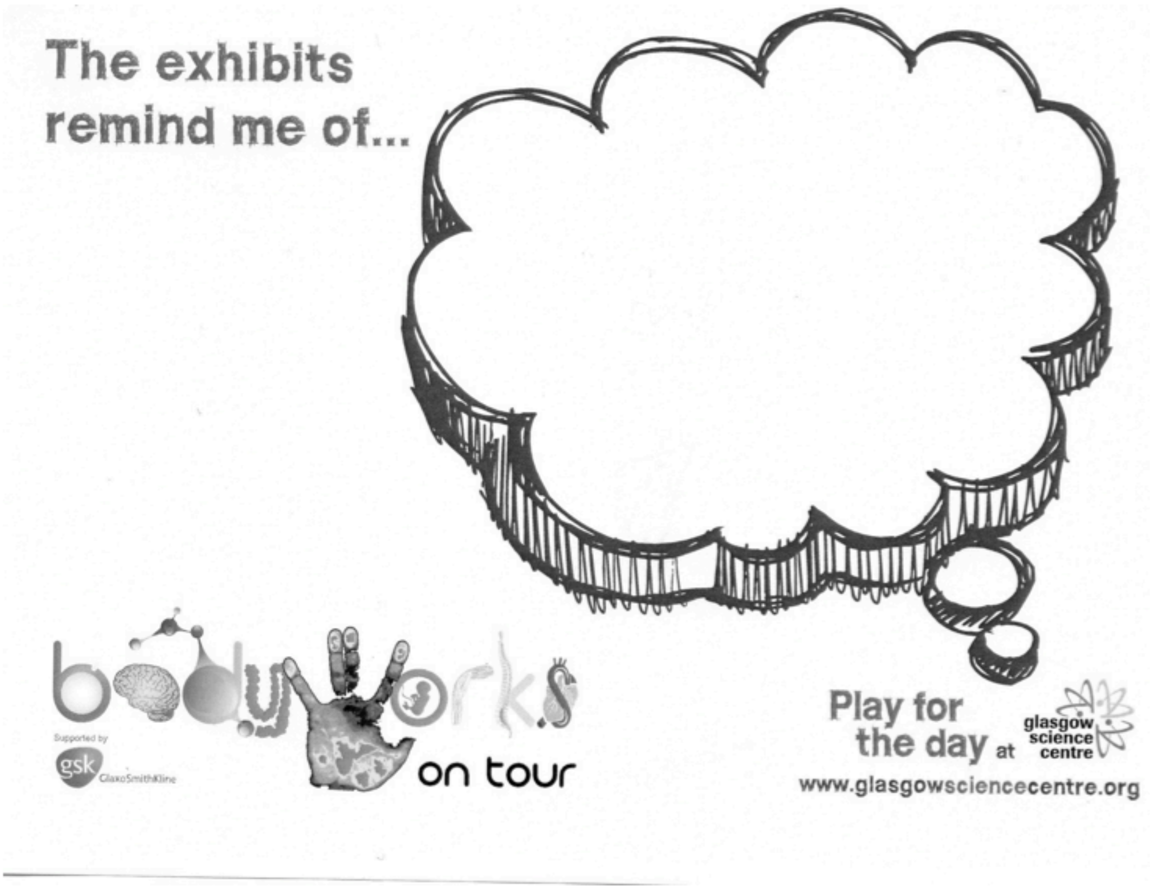
Thank you for taking the time to be involved in this project.

Appendix 4- Example of a coded interview transcription

		Working Knowledge	Free-Choice Learning	Free-Choice Learning details	Increase in Complexity of WK
RESEARCHER	Just about these exhibits. Did you find any of them more interesting than the others or did one of them stand out for you as being particularly interesting?				
SUBJECT	Well I would have to say the blocked arteries one. I was surprised at how hard it was to pump because it was slightly thinner I would have to say. And em, I've not tried the reaction one but yeah I would say the blocked artery one probably got my attention the most.	Understanding			Add
RESEARCHER	Yeah, and have you seen anything about, or can you remember where you've seen things about blocked arteries before or any information you've seen maybe on the TV or in the news or anything				
SUBJECT	I probably haven't paid attention an awful lot but a friend of mine had a heart attack recently and he's stopped smoking and I think that's maybe why I paid attention to that one	Understanding	Why With whom	Someone's health Friend	Reinforcement
RESEARCHER	Absolutely, yeah. Well tell me what you know then about blocked arteries				
SUBJECT	Well I just thought smoking can block your arteries and then obviously that causes heart attacks and strokes and things	Understanding			Reinforcement
RESEARCHER	That's right yeah. And the one beside that then, the Heart beat drum, did you have a go at that? Did it work for you?				
SUBJECT	My son had a shot at that but he's	Perception Understanding			Reinforcement

	probably a lot fitter than me and it speeded up a little bit but not hugely. But I would if I did it it would speed up quite a bit				
RESEARCHER	So overall..				
SUBJECT	I thought it was good, I thought it was really interesting all of it was interesting				
RESEARCHER	And with the Heart beat drum can you think of anywhere where maybe you've heard something the hear beat or heart rate or anything like that before?				
SUBJECT	Em, well I think probably at the gym for sort of fat burning is your heart not to be a certain, in between a certain range for burning fat and getting fitter	Understanding	Where Why	Gym Leisure	Reinforcement
RESEARCHER	Yeah, that rings a bell to me				
SUBJECT	So that's probably as much as I know I'm afraid				
RESEARCHER	That's great.				

