Public Understanding of Science:
(A case study of a coloured community)

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

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Abstract

While the importance of science and technology for society has long been recognised, it has taken on ever increasing importance in the present century. As a result this study, government (The year of Science and Technology – 1998), and other initiatives by concerned bodies efforts are directed to better inform the public about the nature and role of science and technology. It aimed to make citizens both better informed and better able to adapt to the many changes that science and technology have brought, and will continue to bring, to their lives.

Despite these efforts many citizens remain ill informed about the scientific advances, and how technology affects their lives. As a result, most members of the public are unable to form substantiated judgements about matters involving science and technology. It is essential that ways are find to improve the public understands of science and technology.

This study discusses the results of an empirical survey which was conducted in a coloured community in Paarl. The thesis summarises the results of the survey on these issues. It presents data on the public's understanding of science and technology and lists efforts that have been made to improve the understanding of science and technology. The study describes efforts to make information on science and technology more readily available to the public. Finally, it proposed measures that various actors might usefully take to improve public understanding of science and technology.

Sinopsis

Die belangrikheid van wetenskap en tegnologie vir die samelewing word reeds 'n geruime tyd erken, en het veral oor die laaste eeu toegeneem. Hieruit spruit die poging van hierdie studie, die regering (die Jaar van Wetenskap en Tegnologie – 1998), en ander inisiatiewe deur belanghebbende organisasies om die algemene publiek in te lig rakende die rol van wetenskap en tegnologie. Dit poog om die algemene publiek in te lig oor, en in staat te stel om aan te pas by die veranderinge wat wetenskap en tegnologie reeds meegebring het, en nog sal meebring in hulle daaglikse lewe.

Ten spyte van hierdie pogings is verskeie lede van die publiek steeds oningelig rakende wetenskaplike veranderinge en die wyses waarop tegnologie hulle lewens beïnvloed. Gevolglik is 'n groot gedeelte van die algemene publiek nie in staat om ingeligte oordele te kan maak met betrekking tot wetenskap- en tegnologieverwante aangeleenthede nie. Dit is dus essensieel dat maniere gevind word om die algemene publiek se persepsie van wetenskap en tegnologie te verbeter.

Hierdie studie bespreek die resultate van 'n empiriese opname wat onder 'n bruin gemeenskap in Paarl onderneem is. Dit bevat resultate oor die algemene publiek se persepsies van wetenskap en tegnologie, en gee 'n aanduiding van die pogings wat aangewend is om hierdie persepsie te verbeter. Die studie beskryf ook die pogings wat aangewend is om inligting rakende wetenskap en tegnologie meer beskikbaar te maak vir die algemene publiek. Ten slotte, word maniere voorgestel waarop die verskeie rolspelers strategiee geimplementeer kan word vir die uitbouing van die algemene publiek se persepsie van wetenskap en tegnologie.

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BACKGROUND

1.1 INTRODUCTION

It is evident in the current societal structures that science and technology are taking on an ever-greater importance in daily life. Science and technology have brought untold advances in medicine, communication and transportation that have made our world vastly different from that of previous generations.

While science and technology have brought immense benefits, questions have also arisen as to what effects it may have on our lives. The Royal Society's ad hoc group reporting on the Public Understanding of Science has attempted to address the importance and effects of science from a number of standpoints. Although somewhat dated now, the report's identification of issues still remains relevant today. They list the following as important benefits and uses resulting from science:

i 'For private individuals, for their personal satisfaction and well being;

ii For individual citizens, to participate in a democratic society;

iii For skilled and semi-skilled workers, a large majority of whose occupations now have some scientific involvement;

iv. For those responsible for major decision making in our society, particularly industry and government, where few, if any, issues do not have a scientific or technical aspect.' (Royal Society, 1985:31)

It is clear from the Royal Society's report that science and technology have multiple effects and consequences. In addition the report also emphasizes that science and technology also plays a major role in societal decision-making and actions. Thus, the public attribution to value in science and technology is rooted in the social and theoretical understanding of science.

The theoretical and social understanding of science and technology is of primary importance for many members of the public because they see science and technology as an instrument for societal problem solving. For others yet, the main objective of understanding of science and technology is to contribute on a theoretical level to the development and advancement of science and technology. It can thus be concluded from the Royal Society's report that science and technology with its multi-purpose effect have led the public to develop their own conceptualisation and understandings of the importance of scientific theory. Conceptualisations such as these are important for the integration of science into social norms. It implies, for example, that issues such as these below, have taken on an increasing importance for the public.

i The location of nuclear power plants and the disposal of nuclear waste;
ii Blood contaminated with the HIV virus;
iii The planting or use of transgenic plants for food;
iv Recombinant DNA field-tests;
v The use of information technologies etc.

These issues enter into the public sphere when they have an impact on society. It is important to note that the public looks to science for theoretical understanding, but in the same vein see science and technology as instruments for social and economical advancement.

The value that the public has historically attributed to science and technology soon gave rise to a thirst for understanding the theoretical and social impact of science and technology. However, the public was "deprived" of conceptualizing the theoretical understanding of science and technology in the mid nineteenth century through the institutionalization of science into well-defined academies and other scientific institutions. As a result, any contribution of scientific theory to the public advancement in social norms has diminished because of the subsequent professionalisation and institutionalisation of science and technology. The consequence is that a gap soon appeared between the social impact and theoretical understanding of science.

Events during the nineteen sixties and seventies (growing environmental awareness, the threat of nuclear disasters because of Chernobyl) and more recently because of great advances in technoscience (genetic engineering, the human genome project), have made it once again important to bridge the gap between science and technology on the one hand and the public's understanding thereof. The bridging of this gap may achieve the following:

1. The public may be able to evaluate technical arguments, for example, pertaining to the disposal of solid waste, social welfare policy, etc;
2. More young people of all races and genders will be attracted to a career in science and technology;
3. The public will be able to comprehend the beauty and intellectual challenges that science offers them by means of innovative ideas.

Thus, no matter what motivates one's need for an increased public understanding of science and technology, the issue is one of the most intractable and important aspects facing our society today.

1.2 SCIENTIFIC ENDEAVOURS

The need for increased public understanding of scientific knowledge has been argued from a number of standpoints (Connell, 1996; OECD, 1997; Ziman, 1991). Furthermore, it should be realized that the need for increased public understanding of scientific knowledge, in the twentieth century, is not a unique issue. This need has been evident since the nineteenth century right across the industrialized world as a result of the new status that was accorded to science.

Thus, the recognition of the pervasive effects of science on society has produced reactions from a number of groups interested in the direction and control of science. In a comprehensive analysis of the participatory demands of diverse groups interested in the direction and control of science, Dorothy Nelkin identified several groups involved in contemporary concerns that transcend national boundaries. For example:

i. 'The geographic neighbours of much science and technology, wary of the possible impact and potential risk of a noxious facility, an airport extension, or a new power plant, make up one anxious constituency.
ii. The recipients of health care directly affected by the availability of new drugs and biomedical technologies, constitute another well-defined concern public.
iii. This category is composed of those who consume the products of science and technology and whose interest is exemplified by debates over the regulation of food additives and preservatives, such as cyclamates and tartrazine.' (1982:52-52)

It is clear from Nelkin's examples that different groups are interested in the impact of science and technology primarily where it concerns their own interests. They are concerned that science and technology will have a negative effect on well-defined social aspects, for example: health care, food additives, etc. This one reference shows how people's concerns and interests are one set of factors that may lead the public to pursue a better understanding of science and technology. Other motivations and reasons that underpin the public's interest in an improved understanding of science and technology will be discussed later in the study.

