Educational Implications of Research into the Everyday Experiences of Adults

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Abstract

Educational decisions for schools are often made on the basis of assumptions , or underdeveloped notions, about the lived experiences and needs of adults. This suggests that focussed research on aspects of adult experience might provide understandings that could lead to more valid decisions being made in education. This paper examines the potential of detailed studies of the everyday life of adults to inform the development of education, with a particular focus on the areas of science and technology education.

A case study of the everyday life of a dairy farmer is presented to demonstrate the potential of such research in assisting the clarification of some fundamental questions in education. The case study is one part of a larger study commenced in New Zealand which has used extended interviews as the primary methodology to investigate the complex science and technology experiences of a range of adults in in different life situations. The project has selected individuals to reflect diversity in terms of gender, ethnicity, occupation, age and family structure.

The findings suggests that there is significant potential from such a research agenda. In the case of science and technology education, research into adult experiences could inform decisions about the scope of science and technology education, educational aims and learning and teaching approaches.

Introduction

In a challenging paper, Jenkins (1992) has a called for a fundamental reconstruction of the science curriculum and refers to recent statutory curricular changes in England as representing "a lost opportunity" to do so. A fundamental question is raised by Jenkins concerning how much understanding of a conventional science is needed by students in order for them to function effectively as adults in society (1992, p.231) He suggests that "one provocative answer is 'Not very much'. A more cautious response is 'We do not know'".

Yet it is generally the case that curriculum developers in science and other areas make assumptions about, or use very limited research data, to determine the skills, knowledge and understandings that students should acquire in order to become competent adults. There are exceptions to this general practice, and the work of Charters during the 1920s in using activity analysis as the basis for the development of a college program in the U.S. is an extreme - if not notorious -

example (Kliebard, 1977). (His brief was to develop a course which would provide "specific training for the specific job of being a woman", and his data base was provided by 95,000 survey responses from women in terms of what they did for a week (1977, p. 616.)

While such an approach used by Charters appears to have circumvented debate about the curricular aims and content, recent discussion in Australia about what should constitute the school science and technology curricula has been vigorous . Some of the most interesting debate has emerged in the development of the national Statements and Profiles in these domains.

It can be argued that the traditional science curriculum has been a watered-down version of university science, and this has been true even at the primary level, with its strong emphasis on "process skills" science. The content and aims have been heavily influenced by traditional disciplines of science, and we can see in the four content strands of the national Science Statements a continuation of that influence. With the development of the Profile, all sorts of assumptions have been made about what students should end up knowing, and of course, the identification of this is essential to building an effective science curriculum (Rutherford and Algren, 1988, p. 77-78). While there are some innovative elements in the approach being advocated in the new developments, we must question to what extent they are based on sound knowledge of what people actually need to know for their adult life.

This is possibly even more problematic a question in the development of a technology curriculum. For there is far less consensus in defining what technology is as compared to the situation for science. The discipline base of the technology curriculum is also far less secure; but this might be an advantage in the long term. If the conflict can be overcome between areas that are redefining themselves as Technology (industrial arts, home economics etc.), then fundamental questioning might be more possible about the rationale, aims and content of technology curriculum than is the case for science education which is relatively entrenched in school systems.

The promotion of both of these areas is occuring in a political context in which frequent concern is voiced about the economic health of the nation. As we are well aware, in many circles science and technology education are viewed as having the potential to solve some of the prodigious economic and social problems confronting Australia. There is clearly a danger that dominant answers to the question of what knowledge should be learned might be based on this view.

Recent Research on Public Understandings of Science and Technology

Some of the recent research into the public's understandings of, and attitudes to science and technology, may also tend to restrict curricular conceptions of valued science and technology knowledge. In the past decade there has been increased research into conceptions of science and technology of the general population in a number of countries. It is clear that this quickening of research into public knowledge is related to the economic priorities of Governments, and policies that are directed at increasing producing a more productive culture - especially through the schooling system. Intensive debates about scientific and technological literacy have emerged largely out of such concerns, with many writers arguing that notions of literacy should not be overly simplified, and simply tied to narrow concerns about economic life (Kenny, 1988; Schibeci, 1988; Shortland, 1989;

Jenkins, 1990). Shortland notes, for instance that beyond a superficial consensus about what it means to be scientifically literate

lie profound differences of orientation, of outlook, and of aim. That these differences are not more obvious is due chiefly to the deceptive simplicity of the notion of the public understanding of science (1989, p.312)

Research that has focussed on the levels of scientific knowledge of the public has typically resulted in wide media reportage and pronouncements about the serious nature of the levels of ignorance displayed. Maybe the best known project of this nature is that of Durant et al in the UK (1989), and there has been similar work led by Jon Millar in the US (National Science Board, 1988). Closer to home, surveys in Australia and New Zealand have demonstrated that much of the public has limited understanding and knowledge (Eckersley, 1988; Burns, 1990a; Department of Industry, Technology and Commerce, 1991). The work of Eckersley, which provided an overview of Australian research, underlines significant aspects of public attitudes to science and technology, and Eckersley argues that there is a good deal of ambivalence toward science and technology demonstrated by the majority of the Australian population. There are some some findings that indicate that attitudes to science and technology are significantly related to gender and education, with a tendency for males and more educated persons perceiving them more favourably. Some of the recent research has been focussed on school students' understandings and attitudes in Australia and New Zealand, and such research has resulted in similar expressions of concern (for example, Centre for Technology and Social Change, 1990; Burns, 1990b).