Appendix 5 – Comment Card



Appendix 6 - Information given to staff with regards to diary keeping

Outline of project
This project aims to look at the relationships that participants make between their own working knowledge and the BodyWorks exhibition.
Working knowledge is "knowledge that has been generated by the learner's own interests and needs" Falk et al. (2007). Working knowledge is not only facts but also understandings, perceptions and values gained through free-choice learning.
Free-choice learning is "learning that individuals engage in throughout their lives when they have the opportunity to choose what, where, when and with whom to learn" Falk et al. (2007).

This project will look at how individuals construct knowledge by adding experiences, learning, opinions, etc from different sources together. It will also gather information on what sources the public uses to find information, or learn, about science (including health).

Pilot Study
A small pilot study has shown that it is possible to bring out in conversation details of individual's working knowledge in relation to the exhibits as well as evidence of free-choice learning and resources used to acquire knowledge.

Methods
Unstructured interviews
Staff diary notes
The aim of these methods is to obtain a more accurate representation of a mental model by using different methods for participants to communicate that mental model.

Information inside diary

INFORMATION TO RECORD

Date **Location** **Time**

School/Public **Comments on event**

Questions/Conversations/Comments
Who? What? Why? Particular exhibit?

Thank you for your help.

Appendix 7 - Example of diary entry and subsequent transcribed staff interview

Diary Pages

[redacted]

3/6 (6)

[redacted] P.S.
17^{th} May 2011
P1-3

Journey show for P1-3 in morning.

Reaction Timer

After explaining how to use the exhibit a P1 boy said "It's just like 'Whack-a-mole'."

Flex the Muscle

A P1 girl said it looked like an elephant.
Once explained it was an arm, she said it's a weight lifter like my uncle. He has big muscles.

[redacted] PS
18th May 2011
P4-7

Balance Board

A P5 girl said it reminded her of surfing.

Blocked & Normal Arteries

A P5 boy was talking about heart attacks / strokes and said in a film he saw a man use two electric plates to prevent a heart attack.

A P6 girl said her gran had to have her leg amputated because of blocked arteries. She smokes and has diabetes.

[redacted] PS
19th May 2011
P5-7

Balance board

A P5 girl said it's just like surfing.

Mindball

A P5 boy said this is just like how you measure earthquakes by measuring tiny changes.

[redacted] PS
25th May 2011
P1-4

Torso

A P3 boy said he should be good at it because his dad is a doctor.

Transcribed Interview

STAFF D	So, went to ******* Primary School on the 17th May and so we were seeing primary 1 to primary 3. We did a Journey through my body show in the morning followed by exhibits sessions when they came back. So for the Reaction Timer I was talking to a primary 1 boy and I often find when they're that young, you know, they struggle in many ways to use the exhibit. So a lot of our focus is to get them to work it properly and it's difficult to think about abstract things. But this boy said you know it's just like the whack a mole game. so he immediately related that game to something else he'd seen. And that was actually before we, before they were let loose, I was trying to, I take them round and explain how to use the exhibits, and that boy just shouted out, but I think that actually made it easy for everyone else, they all immediately got it
INTERVIEWER	Its funny, cos adults have said its just like whack a mole as well
STAFF D	I was kind of pleased because he was so young.
INTERVIEWER	No that's really good.
STAFF D	Em, for Flex the muscle, a primary 1 girl, I think I maybe asked, you know, what do you think this metal thing is, cos its quite an abstract picture. She said it looks like an elephant, so I explained that it was an arm, and then she said it looks like a weightlifter and her uncle is a weightlifter and he has big muscles.
INTERVIEWER	OK
STAFF D	For Arm endurance, a primary 3 boy just shouted out really loud, its gonna blow, eh, cos he thought it was like a bomb