1.2.1 THE YEAR OF SCIENCE AND TECHNOLOGY

Recognising the fact that science and technology have become one of the main driving forces behind economic growth and innovation, the South African Government declared 1998 as the Year of Science and Technology. This was done to highlight the critical role which Science, Engineering and Technology play in the development of the country and also to focus on the employment opportunities available in these fields.

The forerunner for launching the Year of Science and Technology (YEAST) was the 1996 World report on competitiveness in which South Africa appeared at the bottom of a forty-country list in the area of human resources development of Science, Engineering and Technology. Therefore, the key message that was echoed through the year was that Science, Engineering and Technology are important for the survival of our country in an increasingly competitive world. This emphasized that economic expansion and advancement in science and technology could not be seen as separate issues.

Another aim of YEAST was to demystify science, encourage South Africans to take an interest in science and technology and understand what role it plays in their daily lives. The project particularly targeted the youth, schoolchildren and women. Muffy Koch, Gauteng project manager for YEAST, made the following remarks, pertaining to the Government's initiative:

i. 'It is important to increase the number and quality of students opting for careers in these fields, and to show how increased national support for science and technology is vital to our nation's progress.
ii. Science and technology give people the capacity to make informed decisions about the world around them and help them develop better control over their lives.'(The Star, 1988:14)

Koch also points out that it is not just in the economy that science and technology are important but also in our daily lives.

Unfortunately, on analysis, YEAST warrants some skepticism. If one analyses the projects that were developed for the Year of Science and Technology, a one-sided-science approach is clearly evident. By this I mean that a one-way communication system was initiated from the scientists to the public, with the public only seen as the receiver of the message and as scientifically illiterate. This situation should be viewed against the backdrop of the history of South

Africa - a country with a colonial and apartheid history - which continues to play an important role in the public's conceptualization of science.

As Addison (1998:15) pointed out: 'it should also be realised that some of the obstacles in the way of a major public awareness campaign around science, as much as around heritage, are lack of finance and uncertainty over the cultural perspectives to adopt - western or indigenous, white or black'. Similarly, Nkomo (1998:8) stated that 'the Year of Science and Technology would have been successful had the conceptual base been shifted to also include the illiteracy of western science, as well as real threats posed by modern technology'. Be that as it may, I believe that the Year of Science and Technology was a major step in the right direction to promote an awareness of science among the public. The Year of Science and Technology also played a major role in motivating me to undertake this study and specifically to establish what the perceptions and attitudes towards science and technology are among the Coloured Community in Paarl.

1.3 OBJECTIVES

The overarching aim of this study was to present an overview of the public's attitude towards science and technology and their level of interest and understanding. A search of South African studies has revealed very few empirical studies in the area and no specific survey of the perceptions and attitudes of a particular community. In addition to an analysis of the empirical findings, the thesis will also present some recommendations that touch upon matters relating to policy.

The thesis is structured in the following way:

The second chapter of the thesis offers a brief history of the notion of Public Understanding of Science. Here the aim is to highlight the main trends and changing conceptions of science and its relation to society. The third chapter discusses the methodology followed in the study as well as the main findings under four main headings:

i. Demographics of the sample
ii. Exposure to and interest in science and technology related issues and events.
iii. Attitudes about the nature and value of science and technology
iv. Knowledge of basic scientific facts

Chapter Four covers the implications of the survey with specific reference to:

i. The presentation of science
ii. Understanding of science
iii. Usage of science
iv. The media
v. Forums for dialogue

The final chapter is devoted to a broad range of suggestions for the improvement of scientific literacy and the integration of science and technology into a knowledge-based society.

CHAPTER 2

PERSPECTIVES ON THE PUBLIC UNDERSTANDING OF SCIENCE

2.1 INTRODUCTION

Science is part of our common culture; integrally tied to our social practices, public policies and political affairs. Frequent developments in science and technology continually remind us of our dependence on new technology. 'Although people depend on the continual development of science and technology, there is little understanding of the relationship between scientists and the public' (Sanderson, 1983:76). It must be understood that this relationship plays an important role in the formulation and justification of science.

The absence of sufficient understanding between scientists and the public are the concerns of many governments around the world. Scientific research cost money and the perception of the public towards science is important. Scientists, on the other hand, are also concerned how the public perceives them. Perhaps nowhere is this more acute than in relation to areas of controversy, for example, genetic engineering and the use of animals in experiments. The above quotation illustrates the force of rhetoric in presenting debates to a wider public in the context of popular books: 'Walter Bodmer (1994), a geneticist with a keen interest in promoting public understanding of science, prefers to portray new developments in mapping the human genome as though it is the search for the Holy Grail'. On the other hand, Ruth Hubbard (1990) 'point out that this search calls into question ' what it means to be a human being' and how that might be threatened by the new genetics'.

How do non-scientists see these issues? What might they know about the relevant science? And how might they interpret conflicting messages and pictures of science? The context is one in which governments of industrialised countries express concern over the public's "failure" to understand much science. It is also one in which public perceptions can be up for grabs through powers of rhetorical persuasion. How scientists express themselves in public pronouncements is an important part of communicating science. For the tone of the message can convey as much about science as the message itself.

In 1985, the Royal Society produced a report on the public understanding of science that set in motion a flurry of research activities and policy initiatives. The main finding was that the public knows too little science. The statistics gained from public surveys made for depressing reading. The statistics gained from the surveys showed that very few people could claim to understand much about what is going on in science today.

According to the Royal Society's report there are a number of reasons why we should be concerned about the public's apparent lack of understanding of science and technology. These centre partly on economic issues such as the need for a technologically developed society to have a technically trained workforce. They also focus on science as a part of culture; both for educational and aesthetic reasons is it desirable that people know some science. Another focus is on science for citizenship; knowing something about science can facilitate our engagement with technical decision-making.

To some extent, these are worthy aims. Yet each implies a different context of understanding and perhaps different public(s). Exactly who is 'the public' that is invoked? Is it the woman at the supermarket register or the farmer ploughing the fields? Is it the people who run the council? Does it include national politicians? And does every member of 'the public' have the same need to understand science? None of these people are 'scientists' in the way most of us might imagine, yet each have or need different understandings of science.

Understanding and **science** are also tricky terms. Official pronouncements about 'public understanding of science' are usually concerned with ways in which the public is said to lack knowledge. But understanding might also mean an understanding of the role played by science and scientists in our society. Aside from the problems of definition, the report of the Royal Society fails to address questions of power and also fails to address science in its global context. Our concern here is with the attitudes, needs and desires of citizens, rather than with the economic needs of nations, societies and governments.

2.2 EXCLUSION FROM SCIENCE

In approaching our research we already knew that people often feel they have not, and cannot, play a part in the generation of science. We knew too that the knowledge that people do have is often knowledge associated with people's role in society. This raises many questions about how such knowledge is acquired and constructed. Such observations are not, of course, unproblematic. There is clearly a danger that in recognising and acknowledging these links we put ourselves in the position implicitly supporting people's domestic role. Yet that role is what constitutes the everyday experience of many people. What concerned us more, however, was that any knowledge that the public had, they themselves were likely to see as not being scientific, just because it was what they knew.

The public is beginning to study science as adults maybe because they want to keep up with the children at school. Other reasons for the thrust for science and technology may be the rapid development of the industrialised world and that they want to know what is going on around them. Thus, they want access to that knowledge even if they know that they aren't going to be creating it in detail in the way that scientists do.

Science in many industrialised countries, like Britain and United States, have developed largely as a form of abstract knowledge, and removed from the everyday lives of people. Yet in these countries, in different ways, 'there has been a history of science education that included efforts to democratise it to extend it to working people' (Montgomery, 1994). Indeed, 'this was part of the agenda of the Mechanics' Institutes in Britain in the middle of the nineteenth century that were set up primarily to educate working-class men' (Layton, 1973).