Much of this recent research on the relationship of the public to science and technology, must be critically scrutinised, for there has been a tendency to rely on large scale surveys as the favoured methodology. More seriously, much of the research has made grossly simplified assumptions about the nature of science and technology, has tended to focus on "basic scientific facts", and has not considered how adults and children obtain scientific and technological knowledge and utilise it in everyday life . According to Birke(1990), the public has been portrayed as "inevitably deficient".

Many researchers have ignored, or been unaware of, promising work that already existed in the 1970s (for example, Hanlin 1972) and which has been reviewed by sociologists Etzioni and Nunn (1976). For instance, Etzioni and Nunn argued that while the data they were using were "rather thin", it was clear that

not only are the various segments of the public not of one mind about science, nor quick to change in their appreciation of it, but the same person often has a very complex set of feelings about the various facets and meanings of science, and the picture a survey produces - whether attitudes are more or less modern- depends on which facet it mobilizes in each person (pp. 238-239).

They noted that individual attitudes toward technology are also complex, and that the "overwhelming majority of the public seems to confuse science and technology" (1976 , pp.240-241).

It is reassuring that now there is a growing recognition and critique of the simplified methodologies, assumptions and theoretical frameworks used in the past few years in much of the research. For instance, while recent investigations by Daamen et al (1990) in the Netherlands use survey approaches, the work demonstrates the need to use a more

finely specified conception of technology. They found that an adult typically has different attitudes to different technologies (they included eight different modern technologies), and the attitudes toward "technology in general" are not stable and can easily be affected by how the subject is introduced. The research also suggests that correlations between attitudes toward technology in general and many of the eight areas of technology examined appear to be low.

Some research currently being undertaken in England on science and the public includes projects that are breaking new ground, and these include some that are qualitative and small scale in nature. A useful overview of this research has been provided by Ziman (1991), and although the findings and their interpretations have not been fully realised, Ziman presents some stimulating insights into where this research is heading in terms of its challenge to earlier assumptions. He notes that

a simple "deficit" model, which tries to interpret the situation solely in terms of public ignorance or scientific illiteracy, does not provide an adequate analytical framework for many of the results of our research (1991, p.101).

Ziman suggests that the research is tending to jell around a number of broad principles which he has referred to as Incoherence, Inadequacy, Incredibility, and Inconsistency, and all of these refer to science – not individuals . It is a science whose meaning and usage is actively constructed by individuals in specific life situations. A similar set of comments on this important UK research is made by Wynne (1991), a sociologist in science, who notes that

public uptake(or not) of science is not based upon intellectual capacity as much as social institutional factors having to do with social access, trust, and negotiation as opposed to imposed authority (p. 116).

One strand of recent research, noted by Birke (1991, p. 20), is that when a need develops, an individual "can and will gain understanding of science. But what they gain will be knowledge that suits their particular needs" . We are beginning to see that different people utilise science in different ways depending on its relevance to them in particular contexts.

It is clear that researchers, who are examining science beyond the classroom in adult, complex situations, are at the beginnings of a major advance in development of theoretical frameworks. These advances parallel those experienced a decade or more ago by science educators as they began exploration of what we have come to refer as "children's science"(Osborne and Freyberg, 1985). Children's understandings of scientific concepts became widely researched and the findings have been influential in pedagogical approaches, and the influence of this research is also apparent in the national Science Statement and Profile. Maybe, the promising explorations of adult experiences of science and technology might eventually have a similar impact, leading to the sort of reconstruction of curriculum advocated by Jenkins (1992).

The Focus of the Project

The project reported here commenced in 1991, and became known as the RETEL – Research into the Experience of Technology in Everyday Life –

Project. The research project has been based on a number of assumptions and emerging literature findings, viz.

a. research into adult everyday experience of science and technology will have significant implications for the education of adults and children, and in particular, for science and technology education;
b. technology permeates our lives to such an extent that we can talk of a "technological texture to life" (Ihde, cited in Ferre (1988, p.9), or as Wenk (1986, p.6) suggests "we not only live with technology, we live technology";
c. ambivalence, inconsistency and contradiction are a common feature of individuals' attitudes to science and technology;
d. technology and science are not monolithic, and are not so experienced by individuals;
e. measuring attitudes to science and technology is a very restricted aspect of the total experience of individuals in these realms;
f. research should not adopt an uncritical understanding of science and technology which is likely to result in a tendency to demonstrate deficit public understandings.

RETEL has a particular interest in technology, however the approach adopted for the field investigations has been to make a priori no rigid distinction between technology and science. This approach has been influenced by Pinch and Bijker (1987) who note that one cannot assume that science and technology are "well-defined monolithic structures" but rather they are "themselves socially produced in a variety of social circumstances"(p. 20).

Aims and the research questions

The aims of the RETEL project are to investigate

the skills, knowledge, understandings, valuing, attitudes, feelings of adults in their everyday experiences of technology and science;
the symbolic meaning that different technologies have for individuals in their everyday lives and the nature of the relationships that exist between individuals and the technologies;
the extent to which individuals define experiences as technological and/ or scientific experiences;
the extent to which they are aware of the pervasiveness of technology ("technological texture") in their lives;
the linkages between individual experiences of technology/science and

how these linkages might relate to an individual's generalised conceptions of technology and science; and
the implications of the findings for technology and science curricula in terms of their rationales, aims, contents and pedagogies.

The primary goal of RETEL is to draw out implications of the research for curriculum development . Educators of science and technology assume and hope that their endeavours will have a lasting impact on their students, not only in their careers, but more generally in their everyday lives. But educators really know very little about the long term outcomes of their endeavours. As we have seen, evaluating those outcomes would be really problematic since "so little is known about the needs of students and adults for scientific knowledge"(Jenkins, 1990, p.49). It was to add to that knowledge that this project was commenced.