INTERVIEWER	Right
STAFF D	I don't know, I don't know how, if the timer was running at the time or, cos the timer doesn't actually run unless you are holding the rope
INTERVIEWER	OK
STAFF D	OK so that was all from the same school, from a different school, ************ primary school on 18th May, the exhibits were for primary 4 to primary 7. So the Balance board reminded a primary 5 girl of surfing. So she was thinking about that on that exhibit. For Blocked and normal arteries, a primary 5 boy was talking about heart attacks and strokes and then in a film he saw a man use to electric plates to prevent a heart attack. So he was thinking about a thing, which doesn't prevent heart attacks but you know. But he was certainly thinking about other things in medicine and things he'd seen on TV. Which I wonder if I was discussing what happens when arteries get blocked or if he just came to that conclusion
INTERVIEWER	Thinking himself, yeah, its hard to know
STAFF D	Its always slightly morbid if they start relating it to their family or something.
INTERVIEWER	I suppose he could just be thinking, arteries, heart, heart attack
STAFF D	Yeah, yeah. In the same class, a primary 6 girl said that her gran had to get her leg amputated because of blocked arteries and she smoked and had diabetes.
INTERVIEWER	So if she's linked all that together, it's pretty smart.
STAFF D	Yeah, quite a morbid class, I didn't like that. Em, so a different school again, Lauder primary school, on the 19th May it was primary 5 to primary 7. Eh, with Balance board, the exact same, a primary 5 girl said its just like surfing
INTERVIEWER	OK Where is ******? Is it
STAFF D	That's actually quite close to ***********
INTERVIEWER	Yeah, I was thinking it must be an East coast thing, surfing
STAFF D	Yeah, cos that was the same, we stayed over in that area. I must have had déjà vu at the time but not really. Em so Mindball, a primary 5 boy was looking at the graph created by the electrical signal and said that its jus like how you measure earthquakes, by measuring tiny changes. So he looked at the graph and thought that it reminded him of the earthquake thing
INTERVIEWER	That's good
STAFF D	Then, I can't pronounce this ********, I want to say, primary school but that was the 25th May primary 1 to primary 4. With the Torso exhibit a primary 3 boy said, he should be really good at it because his dad is a doctor.
INTERVIEWER	OK, that's great
STAFF D	And that's my comments for that period
INTERVIEWER	Very good

Appendix 8 - BodyWorks development paperwork

GSK Outreach Programme PID v11.doc

Programmes Project Initiation Document

Project Details

Project Title	GlaxoSmithKline (GSK) Life & Health Scotland
Project Leader	[redacted] Glasgow Science Centre
Description	A four-year funded Life & Health Outreach programme. supported by GSK. The project will support to teachers, pupils and family audiences across Scotland to effectively engage with the new Scottish Curriculum for Excellence; and ideals of healthy living choices to inspire people to improve the quality of their lives. With emphasis on the 'Our Living World' component of the curriculum, this programme will utilise specially designed tabletop exhibits and activities to support effective learning and teaching in science.

GSK Exhibit Development.doc

GSK outreach exhibition

Exhibit description

This is an outreach exhibition on the subject of Life and Health. The exhibition is primarily aimed at late primary and early secondary school pupils, approximately 9 to 14 years. However, there will be a few exhibits that are targeted specifically at early years and these will not be taken out to older children. These few exhibits will be combined with some of the other exhibits to be used for early years groups. The interpretation on the exhibits taken out to early years groups will be changed to reflect their skills and level of understanding.

The exhibition will cover the topic of life and health with the emphasis being on sport and health. The exhibition should aim to inform the visitors about their bodies and what they can do to be fitter and healthier. The exhibition will cover the topics of:
Anatomy – anatomy of the human body will be covered from a health and fitness aspect. This will include organs, muscles, bones, joints, ligaments and tendons.

You and your body – looking at body comparisons between visitors: what can your body do? This is in terms of health and fitness, such as flexibility, reach and grip strength tests.

Health and healthy living – looking at lifestyle factors affecting health, such as, smoking, diet, fitness and perhaps alcohol.

Sport and fitness – looking at different sports and means of getting fit and their affect on the body, such as cardiovascular system, muscles strength, training and fitness.

The exhibition could be developed as a full package or project to cover A Curriculum for Excellence for science. The exhibition and shows and workshops, combined with pre and post visit materials could be developed to tie in with the curriculum. When a school signs up for the outreach exhibition, they can use the toolkit to take their class through the necessary modules relating to Life and Health for a specific age group (in this case 9 to 14) based on the requirements on the curriculum.

How does it work?

The exhibits will be portable and easily manoeuvred so that 2 staff can set up the exhibition in a very short time.

The text panels will be designed to be easily interchangeable to allow different interpretation for different audiences.

Perhaps some of the exhibits that requires visitors to test themselves, i.e. blood pressure, and then try some physical exercise and re-test, a timer of some description could be included. Perhaps an egg timer to allow the visitor to exercise for 30 seconds to a minute and then try the exhibit again to see if there is a difference.

Evaluation

Signage

There will be two lots of signage: one lot for the main target audience, and one for early years. Not all of the exhibits will be interpreted for early years, only those that are suitable for the age group.

References

GLO's

Knowledge and understanding – the visitor will gain an understanding of their body and how it works. They will learn the reasons why it is good to maintain a healthy lifestyle. The visitor will make sense of why it is good to keep fit, eat healthily, not smoke etc, and make links between bad lifestyle and ill health, weight gain, ageing etc.
Skills – visitors will learn physical skills, by showing them how to improve grip strength etc.
Attitudes and values – the exhibition may change visitors' opinions about health and healthy living: they may change their mind about smoking, eating fatty foods, not exercising etc.
Enjoyment, inspiration and creativity - this exhibition will be fun and potentially inspiring.

Development history

The exhibits are going to be developed by an exhibition builder. Many of the exhibits will be standard, exhibits that already exist, with a few original exhibits.

Last updated

9 September 2008

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