According to Layton et al (1986) 'the move to make science education more abstract was ultimately political, the establishment of an elite kind of knowledge'. Science education became increasingly linked to class. 'Science for what has been called 'specific social purposes'; a more popular and accessible kind of science, began to disappear from the educational agenda by the late nineteenth century' (Layton et al, 1986). 'In the United States claims were made during that century that science education should be for all, for the 'good of the common man' (Montgomery, 1994, p.66). But more academic approaches took over during the early twentieth century, as the importance of scientific research for national development became clear. With the rise of academicism, science teaching became a matter of repeating 'great' experiments. As Montgomery (1994) argues, the science popularised by this type of teaching, in an era of mass education and growing competitiveness, was thus an inevitable and heroic march upward to the present, enacted by lone investigators employing the tools of genius, students commonly recapitulated this simplified and purified science, which thus remained a coveted professional image for decades to come' (pp.154 - 155).

Contemporary debates about the public understanding of science rest on a historical background of popularisation of science and the extension to the public of developments in scientific knowledge. Yet this wider context is absent in science teaching today. Instead, we have seen an emphasis on the need for scientists to popularise science. Some would argue that this comes from a scientific establishment concerned less with the benefits to the citizenry than for the need to defend its own interests. The concern here is not with empowering people but with making sure that they know what the scientific establishment wants to tell them. Dorothy Nelkin, in her book *Selling Science* (1987), in which she analyses the ways in which science popularisation operate, has made this point quite clearly.

Most people have only limited access to science. Perhaps more importantly, many people believe that they can have only limited access or understanding. This belief is a result of years of exposure to an educational system that marginalises people whose knowledge does not fit establishment norms.

In writing about how conventional education perpetuates existing patterns of social power, Paulo Freire (1970) discusses 'the need for a radical education that empowers people, distinguishing that from the banking system of education that prevails today'. Perhaps in no area of inquiry is the banking system more predominant than in science. In order to study science at higher levels, people are expected to have acquired particular information, to assimilate the requisite number of facts. Freire recognised the way in which such education disempowers people. The public may not acquire the requisite facts because the requirements themselves tend to assume previous experience that is not theirs.

This view of lay people as deficient in their knowledge of the facts disempowers those who are defined as lacking these facts. In writing about her own education, Bell Hooks (1994) has described the painful transition from experiential education to the distancing and disempowering pedagogy of elite (white) institutions: 'School changed utterly with racial integration. Gone was the messianic zeal to transform our minds and beings that had characterised teachers and their pedagogical practices in our all-black schools. Knowledge was suddenly about information only. It had no relation to how one lived, behaved' (p.3). Later she adds that 'I learned that far from being self- actualised, the university was seen more as a haven for those who are smart in book knowledge but might be otherwise unfit for social interaction' (p.16). That is a theme understood by many people, for whom their own knowledge; be that common sense or skills in social interaction, was something to be valued in contrast to the factual and alienating knowledge of science.

Official pronouncements about public understanding of science have largely failed to consider how and why people understand things. 'Many such pronouncements have perpetuated the image of a public sadly misinformed and ignorant of science and technology; creating what has been termed a deficit model of the public' (Wynne, 1991). From the public's perspective, that model is likely to be gendered and to ignore the wider context of knowing. It also ignores the way in which subjectivities are denied by formal educational practice, especially in teaching science.

This is one of the important themes of our research that focused on the public perceptions and attitude of science. Some people tend to juxtapose 'common sense' with scientific knowledge. Common sense is what a person might know already; that is his own knowledge. This theme is also echoed in other works; Luttrel (1989) for example, notes how working-class people claim their own common sense as a superior kind of knowledge which is of more use than anything learned from books'.

2.3 PUBLIC SCRUTINY OF SCIENCE

Concerns with the public understanding of science or the lack thereof has been fuelled by various large-scale surveys into people's attitudes toward and understanding of scientific information. 'Among the questions asked in the United States surveys were a set which, the researchers felt, tapped into people's understanding of what it means to do science or to study something scientifically' (Bauer and Schoon, 1993). Perhaps predictably, few of the respondents achieved a high score on measures of scientific understanding.

A parallel survey in Britain in the 1980s produced similar results. When people were asked about interest in scientific discoveries, there was little difference between the British survey and similar surveys in the United States (Miller, 1993): approximately 40 percent claimed to be interested and 15 percent claimed no interest. There was, however, a striking contrast between the two countries in terms of self-professed interest in new medical discoveries. In the United States, 71 percent claimed considerable interest, contrasted with 49 percent in Britain, and 10 percent in Britain claimed they were not at all interested in new medical discoveries compared with 3 percent in the United States.

'Media attention was caught by a quiz of scientific knowledge. A number of the questions were what the researchers called morale-booster questions; they felt that it was very likely that most people would get them right' (Miller, 1993, p238). For example, they asked whether it was true or false that hot air rises; and 97 percent of the population sampled in both British and the American surveys got the answer correct. But there were a number of questions that many got wrong. For example, less than half the American sample and under a third of the British respondents knew that electrons were smaller than atoms. Similarly, only 63 percent of the British sample knew that the earth goes round the sun, rather than vice versa. Another question asked whether it was true or false that antibiotics killed viruses as well as bacteria. Here, only 29 percent of the British sample gave the correct answer and 26 percent of the American sample. In both countries, younger people tended to know more than older people, males know more than females, and middle-class people more than working-class people.

Similarly, only about a quarter of respondents in the British survey knew that antibiotics are ineffective against viruses, but then, how many had the experience of doctors' prescribing antibiotics for them when they were sick with viral infections? Interestingly, people were more likely to get the answer right in recent U.S. surveys, perhaps as a result of their experiences of taking children to the doctor.

Large-scale surveys have the advantage of statistical reliability, in that they draw on large numbers of people and provide a more representative sample than smaller scale studies. They can also provide a fairly coherent set of questions that could then be compared across different countries or cultures. Nevertheless, surveys do have many critics. A primary criticism has been that they perpetuate a deficit model, implying that the public lacks appropriate knowledge. The implication for science education is that people are empty vessels that need to be filled up with the right liquid information.

People are not, however, empty vessels. We accept or reject information and make sense of it by reference to context and to our past experiences. Other research suggests that people often have a complex understanding of science. Anti-science reaction occurs in particular contexts in which people have learned that scientific expertise is either fallible or can be trusted. Many people are highly critical of scientific research and medical practice because, the public have too often fallen foul of medical experts. Antagonism to science is widespread in communities for good reasons.

'In research into how people might perceive science, one study focused on sheep farmers in the northwest of England after the Chernobyl fallout' (Wynne,1991). For some time, there was a government ban on movement of the sheep from the hills. The researchers were concerned to find out how the farmers understood what was going on and their opinions of government statements about possible risk. Farmers were angry about what they saw as continuing delays in getting their stock to market; they were also sceptical about whether the government experts did in fact have adequate information on the levels of radioactive cesium in the grassland covering the lower fells.

The dominant view suggested by the researchers assumed a deficit model: the farmers had failed to understand the message. But there was also failure on the part of government experts to understand the contexts in which the farmers were working. The officials did not appreciate that science can be parochial - the farmers might know more than the researchers about the different rates of grass growth and the ways in which these grasses might take up radioactive cesium. Nor were official idealized measurements of radioactivity related to the way water collects in small ponds on the fells and which ponds sheep prefer to use for drinking. Government experts paid no heed to the specialized knowledge of the people; instead, they simply assumed that the sheep farmers did not know enough of the science.

Information is also something that people may choose to reject. The Cumbrian farmers, for example, refused to undergo whole body radioactivity scans on the grounds that, if doctors discovered high levels, nothing could be done about it. At the same time they were angry because their requests for water analysis were ignored - even though water content could be corrected. From the perspective of the sheep farmers, useless knowledge was offered but useful knowledge was denied.