Methodology

The methodology of RETEL has been based on the need
a. to explore in depth the complexities of individual experience, and an interview approach has therefore been selected as the primary research tool;
b. to examine the diversity of experiences in society, and as a result individuals have been chosen to represent a broad cross-section of society; and
c. to explore experiences of different areas of technology, and therefore interview questions have focussed on a number of areas of everyday life, including paid work, homelife, health, leisure, and transport.

Subjects:
Individuals have been selected on the basis of preliminary information about their occupations, life situation, age, gender, ethnicity, social class. Equal numbers of males and females have been chosen. Eight individuals in New Zealand were interviewed during 1991 and 1992; and a further eight will be chosen and interviewed in Australia.

Interview:
The interview schedule consists of five sections.
Section I collects background data on the subject.
Section II is a major section which explores an individual's experiences in an aspect of housework, paid work/unemployment, health, and leisure or transport. The particular aspect in each area is nominated by the subject as one that has major significance for them.
Section III explores a subject's generalised conceptions of technology, science and the inter-relationship of technology and science.

Section IV asks subjects whether they perceive technology/science in each of the aspects of their everyday life previously discussed in section II.
Section V involves free-ranging discussion of my perceptions of inconsistencies and uncertainties voiced during the interview, and also investigates why they believe they have experienced technology in the way that they have (e.g. has gender, age been significant?).

It should be noted that as the interview proceeds there is a decided shift in the stance of the interviewer. In the introductory comments, and in sections I and II, the researcher does not introduce the terms "technology" and "science", but rather speaks of "things you use", or products and appliances. If interviewees introduce the terms , then I use them cautiously and in terms of their own meanings. In this section, the stance adopted is very much that of the naive listener. It is only in subsequent sections of the interview that I use the terms of science and technology extensively, but even then, only with a sensitivity to the interviewee's conceptions. In the final section, however, the stance again changes and here interviewee's are invited to reflect on what they have said earlier. Typically I will challenge individuals and introduce other conceptions of science and technology in clarifying where individuals position themselves in the discourse.

Central Concerns: A Case Study

From the analysis of interview transcripts, it is possible to present some emergent findings that revolve around two major concerns. The first of these is focussed on the contexts in which knowledge of technology and science are constructed and utilised in everyday life situations. The second major concern is to examine generalised conceptions of technology and science, and how these relate to specific conceptions of these areas in particular everyday situations.

To share initial insights into these two aspects of the RETEL project and their curricular implications, we present a case study of one subject. That individual is George Lane (a pseudonym), who is a 33 year old dairy farmer in the Waikato District of New Zealand. George grew up on a dairy farm not far from where he now lives. He completed high school and a three year diploma in architectural drafting at a technical institute (but has never practised). George has spent virtually all of his adult life in dairy farming, is married and has a baby daughter. The farm that he now owns has 300 cows on it and he employs some labour.

1. The Contexts of Everyday Knowledge of Technology and Science

An examination of the data has suggested that the context of the construction and use of everyday knowledge can be analysed so that we can identify: key factors that constitute the context, motivations for seeking knowledge, sources of knowledge, evaluation of knowledge, and the breadth and depth of the knowledge constructed. The interview with George Lane, not surprisingly, centered around one of his essential challenges, that of growing grass, and it is this that is the major source in the following discussion.

a. Key factors that constitute the context

An overarching factor in the context in which George works is the economic one. He notes that

We're on touch and go. If this situation stays for say three years we'd be a marginal farm.. . . . .In the situation we are in, in the spring, I can make a decision that will consequently affect my season's production. It could very easily knock anything up to thirty/forty thousand dollars off my income.

George recounts "one of the hardest lessons that I've ever learned" when a decision he made about grazing his cows one year resulted in such a loss. He says people are not aware of this "management side" to farming and how mistakes cannot readily be rectified.

In the farming context there is also a range of legal requirements that must be met, including health requirements and the eradication of noxious weeds. The latter activity is taken up below.

George's network of social relationships is a wide one, and it is crucial in providing him with many knowledge resources that relate to his farming activity, and this is discussed further below.
One important aspect of the social context identified by George is his family: for example, the pregnancy of his wife and the birth of his daughter quite clearly have affected the way that he now treats his knowledge about poison sprays. He notes that

I've done a heap of spraying but I think I'm becoming more and more aware of those types of things. . . because we've had a baby, and have have been enlightened by those type of things that are happening. It scares me.

Such a comment reminds us that contexts are dynamic: that as they change so will the need and perceived need for knowledge change. Further, existing knowledge that has been constructed may well be reconceptualized.

b. Motivations for seeking knowledge

Economic aspects of the context both allow and demand of George to seek knowledge. His position in the economic structure as an owner-farmer gives him a significant level of control over his production activities, but for economic viability and success there are pressures. This is clearly why George sees the necessity to be a learner:

Well, I don't think you can ever stop learning. Like it goes back to the old story that you should learn something new every day. I think you have got to, you have got to be open to suggestions all the time because just the slightest little difference–.