Discussing such studies of how people react to scientific expertise, the researchers concluded that the main insight 'is that public uptake or otherwise of science is not based upon intellectual capability as much as social institutional factors having to do with social access, trust and negotiation, as opposed to imposed authority. When these motivational factors are positive people show a remarkable capability to assimilate and use science or other knowledge derived inter alia from science' (Wynne,1991, p.116).

2.3.1 Science Policy Approach

The policy implications of an approach, which stresses that people can reflect upon their relation to scientific knowledge are very different from those of the deficit, top-down model of the survey approach. Surveys have been informed by a particular rhetoric of encouraging and nurturing democratic participation. According to this the level of public scientific literacy must be raised to that required to make informed judgements. Yet, as Wynne (1991), noted the recommended ways of achieving this are based on the power relations of a dominant science and a subservient public.

Thus, the Royal Society recommends that the amount and quality of science education should increase and that scientist should actively popularise it. Yet such actions are deeply imbued with power. They imply that the scientific community is the active holder and disseminator of knowledge; the public is merely the passive receiver. There is no room in this model for people actively to create their own understandings, nor to use these. If they do, what they create will not be called science.

'Science, as we now understand it, is a particular way of knowing the world that grew up in the context of European expansion and the development of capitalism. It is also a worldview thoroughly grounded in gender and race' (Harding, 1992). It has come to be seen as representing some ultimate truth, and in so doing, the practice of science has involved the denial of other ways of knowing the world. 'Scientists energetically dissociate themselves from what they believe to be pseudoscience (such as astrology, or even homeopathy). They also ignore the expertise of those people deemed to be non-scientists and of communities whose knowledge's are not generated by those who are recognized as scientists' (Schiebinger,1993).

2.3.2 THE GOLDEN AGE: Unbridled public faith in science

The gap between the scientific expert and members of the public who are believed to be ignorant of or uninterested in science is a relatively recent phenomenon. During earlier centuries, some historians of science have argued, there was more general interest in science as another form of human knowledge.

Scientific knowledge in Europe in the eighteenth and nineteenth centuries was disseminated in a number of ways, including the activities of the Mechanics' Institutes and the literary and philosophical societies.

The contribution of new scientific apparatus also intensified the dissemination of scientific knowledge. According to Porter 'by the development of scientific apparatus the public had developed outstanding indigenous craft skills' (1985: 78). By obtaining skills from the manufacturing of this apparatus, the public also became aware of the tremendous value of science. Scientists, on the other hand, by using these apparatus acknowledged the outstanding crafting skills of the public. The appreciation from both sides pertaining to their skills paved the way for science to be discussed within the homes of the working class and the market places. The public demonstrations by travelling lecturers, and books, magazines and pamphlets further intensified popularisation of scientific knowledge.

It should be realised that during this period not only did science expand, but other parts of national life as well; for example industrial production and education. Nevertheless, the expansion of science during this period among the public was exceptional. The expansion of science can be attributed to the fact that the public saw science as a symbol of advancement and of diverse interests. This is evident in Thackray's (1974) analysis of the 'multiplicity of science'. He identified seven reasons why members of the city's Literary and Philosophical Society chose science as their intellectual genre. 'Science had possibilities as polite knowledge, rational entertainment, value-transcendent pursuit, theological instruction, professional occupation, technological agent and as intellectual ratifier of a New World' (1974).

However, for people outside the scientific community, the multiplicity of science and the contributions of scientists had quite a different meaning. 'People in the working class of society, such as Thomas Paine, saw the advancement of science and science education as the keys to freedom, truth and progress' (Simon,1972:12). Richard Carlisle's *Address to Men of Science*, written whilst imprisoned for publishing Paine's *The Age of Reason*, summarily 'looked to science to banish superstition and persecution from the face of the earth' (Wiener, 1983: 63).

Science was viewed as a multi-faceted resource capable of serving both the intellectual community and the public at large. At one extreme it was used for the confirmation of religious beliefs; at the other, to undermine them. 'For some its value-transcendent characteristics were a unifying balm for society troubled by unrest; for others, its potential for control of the material world made it a destabilising agent especially, if proficient were drawn predominantly from one sector of a stratified society' (Powell, 1832: 197-8). Russel further stressed that 'organisations of scientific knowledge were constructed according to a plurality of social purposes and a contextual commitment to individualism; voluntarism and self-help, which enabled a rich variety of textual and institutional responses to emerge' (1983: 226-7).

The interest that both the scientific community and the public demonstrated towards science was an indication of the transcendent value of science. Science manifested itself in both formal and informal education contexts. Inkster echoes the diversity of science by stating that 'science had achieved a degree of popularity at all levels in society' (1981: 80). Bud and Roberts also stated that 'science was at the centre of the working class faith and progress' (1984: 124).

The diversity of science was evident by the start of the First World War. During this war there was an increase of science-based medicine and of science-based industry. The development of science-based medicine had further increased the public's awareness of the social and economic power of science. People's attention was now directed towards the application of science: **for science was seen as the way of getting things done**. Frederick Lewis Allen writes that 'the prestige of science at this time was colossal. The man in the street and the woman in the kitchen, confronted on every hand with new machines and devices which they owed to the laboratory, were ready to believe that science could accomplish almost anything' (1964: 164). Scientists had conveyed science to the public as an economic resource, an instrument of progress and a servant of technological needs. Thus, scientific values penetrated many social and political institutions, for example, the increased emphasis on technical expertise in government, the growth in literature and arts. In this context, the presentation of science was defined as the enlightened basis of a community.

Some historians have suggested that an important feature of this interest in popular science was the development of what has been called 'science for specific social purposes.' 'Chemistry for precious metal prospectors in the 19th century was different from chemistry for agriculturalists and again from chemistry for public health officials' (Layton et al.,1986,p.30). Scientific instruments, too, were part of the general culture, so that the *London Magazine* of 1828 could report that, 'in every town, nay almost in every village, there are learned persons running to and fro with electric machines, galvanic troughs, retorts, crucibles and geologist' hammers' (Tobey,1971,p.124).

What seems to have mattered was the question: what do we need to know for such-and-such a purpose? This approach to knowledge, rooted in need-to-know and experience, is quite different from the approach embedded in science education today, which is too often far removed from everyday life and whose 'need-to-know' is related to technological control over nature.

2.3.3 Factors Contributing to Change

By the turn of the twentieth century, science as part of everyday life had begun to change, to develop into the distant institution it now seems. 'Science conceived as an apolitical, universal, empirical and uniquely objective form of knowledge came to dominate' (Stepan and Gilman, 1993).

Three factors contributed to this change: the first was the growing professionalization of science. The scientific community increasingly pursued its own interests, or those of particular individuals or groups in power (today, these are largely governments and funding agencies). A second, not unrelated, factor was the adoption by schools of a science curriculum marked by abstraction and apparent disconnection from the social values of the wider society. Third, this change in science education took place alongside a move to deradicalize the self-education practiced in many working-class communities and to replace it with 'provided' education; that, in turn, was intended covertly to instil the values of the more powerful classes.

The Mechanics' Institutes, for instance, had begun by being centres of critical political education for working-class people. But those interests changed in the 1820s through the 1830s, as local businessmen pushed for change. They saw the institutes as 'potential centres for technological innovation and scientific discovery. With their help they felt the Institutes could produce many more Watts and Stevensons from the ranks of the working class' (Cowburn,1986,p.110). Thus, the Institutes began to move away from their radical origins and to become incorporated into the values of those in power.

The emphasis on abstraction in the development of science education served the interests of particular groups in society. It taught a particular kind of science, divorced from people's needs and lives. And it had a number of consequences. It encouraged the rote learning of scientific facts, separated from any kind of context. Pupils must learn to reproduce some ideas in order to pass examinations but often feel that they do not really understand. It also makes learners become passive receivers of knowledge and teaches them to ignore or devalue their own cultural knowledge.

Abstraction is deeply embedded in the practice of most educational institutions. It is not unique to science although it is undoubtedly in science where it is most explicitly and highly valued. Abstraction creates conditions that marginalize many, particularly those who are poor or non-white. In analysing reasons why young people from poor families drop out of high school, Michelle Fine and Nancie Zane (1991) point out that educational practice typically ignores private lives, where there may be particular difficulties or struggles. Many young people dropped out, they learned, because of family responsibilities - not because they felt these to be excessive but 'because their schools imposed an artificial split between 'public' and 'private' issues'. Science is taught as decontextualized, and even if it is taught in ways that might connect it with the world around us, that is likely to be the public world (and a public world defined by a tiny elite), far removed from 'private' life. Small wonder, then, that many people feel that science is irrelevant.

2.4 CONTEXT OF SCIENTIFIC UNDERSTANDING

In this section we discuss the results of a survey on people's perceptions of science. As a starting point for our research into how people outside professional science perceive it, we explored some of the images encountered by the Foundation for Research Development (FRD), in conjunction with the Centre for Science Development (CSD) of the Human Sciences Research Council (HSRC), when they undertook a survey on scientific literacy and attitudes towards science and scientists in 1995.

This survey was undertaken against the backdrop of the government's awareness of the importance to enhance the public's (especially those in the rural communities) understanding of science, engineering and technology. The white paper published by the Department of Arts, Culture, Science and Technology (1996) emphasise the importance of establishing a national campaign to promote the public understanding of Science, Engineering and Technology (SET). But the survey was also undertaken to clarify the extent and nature of the public understands of possible aversion or disinterest in SET. The results of these surveys are reported in this section.

South Africans ranked 18th out of 20 countries in their knowledge of the natural and environmental sciences. During 1993 and 1994, researchers in 19 countries (excluding South Africa) used a list of 12 questions to test more than 25 000 people in terms of their natural and environmental sciences literacy. A separate survey in South Africa was based on the same survey questionnaire used in the other 19 countries. This was the first time that a fully representative survey of public understanding of science had been undertaken in South Africa.
The results of the surveys, which were run simultaneously using the same population sample, are presented. The first is the survey on natural sciences and environmental literacy using 12 statements to test people's knowledge of basic scientific and environmental facts. The Canadians emerged as the best informed with a score of 7.58 out of 12. New Zealand came second with a score of 7.52 followed by Great Britain (7.49) and Norway (7.15). The United States lagged behind seventh position with a score of 6.57. South Africa came near the bottom of the list, in 18th position, with a score of 5.11, clustered with countries that used to be part of the Soviet block, including Slovenia (17th), Russia (19th) and Poland, which came last with a score of 4.33.

A further five statements were included in the survey to determine people's attitudes towards science and technology. The agreement or disagreement of people with these statements indicated their attitudes and feelings towards science and technology and the extent to which they appreciated its impact on their lives. For example, agreement with the statement - 'Science and technology can make our way of life easier and better'; indicates a positive attitude towards science and technology. The other statement where agreement indicated a positive attitude was; 'The benefits of science are greater than any harmful effects'. The average percentages of people from 15 countries, including South Africa) agreed with these two statements. South Africa ranked 14th out of the 15 countries with an average score of 54 percent agreement. The United States scored 78.5 percent, followed by Denmark (77.5%), Spain (74%) and France (73.5%).

The second set contained the statements; 'Science and technology are changing our way of life too fast', and 'Scientists cause people to depend too much on science and enough on faith'. Agreement with these two statements was taken to indicate a negative attitude towards science and technology. The countries showing the strongest agreement with these statements were Greece (76%), followed by Portugal and Japan, both with average scores of 63.5 percent. South Africa fared better on these two statements with an average of 49.5 percent agreement, which placed it in 9th position, on par with Italy. Belgium showed the least agreement with the statements (42.5%), followed by the United States (43%) and France (46%).

A survey on human science literacy was also conducted by measuring 13 statements to which the possible responses were 'agree, disagree and don't know'. Respondents were also free to elect not to respond to any given statement. A don't know response or an avoidance was regarded as indicating a lack of knowledge about the concept concerned. When respondents endorsed statements reflecting illiteracy, their responses were treated as correct, and given a score of 1.

The 13 statements were grouped into five categories for analysis, namely the behavioural and social sciences, economic sciences, language sciences, political sciences and the arts. The average score achieved was 4.51 out of 13 (which represented a literacy rate for the human sciences of 34.7%). Respondents fared best on the statements included in the economic sciences (42% correct responses), followed by the political sciences (37%), language sciences (35%), behavioural and social sciences (32%) and the arts (26%).

Males achieved slightly higher scores than females (36% and 33% respectively). The higher the respondents' levels of education and the greater their access to television and newspapers, the higher their scores tended to be. In South Africa scores for whites (65%) were higher than those for Indians (48%), and both groups surpassed scores obtained by coloureds (31%) and Africans (27%).

The survey has demonstrated specific differences between countries and social groups. We believe that such differences have implications for adults' education and public understanding of science in South Africa. The results obtained from people's attitudes towards science and technology are the most important because they dealt with the public perceptions which are more crucial to the success of science and technology development programmes than widespread general knowledge of scientific facts.

2.5 SUMMARY

The broad arguments of this chapter can be summarised as follows:

i. Compelling reasons have been pointed out why ways should be sought to increase public understanding of science;
ii. It was also pointed out that if science is to be returned to the public to assist in their empowerment in relation to problems with a scientific dimension; then it will need to be structured in ways that relate to the public.

It is the last of these propositions, which I will explore in more detail in this study. The aim is to explore what adults perceive to be their needs for scientific knowledge in relation to the concerns they have defined themselves. Only then will it be possible to discern the function and structure of the necessary institutional provision.

CHAPTER 3
RESULTS

3.1 INTRODUCTION

In South Africa, the promotion of a better public understanding and awareness of science and technology (S&T) enjoys the active support of government. The reasons for government support are twofold. Firstly, government recognise that for the future development of the country, it is essential to produce scientists and technologically skilled people that have a general appreciation for S&T. Secondly, results of a recent survey by the Foundation for Research Development (FRD, 1996) indicate that such an appreciation among South Africans, and especially the black and coloured populations, is lacking.

The survey conducted by the FRD on scientific literacy and attitudes towards S&T covered both the natural and human sciences. Thus, it is important to use this particular survey as our place of departure. Our focus here are on the attitudes and feelings of coloureds towards S&T and the extent to which they appreciate its value for society.

3.2 METHODOLOGICAL APPROACH

To establish the attitudes and feelings of the coloured population towards S&T we made use of a sample survey which was administered through personal interviews. The data for this survey were collected in the Paarl district. The population was stratified using socio-economic status as stratification principle. The sample was also designed to reflect the population of individuals over the age of 18.

The survey questions were formulated after an in-depth reading on the subject and consultation with the supervisor. Most of the questions were obtained from United States and British surveys which dealt with the public's understanding of science (see Buaer and Schoon, 1993; Miller, 1993). Questions were also obtained from the study of the FRD in 1995 (SA Science and Technology Indicators, 1996). We adapted some of these questions for the purpose of our study where appropriate.

The draft questionnaire was pilot tested. We administered the questionnaire to five respondents representative of the socio-economic status of the sample. On the basis of the pilot we decided to translate the questionnaire so that it would be available both in Afrikaans and English.

We used multistage cluster sampling to obtain the final sample. Households and respondents were drawn from clusters with equal probability using a serial sampling procedure.