Another significant factor in George's motivation to seek knowledge about farming is his admitted fascination with technological innovation and artefacts–and this marked interest is not simply driven by economic concerns. We will take up this aspect again later in the discussion.

c. Sources of knowledge

One is struck by the great range of sources from which George seeks and obtains knowledge about his everyday practices on the farm. These sources include past farming experiences, his dairy farming brother (" the guru of growing grass"), a veterinary friend, dairy companies who provide daily production reports, a consultant from the Ministry of Agriculture (for whose advice he pays $4000 per annum), Field Days, conferences, open days, other farmers, the mass media and controlled experimentation on his farm. There is clearly great complexity in the ways which George will make sense of information and develop understandings from these sources, which may well be conflicting.

d. Evaluation of knowledge

In constructing knowledge to be used in everyday life on the farm, George will evaluate the knowledge that he obtains. This will decide what he selects as worthwhile, and influence the way he will make sense and incorporate new knowledge into his existing stock of knowledge. On what basis does George accord significance and value to the knowledge that he obtains? In the case of his brother, the guru, George notes that he has undertaken an agriculture course and "he's been on the farm ever since he was fifteen", so both life experience and formal training are seen as important attributes by George. Not surprisingly there is a strong pragmatic element in his evaluation criteria. George comments, for instance, on the way he has treated knowledge from a previous Ministry consultant:

We used to have one and we went away from it because we thought they were too conservative, their whole attitude was very, very conservative but, now the government has made [farmers] pay for their own. The conservative guys have tended to be filtered out and the aggressive, go-ahead people have come in and these guys are brilliant.

The status of the source will obviously influence the evaluation of the knowledge from that source, but we will also see later in the discussion that the evaluation will be linked to the context in which the knowledge is sought and obtained.

e. Breadth and depth of the knowledge constructed

The breadth and depth of knowledge to be taught and learned is of course a central curriculum question. But it is also a vital question for the individual in everyday life situations, although there may not necessarily be a conscious decision to seek or limit specific knowledge. It seems likely that individuals will construct detailed knowledge in some situations, but in others the knowledge will be neither extensive, nor detailed. This has been borne out in the early analysis of the project data.

In George's case, there is obvious awareness on his part about many aspects of the ways he seeks out, selects and limits knowledge. Toward the end of the interview he comments:

I feel myself that the way I operate here . . . . that I shouldn't get too involved in any one aspect of it rather than have a basic knowledge of a lot of it. Because all said and done I am here ... the whole reason why I am here is that if I can't make a profit at the end of the day, I am not going to be here much longer. So what I'd like to do is to know as much as I need to know to be effective in that area, but then in areas I think I should actually know more. But why the hell know more if I can get by with knowing that much and still do a good job. Knowing more. Is that going to make it any better? If it doesn't make it any better why know more? Even though you think ... you'd like to and you should know more ... if you can understand my meaning?. . . . . The other too, I think with the wide variety of things I have got to know ... like no. 1 I've got to be a horticulturalist, I've got to be a veterinarian, I've got to be a mechanic and I've also got to be a businessman. Now if I try to do all four of those skills very well, I am not going to make the grade. So I've got to pick out certain skills that I've got to know a lot of and the other skills that I've just got to know a bit of.

The complexity of the context in which he works clearly places demands on George that must limit the time he has to construct detailed knowledge in some areas. A factor that enters into decisions is a cost benefit one, and this is evident when George talks about the mending of some particular artefacts. While he will investigate and fix breakdowns of some of his farm machinery, when it comes to the home microwave he would not, for he says that he

can't see the point in me knowing too much about it. I know enough to operate it. So,leave that to a person who does know a lot about it and me spend more time worrying about other things.

(A very similar comment was made by another subject in this project about her microwave oven, and interestingly she works in the field of electronics.)

It is interesting to note that George talked about the way he limits the pursuit of knowledge from his veterinary friend:

Say the vet comes to talk to me and he'll ... start talking about a reason for this happening. Now I will take the information I want from ... I'll let him talk, I'll ask a few questions ... I'll ask basic questions to find out, OK, how I can improve that and that but he'll tell me ... why it's happening and how it's happening and everything. I'll extract the information I need to rectify it and that's it. As far as the rest of it goes I don't want to know about it.

In referring to the central activity of growing grass, George states that it is not really necessary for him to know the details of the biochemistry involved. Further, he can depend on his brother's detailed knowledge:

what I go and look for is I want to grow a plant, that nice, beautiful,

healthy plant . Now I basically know how to do it as far as what I put on that to make that grow like that. Now I don't know the chemistry attached to growing that. I don't think ... I suppose I should know ... but to me I don't think I should know, if you know what I mean. . . .Well, I should know in the sense that it could be valuable and if it doesn't grow I could then do it myself. I suppose I am lucky I've got a guy who's had forty years of experience of growing grass. Now I've got his information I can tap into.

Here we see a distinction being made between different types of knowledge: it is not simply a case of knowing more or less. George is content with "knowing how", and he is not as concerned with "knowing why", but does recognise the potential value of such knowledge.

George says that he considers himself "a lazy learner. . . . I'll learn as much as I need to get through and that's it". This attitude he sees as being true of his time at school where he "learnt as much as to get a pass mark". We will also see later that his experience of school science was to have a profound influence on his development of scientific knowledge in later life.

He also suggests that the complexity and difficulty of understanding can enter into his decision not to pursue the construction of specific knowledge. For instance, in talking about fertilisers he mentioned sulphur and nitrogen, and on being asked to go further in explaining, he said

The chemical side of it, no, I couldn't. Your pH's and all that. No. . .that's . . .I've got myself to a certain situation and I think if I go any further it's going to be too much to try to understand and I don't think I have to.

He admits to having limited knowledge about the growth of grass and the process involved in the cow's production of milk. His overall instrumentalist view of knowledge is captured in his statement

But what I. . . I feel I've got to know is how I can produce. . .that beautiful plant and I know that that is going to turn into beautiful milk. Turn into beautiful dollars!

2. Generalised Conceptions of Technology and Science

The general conceptions of, and feelings about, technology and science held by George are discussed below, and then his view of their relationship is analysed. The links of these ideas to his everyday experiences in specific situations are then examined.

a. Technology: General conceptions and feelings

Technology in general is seen in a very positive light by George. He thinks that:

It's exciting ... technology it's definitely ... I think it is good in the sense that it is an advancement. Continually advancing which I think is necessary. . .To me technology is like the science of trying to make everything better.