Standard survey practice was adhered to throughout, including the use of trained fieldworkers, randomly selected respondents and proper techniques.
The results of the survey are presented in this chapter under four main headings:

1. Demographics
   - Gender
   - Educational level
   - Income

2. Exposure to and interest in S&T related issues and events
   - Media (TV & News) coverage of S&T
   - Visits to places of cultural and scientific interest

3. Attitudes about the nature and value of S&T
   - Scientificity ratings of nine science fields
   - Attitudes towards the value of science (13 statements)

4 Knowledge of basic scientific facts

- Problem statements
- Factual statements

For each of the last three content categories a profile of the total sample is given, together with a breakdown for gender, age and socio-economic status.

3.3 Demographics

The gender distribution in the sample is roughly 50/50 (49.6% male and 50.4% female). As can be seen in Figure 1, the sample was relatively young, as almost 50% of respondents were younger than 35. The modal age category is 35 to 44 years (28%).

Figure 1: Age distribution of sample

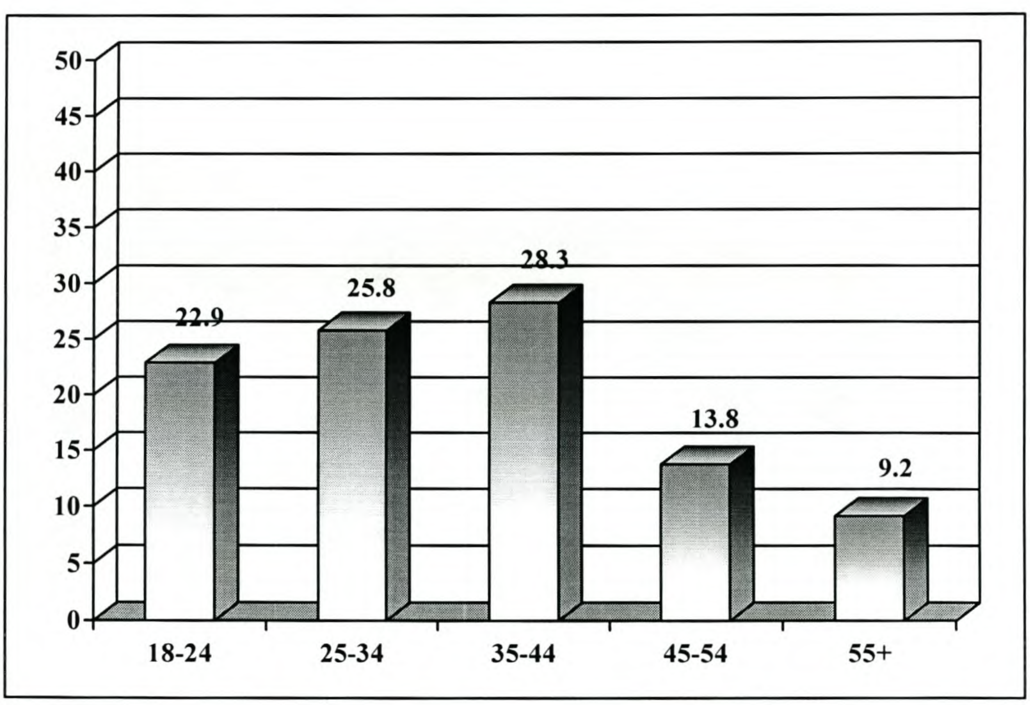
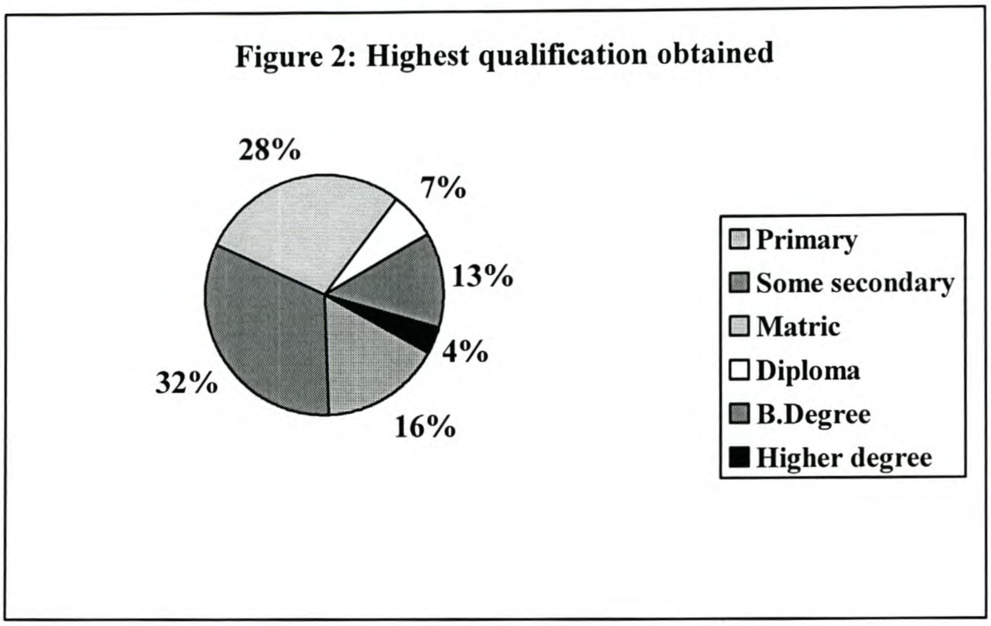


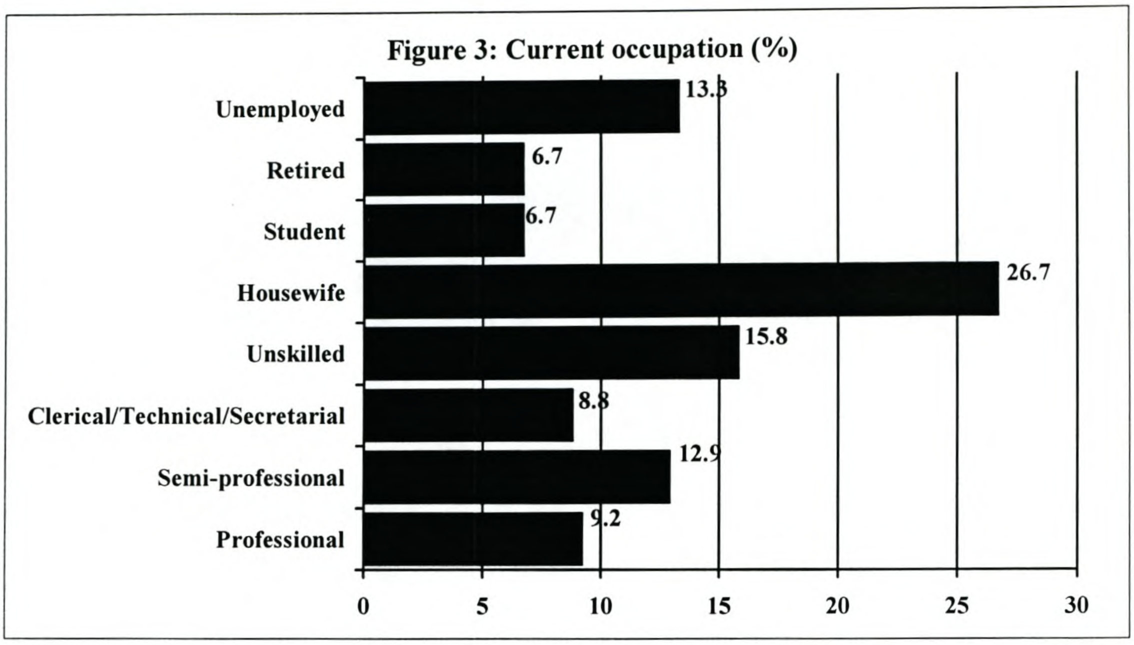
Figure 2: Qualification distribution of sample



It is apparent from Figure 2 that close to half of the sample (48%) never completed formal school education (of which 16% only attended primary school). Moreover, low percentages of 13% and 4%, respectively, have a first bachelor's degree (university or Technikon) and a higher degree (postgraduate). All percentages are based on a sample size of 227, as 13 respondents failed to specify their qualifications. It is also noteworthy that of the 4% with a higher degree, 3 respondents majored in Education, 2 in the Arts & Humanities, and 1 each in the Social Sciences, Economic & Business Sciences, and Medical & Health Sciences, respectively.