The influence of the mass media on his views is apparent, and he asserts that "basically my technology comes from TV or reading things in the papers. Now, I thrive on that sort of thing". But a good deal of his enthusiasm is buoyed up by frequent visits to places that involve technological innovation:

I love going to places and finding out new little bits and pieces, how people have thought out different ways of doing things different ....like field days, you go and look at some of the things they have done there. Now the thing I like about that is that you've got right from the technology as far as milking cows to making hay to foods to ...

And he is intrigued by inventiveness involved in technology:

I always ... in the back of my mind when I see something like that, I think well, some brainy bugger's done that. Now someone's sat down and thought that out. How clever he must be ... That's my first thought. It's a bloody clever thing that. He's pretty switched on to have done that.

He is also motivated to be interested because of the potential innovations have for his life:

The other thing is that anything that's going to make it quicker and easier and better ... like better grass seeds, better sprays, better medicines ... it's all got to be for the good of everyone.

It is interesting to note, given these foregoing comments, that when George was asked "How much technology do you think you use in your life?" he did not immediately recognise its pervasiveness. He said in response:

I suppose we use a fair bit. Like bits and pieces. Like yeah, I suppose we do ... like I'm forever trying ... we're forever trying different things to improve other things, you know what I mean? Like using the technology available to improve what we've already got. I think yeah, no we use it a bit, yeah.

In terms of a sense of control, George distinguishes between "technology in general" and technology he selects and utilises.

I can control it directly as to what I want to use it for. But that's only at my own situation, but the rest of it no, I don't think we ... I haven't got any control over it. I think it's just going wild, I reckon technology.

For George this wildness is related to its "phenomenal" advancements. But George exhibits some environmental sensitivity with regard to the impact of technology:

The only thing I would be concerned about is if it's going to ... to damage the environment. It would worry me ... it does definitely worry me. I'm not happy about that at all.. . .I think we've already done it but, I think the advancement of technology is now trying to turn it back the other way . Which to me is a good thing.

So we see that George's general optimism about technology extends to its ability to solve the problems it has itself created.

b. Science: General conceptions and feelings

The initial comments made by George about science were stereotypical ones, and their negativity contrasted sharply with his general valuing of technology. For George,

when you talk of science I think of a whole lot of mad scientists, you know what I mean? Like people looking down test tubes and figuring things out. Just ... and I think of like ... I think it is necessary but ... science to me always generates this thought of people ... I don't know ... just without very much thought goes into like all that concentrating on some chemical or some ...the scientists I've always imagined like ... you start talking to them and all they want to talk to is to go back to some experiment or something. . . . going to field days and ... you'll go through a section on a certain part of ... something to do with cows or breeding and they'll have a scientist there and he's possessed by this little fact ... they are that intelligent that they have become narrow.

As has been found for some other project subjects, science is identified by George with one of the sciences:

when you say science I think of chemistry. That's the first thing I think of and then I think oh, no you have got your physics and your biology so and that type of thing. But that's the first thing. As soon as you say science I think of chemistry.

But on reflection he goes further, and has a somewhat more positive image of science:

But when you say that I also think that I suppose I should ... you should ... think of the inventiveness of science that line as well.. . . The guys like ... because I am a dairy farmer I think of people who have developed new products for the dairy industry. That type of thing, you know what I mean?

His negative feelings about science, it appears, are largely an outcome of school science: George notes that he" hated it as a subject at school and that's stayed ..." These negative conceptions and feelings about science are continuing to have important impacts on George's behavior and his openness to scientific knowledge. He comments that

if you asked me to go and have a look through a scientific laboratory or whatever or do something connected with science, no I would definitely not be interested. If you asked me to go and look at a new experiment and that as far as a mechanical thing or a technological thing, yeah I would be very keen. And the sense I am still interested when they say they've now developed a product out of this, I'll stop and look at it but I wouldn't make any effort to ... and if you produced it in front of me I'd look at it but if I've got to go ... do you get my meaning?

He illustrates the point:

You can go down and look at soil samples and that type of thing. [But] I'll walk straight past that. OK. That's one thing that I should look at because it is directly in relation to ...I feel that the information they are going to give me is above what I can understand. That would be my biggest fear....I wouldn't want to go along there and get something thrown at me and then walk away and sort of think what I couldn't understand.

And this fear emerged in school science:

I suppose I could never get a decent grip of it. I liked the physics side of it which I could understand because I like the mathematics side of it but, as far as the chemical side and that type of thing no I just couldn't understand it.

This self-imposed restriction on learning more science contradicts George's claim, noted earlier, that he needs to "be open to suggestions all the time". But George is well aware of this limiting behavior, and he makes a very significant statement about its possible impact on his understandings in everyday life:

But the funny thing about it is I think to myself that I should make the effort because it is so important to what I am doing.

George provides a good example of the widely recognised failure of science education to empower persons as future citizens (Jenkins, 1992, p.243).

c. Relationship of technology and science: General conceptions

We have seen how George clearly distinguishes science and technology much of the time in his conceptualisation, and there are very different feelings about these areas. When asked directly to comment on the differences, his answer is complex:

Technology to me is a practical version of science. Now ... it's more understandable ... I suppose I can relate to it a lot more and I find it easier to relate to. I think that is why ... But really they are both exactly the same ... I feel they both come from the same direction. . . Like they are related in the fact that science and technology are the same ... I suppose it goes back to an experiment doesn't it? They are both doing experiments on different things . . . . .[T]echnology. That's more practical than ... Mainly because I can't understand science... To me technology is a practical side of science and you can see it.