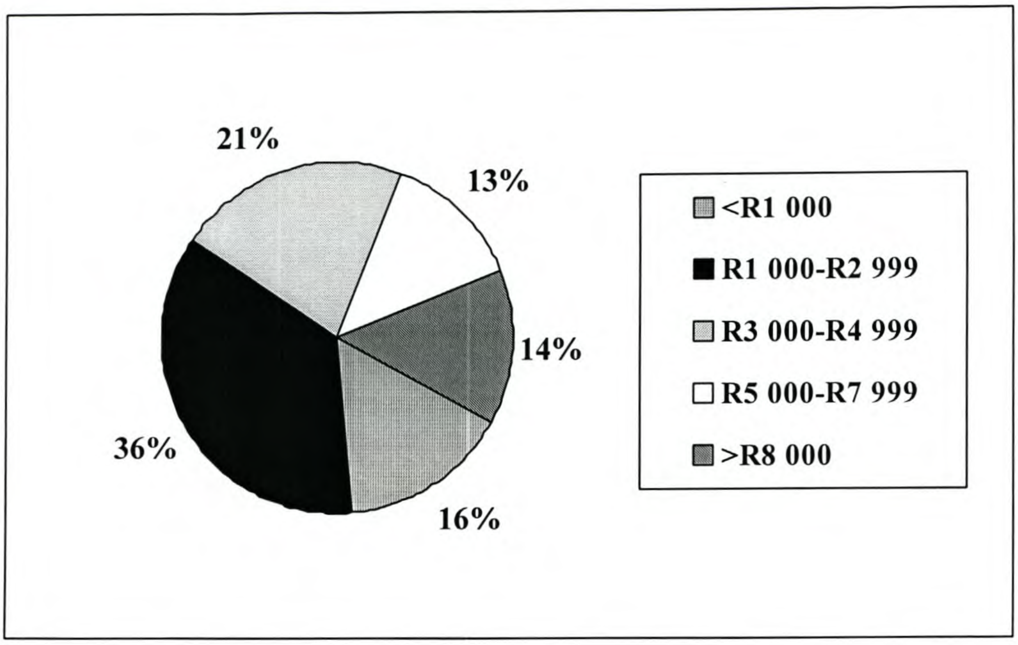
The relatively low levels of education among the respondents are reflected in their current occupations (Figure 3) and total monthly household income (Figure 4).

Figure 3: Distribution of occupations



Inspection of Figure 3 shows an economic inactivity rate of about 53% (i.e. unemployed, retired, students and housewives). Housewives constitute the single biggest category, namely 26.7%. The two groups of economically active respondents with the highest frequencies are unskilled labourers (15.8%) and semi-professionals (12.9%). The latter primarily comprises teachers and nurses. As far as total monthly household income is concerned (Figure 4), just more than half of the respondents (51.5%) have a total monthly household income of less than R3 000 (N = 239). The modal category is R1 000 to R2 999.

Figure 4: Household income of sample



In order to create an index of socio-economic status (SES), total monthly household income as well as the respondents' highest qualification were combined. The procedure entailed three steps. Firstly, the six categories of highest qualification obtained (Figure 2) were reduced to four, and the five categories of total monthly household income (Figure 4) to three. This resulted in two new variables with distributions as summarised in Table 1 below.

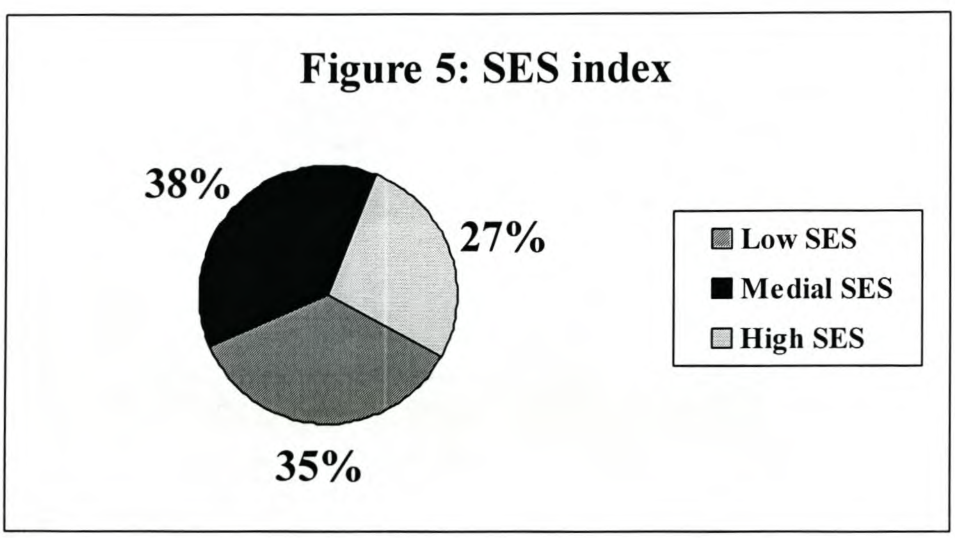
Table 1: Recoded variables used to create SES index

Variable	N	%	Value assigned
Highest qualification obtained (N = 227)			
Some primary school	37	16.3	1
Some secondary school	74	32.6	2
Matric or diploma	79	34.8	3
Degree or higher	37	16.3	4
Total monthly household income (N = 239)			
Less than R2 999	123	51.5	1
R3 000-R4 999	51	21.3	2
R5 000 or more	65	27.2	3

Secondly, a value was assigned to each variable category (lowest category = 1, see Table 1) and these values were summed across variables to yield a single score for each respondent. The scores ranged from 2 to 7 and with the following percentage distribution: 2 = 14.2%; 3 = 21.2%; 4 = 23.5%; 5 = 14.2%; 6 = 16.8% and 7 = 10.2%.

Lastly, to produce a convenient number of categories for cross-tabulations and other statistical analyses, the six scores were reduced to three in the following manner: Low SES (scores 2 & 3); medial SES (scores 4 & 5) and high SES (scores 6 & 7). The resultant SES index is summarised in Figure 5.

Figure 5: Socio-economic statis index of sample



To check the validity of the SES index, it was cross-tabulated with two variables that relate to socio-economic status, namely living area (Figure 6) and whether or not the respondent has a computer at home (Figure 7).

The distribution shown in Figure 6 is in accordance with the general expectation of the researcher, namely (1) Amstelhof, Chicago and Lantana = predominantly low SES, (2) Charlestonhill and New Orleans = predominantly middle to high SES, and (3) Klein Parys = predominantly high SES. This cross-tabulation of living area with the SES index is statistically significant [Chi-square = 102.28; p = 0.000; Cramer's V = 0.476]. The association between SES and access to a household computer in Figure 7 also confirms the validity of the SES index.