During the interview George shifted ground on the distinctions that he had been making. This changed view is evident in his responses when he was asked whether there was technology and science in each of the activities and artefacts that he had previously discussed. He made interesting comments on this shift, and became obviously involved in exploring his own understandings.

Well actually now that you've made me think of these different things, like you asked science and technology. Like now OK, at the beginning I definitely separated them now as I've gone through each one of these I'm now wondering whether you've got to chuck the whole lot together really. Like technology basically is ... I think you've got to put the capital there as science and then you've got your different versions of it, and technology is part of it. ... science is the heading and then you break it down into different aspects. . . .Up until now I've never thought of that.

He noted that he was just "trying to figure out. . . .what the hang we actually do, where I group those thoughts", and in similar vein,

when I stop and think about it, I think yeah ... they should really be grouped together. But I don't, I am interested with technology but I'm not that fussed on science. I'm interested more on the practical side of things ...

This shift in position on his conception of science and its relationship to technology appears to have resulted in a re-evaluation of its worth to his everyday life:

To me [Science] is very important because it's in my industry, it's a major advancement of the different bits and pieces. No it is, it is important all right. But, it goes back, I just want to know how it's going to affect me and take that information.

And he appears to suggest that ultimately technology is based on science:

Well, I think [science] steers you in different directions. The information that comes through... as basic information about your health or whatever, about products that are available. Like really when it all boils down, it is a science. . . It's the original ... science of that and where that information came from.

We clearly have some evidence of instability in conceptions here, and we have observed that this is the case with other subjects. This observation tends to support the findings in the research of Daamen et al (1990).

The problematic distinction between science and technology has been argued by Jenkins (1992, pp. 232-233), and he notes that the distinction is often more apparent than real. As we examine George's conceptions, we can see some supporting data for these contentions.

Maybe this lack of clarity and certainty in the adult population about the relationship of science to technology is reflected in the vigorous debate in education circles over differing conceptions of science and technology .

d.Everyday knowledge and generalised conceptions of technology and science

We have only begun to explore the relationships that exist between generalised conceptions of technology and science and particular knowledge that has been constructed in specific, concrete situations. Space limitations also restrict our exploration here of the emerging complex picture, but for George we can provide some glimpses of this.

George recognises that he is dependent on technology "for the improvement of our operations" . I think it's all very important for everything you do . . . . .." Given what we have seen are his quite restricted conceptions of science, it is not surprising that George is less certain about the relation of science to his everyday operations.

I think I should ... [when it's] all said and done I use it a lot more than I actually give credit for it. Like I'll use the science of chemicals to try and grow grass, I also use the biological side of it to make my cows health very good. Which are two very important things on my farm and yet I don't like to get involved in it.

Very significantly George has some very fixed notions of where science and where technology is located in his farm life, and these emerge from his deeply held distinction between these areas (in spite of discussions that linked the two during the interview). In discussing growing grass and producing milk, George made a good deal of use of of chemical concepts and theory. For instance,

This soil is a very sandy pumicy soil, so it can't hold sulphur, so that leaches out. Sulphur is very necessary for your grass. Sulphur stimulates nitrogen and nitrogen makes your grass grow. I couldn't actually go into the chemical part of it. [And later he explains] They have now found. . . .if a cow can get as much sugar as it wants to eat . . . the sugar level totally has got a direct response to all its

other minerals. . .If you lift your sugar you lift your magnesiums, your coppers, your cobalts.. . . . . .

When his ideas about science and technology were challenged, George was insistent that fertilisers is chemistry, a central aspect of science:

I look at in the sense of it goes back to... when I think of fertilisers I think of pHs, nitrogens. (I: And that's science?) To me that's science. (I: It's not technology?) No.

We might consider that in growing grass there is a great deal of technology, but this is not George's conception. He emphasises that it is "more as science of growing grass"

A most interesting set of distinctions is made by George while explaining the workings of his motorbike. He sees the technology in the motorbike as "just the mechanics of it, just the workings of it. . . .To me science is in the combustion part of it, then everything else around it is technology." Combustion involves two products being mixed to create an explosion and "to me that's science". When asked about braking George was quite clear that that is technology because that involved mechanics.

While we may be surprised at such distinctions, there is a great deal of consistency in George's position that tends to equate anything to do with chemistry (and biology) with science, and physics equated with technology. This sort of distinction is evident in some other subjects who were interviewed. We must ask what implications there are, if any, from such categorisation and understandings. Is this simply an artefact of the interview? Or does this have a real impact in the lives of subjects? In George's case we have already seen that there does appear to be significance in such constructions: in particular, very different attitudes and behaviors are called forth by notions of technology and science. On the other hand, growing grass is at the centre of George's activities and we must wonder to what extent he actually reflects on his role in the "science of growing grass" as a scientific activity. In practice, we might argue that he is a technologist of grass growing, as well as someone who has constructed a not inconsiderable body of scientific knowledge related to grass growing.

3. Behaviors, Contexts and Everyday Knowledge

From the analysis of data, it appears that is possible to develop a typology that helps us understand how patterns of behaviors, contexts and everyday knowledge are interrelated, and to discuss these typologies draws together many of the threads of the previous analysis. In particular, the typology helps us understand how knowledge comes to be utilised in very different ways by an individual. Such understanding should have significant value for curriculum development. Four types have been identified for George, and these can be referred in terms of his behavior which is marked by Constraint, Experimentation, Uncertainty, and Ambivalence.

a. Constraint

In this case, behavior has a major element of constraint which comes from the context; not only will knowledge be constructed within significant contextual constraints, but constructed knowledge cannot be utilised in the way most desired by the individual.

Part of the legal context in which George farms, noted earlier, is governmental regulation of weed growth. George is expected to control or eradicate noxious weeds: if he does not do so he is liable to prosecution. George complies by using weed sprays, but he is far from happy about this:

'Cause it's not good for you. The sooner they develop something that we can get away from weed spraying I would be very happy.. . . . The chemicals used to doing that are ... they're just not good for you.

George has knowledge of the sprays' constituents and their possible effects:

Well, you've got your 50 Ds they're all hormonal. . . .. they are made basically from hormones, so like ... so continued spraying of them will definitely affect you. It will either make you sterile or that type of thing.

Recent changes in his family situation have altered the context in which he sprays and have influenced his sensitivity to what he is doing:

Like OK, we get the farm sprayed every year. Last year with Linda being pregnant when he was coming I had to say OK, you've got to give me two days notice so Linda can stay in town for a couple of days, that type of thing.. . . .Like, I can go out and spray and I can come back and I'll be perfectly ... I've done a heap of spraying. but, I think I'm becoming more and more aware of those types of things. [This is because] we've had a baby ... and you have been enlightened to those type of things that are happening. And it scares me.

Clearly we can see tensions between the context, George's behavior and his existing knowledge.

b. Experimentation

In marked contrast to situations of Constraint, behavior marked by experimentation on the part of the individual occurs in a relatively free context, and Experimentation involves active use of existing knowledge and a seeking for additional knowledge. A number of instances of this behavior were portrayed by George in his work as a farmer. Clearly the economic context looms large: George's ownership of the farm allows him to experiment, but economic forces also prompt these attempts to lift productivity and increase returns.

In one instance, George has knowledge about overseas practices in dairy farming and is convinced that there may be merit in these for him.

Now people from the States, Europe they feel that New Zealanders have their cows in the condition of controlled starvation. That's the way they term our farming. . . .We hold our cows in a condition of controlled starvation. They don't think we feed them enough. Which could be very true, I don't know. You can't really get into that argument without seeing both stories.

Openness to new ideas is an approach that George claimed for himself, and this is evidenced in his willingness to give a radically new approach a trial:

So what I am trying to do is I am cutting my cow numbers down at the moment which some people say is crazy and by cutting the cow numbers down I'm increasing the food available to them. Theoretically, I'll get more production so I'm actually running less cows that will make it easier to grow grass, that will save me on my animal health, it will save me on my just general farm maintenance side. Consequently I should be better off.

He says "Well, we did it last year and we did record production". As a result of experimentation he has constructed knowledge that the new approach works, and we sense a congruity between knowledge, context, and behavior.

c. Uncertainty

Behavior marked by uncertainty occurs when the effects of a technological artefact are not considered to be known with confidence, but typically factors in the context support the continuing use of the artefact. A nice case of such a situation revolves around George's usage, feelings and understandings about the home microwave oven which he has had for five years, and in which conflicting knowledge has been constructed from different sources.

At the time that he began to use the microwave he reports that "I wasn't too sure about it. Like five years ago a friend of mine says that it's just nuking food, it can't be good for you". In spite of this comment he persisted with its usage, values it highly for its convenience, and admits he has become dependent on this artefact. Indeed the arrival of the baby in the family has made him learn more about it "because we're trying to get food faster and quicker". Uncertainties linger:

I'm not too sure. I'm not too sure ... I've definitely ... sometimes I'm a bit nervous about it because OK, you'll open it and you might put your hand in there and you will feel, the waves whistling around.. . .Yeah, you can get a current on your hand .... it must build up with the electricity in there. Now ... I don't know. It just ... it does worry me ... yeah

When George is asked about his understandings of the science involved in the microwave oven he is unsure:

I don't fully understand the principles of how it actually does it. I know that it ....
Well, it starts in the inside and heats its way out. A series of ... forces or currents or whatever going through and they vibrate more ... the faster they vibrate the hotter it gets. ... I'd say it would be a ... it's not sound ... it's ... I'm not too sure.

In the interview George was asked whether it "mattered to him" that he was not sure, and he said it did not. And this was because he could rely on the knowledge of a friend (in a similar way that he could rely on his brother's detailed knowledge about aspects of growing grass).

Well ... it's quite funny I've got a very good friend in Auckland and he's an actual mechanical engineer. Now he tells me that it's quite all right and he loves his microwave. Now a lot of it ... I go to him and I think "Oh, well if ... he is a health freak and ... He actually goes the other way ... he goes, as far I'm concerned, he's too fiddly ... he gets into things too deeply.. . . . .I just think that if he's prepared to have one I suppose ....

Questions arise as to whether George might be more certain about the use of the microwave oven if he too had constructed understandings for himself more"deeply".

d. Ambivalence.

An ambivalent situation is one where technology has insinuated itself–but also been chosen– in an individual's life and where the individual has both conceptions and feelings about the technology which are unstable and frequently shift from positive to negative. There is a tension between behavior, feelings and knowledge. A very notable example in George's life is his relationship with his motorbike.

Before he purchased the motorbike four years ago, he happily "used to walk everywhere" over his farm. George is now in a situation where he considers its value for work time is "fantastic". He is dependent on it and this dependency "gets worse". Interestingly he reports how his relationship with this artefact changed over time:

First year you tend not to [be dependent on it], the second year you are getting more possessed by it, the third year you're ... and I . . .I think in another five years you just couldn't live without a motorbike.. . . Well now that you know it is there you tend to get on it and do these things before you actually stop and think ... you are just on the motorbike driving somewhere and you think well, it would have been a lot easier to have walked across here. Like ... my classic example ... it's not so much myself I suppose. It's looking at labour units using my motorbike. . . . . Labour units, people working for me. OK, you will say shift a fence over here and they'll get on the motorbike and they'll drive right around the races and then come over here. Now all they had to do was walk across that paddock there and they would have had the fence half finished. That annoys me ... about the motorbike. (I:But you do that sometimes yourself?) Dead right! and it gets worse and worse.. . . .

While the motorbike is prized for being a time saver, its usage is also often seen as uneconomic. George comments on a number of instances and says" Now to me that is an absolute total waste of resources". He also comments that such usage of the bike is also not good for his health:

I'll ride around on the motor bike all day I'll come home here and I'll put my running shoes on and go for a run. . . .Now to me that's crazy. Why not walk around the farm all day?

We can see here then that a technological artefact purchased with certain usages in mind to increase productivity has had unforseen consequences, which are known, and are viewed negatively. But it appears that in spite of his knowledge this technology is not within the total control of George:

Yeah, no, just ... you just tend to get on it and go. Before you actually stop and think you could have done it easier . ... and the more and more you use it the more and more you just tend to do those things.

Again we note a complex of relationships between context, knowledge and behaviors. There are interesting questions raised about "rational" behavior, and the relative influence of knowledge about technology on that behavior.

Conclusion and General Implications for Curriculum

The RETEL Project is based on the assumption that by exploring the complexity of the adult experience of technology and science in everyday life it will be possible to draw implications of significance for education in these domains. Analysis of data thus far suggests that this assumption is a very reasonable one. Indeed, it is possible that the wisdom exhibited by subjects in this study might help with some significant current problems in curriculum. For instance, curriculum developers might clarify understandings of the differences between science and technology using ideas from the general population, rather than rely only on theoretical analyses (such as that proposed by Gardner (1990)).

While my major interest in this project has been with school curricula, it is obvious from the analysis of data that there are also major implications for the education of adults. I have been struck by the marked interest shown by the subjects in the project: a number were keen to prolong the interviews beyond the one and half to two hours taken. Pat Mc Dermott (of the Schools and Curriculum Division, DEET) has suggested to me that this is possibly because "there's a lot of hurt out there in the community". If it is true that there is a great deal of ambivalence, uncertainty, and constraint in the manner in which adults are experiencing technology and science, then maybe consideration should be given to forms of support and to the provision of forums in which adults could work through "the hurt". Such a response might help some adults to develop more effective control over their scientifically and technologically textured lives.

It is not possible from this one case study of a male dairy farmer to draw generalisable conclusions for education. When fuller analysis of other case studies has been completed, it should be possible to make more explicit the influence of critical factors such as gender, ethnicity, occupational status and social class on the processes analysed in this paper.

However, it is possible at this stage to point to an emerging framework of concepts which can be used to analyse everyday experiences of science and technology, and to see how these might impinge on science and technology education in schools. While some of the ideas and implications may not be new ones for science and technology educators, they may well reinforce principles of effective curriculum that have been advocated from starting points that differ from that of this study. The following are significant findings in the study reported here:

a. Experiences in science and technology are a continuing and integral part of everyday life.

b. Everyday technological and scientific knowledge is constructed by individuals in dynamic contexts, economic and social elements being critical elements.

c. Individuals have multiple sources from which to construct technological and scientific knowledge and there is a real potential for conflict in this knowledge that will require evaluation and some form of resolution by the individual.

c. The breadth and depth of knowledge constructed by the individual is influenced by the context in which that knowledge is constructed and to be utilised. It will always be a complex question as to whether it is necessary and/or desirable to possess deeper or qualitatively different forms of knowledge.

d.Individuals construct generalised conceptions of technology and science; with distinctions and relationships between them possibly unclear and unstable.

e. School science experienced decades previously can have a lasting impact on conceptions and feelings associated with science and technology.

f. It is likely that the perceived relationship between generalised conceptions of technology and science and their recognition in everyday activities is highly complex and varied: the relationship cannot be taken for granted.

g.There is a complex interaction between everyday knowledge of technology and science, contexts and individual behaviors. For any individual, the inter-relationships are likely to be frequently shifting.

Such preliminary findings give strong support to the development of curricula in science and technology whose rationale, aims and pedagogy are directed towards:

i. emphasising the social, economic, political context in which they occur, and this has been strongly advocated by S-T-S supporters such as Carter (1991). My position is similar to that of Jenkins (1992, p. 231) who suggests that the science curriculum could be relocated within a range of learning contexts involving technologies which will affect people's lives "directly, personally and sometimes, adversely", and that of Fensham (cited in Hlebowitsh and Hudson, 1991, p.569) who argues that there is a need to alter the content of the science curriculum by adopting "a view of science from a position in society rather than from within science itself";

ii. assisting students to distinguish but also to relate science and technology, and recognises this relationship as changing in different social and historical contexts;

iii. relating science and technology to the everyday lives of students in a critical and reflective manner so that their relationship to science and technology is an empowering one;

iv. assisting students to evaluate the worth of knowledge of different kinds and from different sources;

v. recognising that feelings, values and constraints of the context will always affect the student's construction of knowledge, that this is not necessarily irrational, and that these factors will continue to operate throughout life.

In summary, this type of research could provide pointers to the ways that the construction of knowledge in school settings might more closely parallel the ways that adults construct and utilise scientific and technological knowledge in everyday settings. The findings suggest that the curriculum should encourage the establishment of learning environments that provide students with the opportunity to develop scientific and technological skills and understandings that are contextualised and purposeful – thereby reflecting the manner in which adults experience science and technology in their everyday lives. These findings also suggest that this type of research could justifiably be extended to other adult experiences in everyday life to inform curriculum development in other domains.

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