Figure 6: Living area by SES

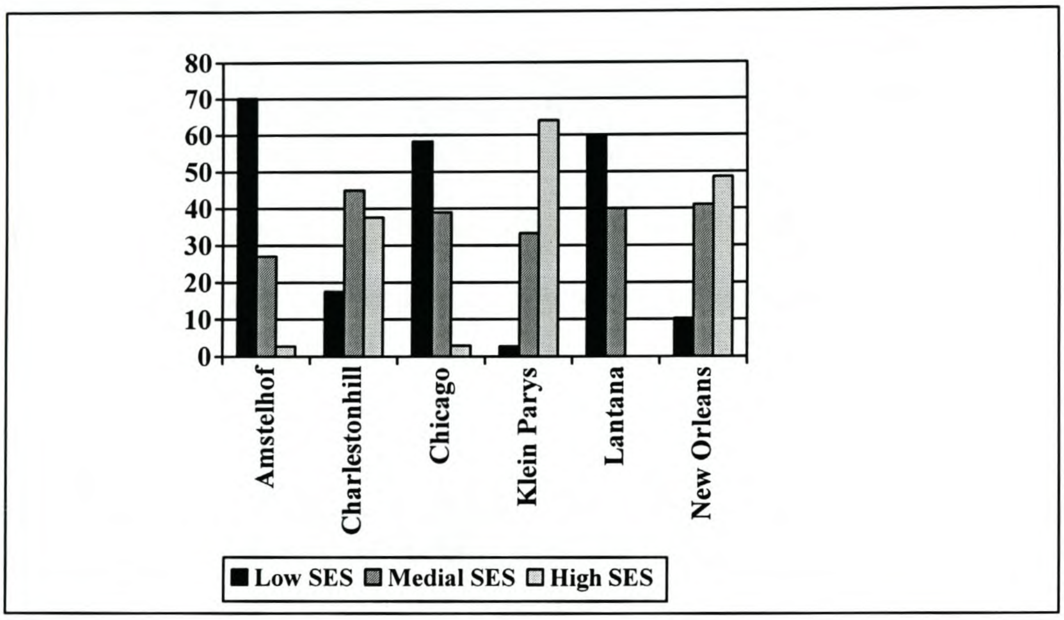
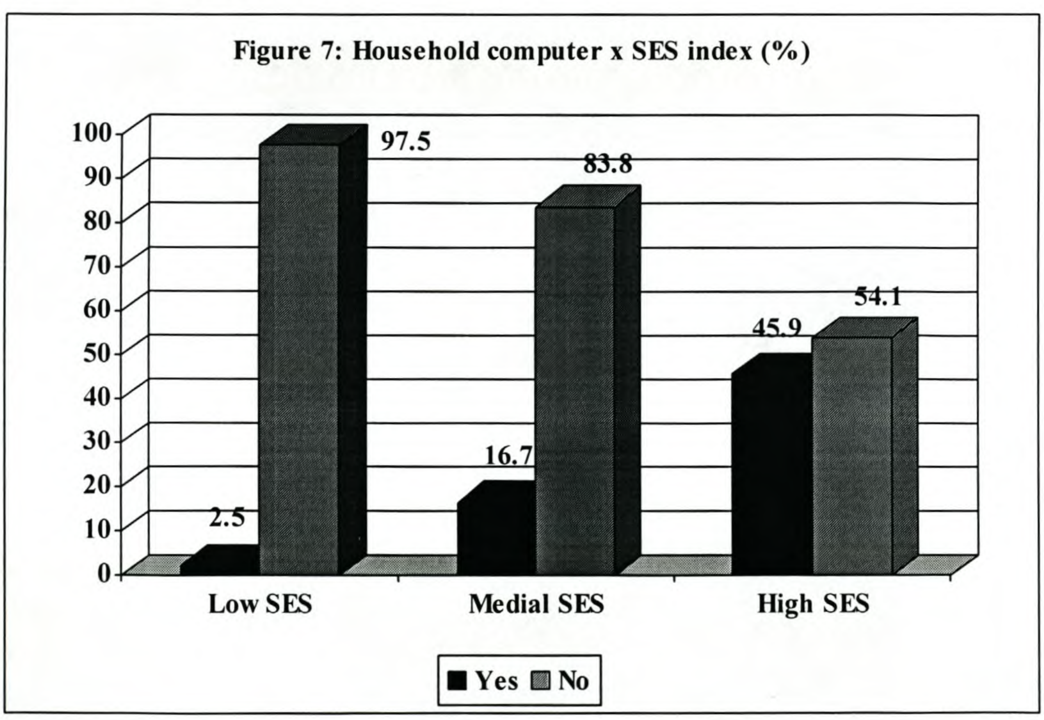


Figure 7: Computers in households by SES



Access to a household computer correlates significantly with the SES index [Chi-square = 41.773; p = 0.000; Cramer's V = 0.432], with only 2.5% of low SES respondents having a computer, as compared to 16.7% and 45.9% of medial and high SES respondents, respectively. In the total sample (N = 238) only 18.9% of respondents indicated that they have a computer at home.

3.4 Exposure to and interest in S&T related issues and events

To gauge how informed the sample is about general matters, we also asked how many watch news on TV or listen to news on the radio and how often they read newspapers per week. Figures 8 and 9, read together, imply that a significant portion of the sample has moderate to high exposure to current news events. This is derived from the fact that, 73% of respondents watch TV news, 58% listen to the news on radio and 84% read the newspapers at least once per week.

Figure 8: Exposure to news on TV and radio

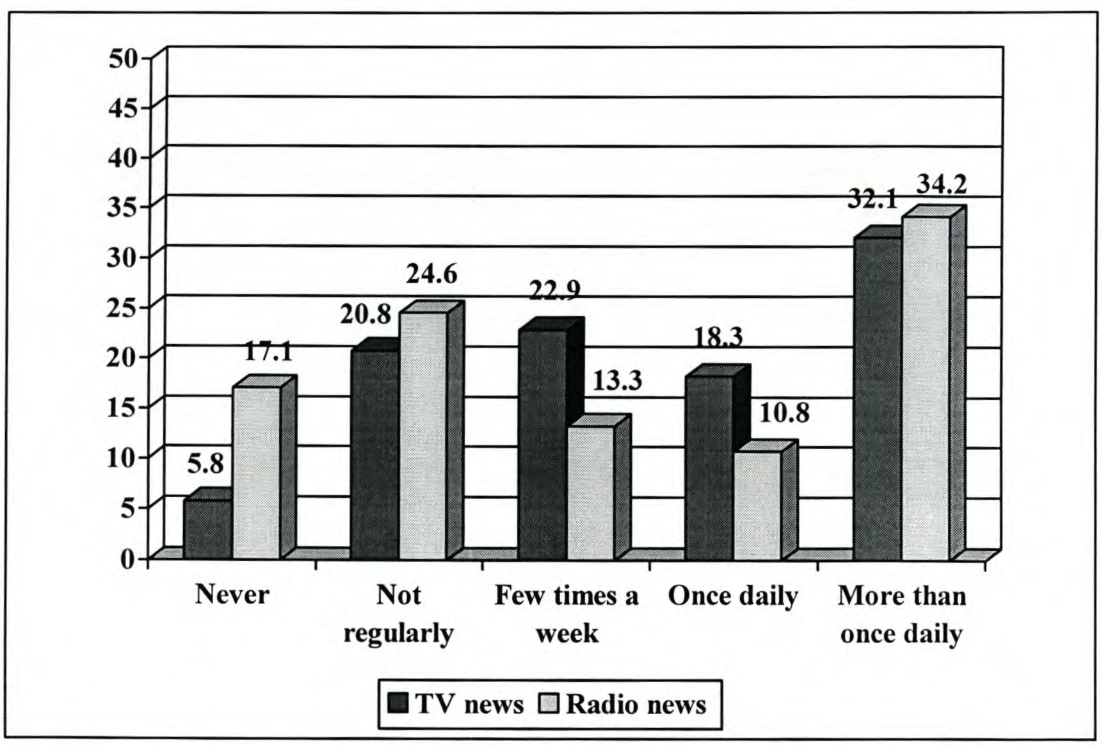
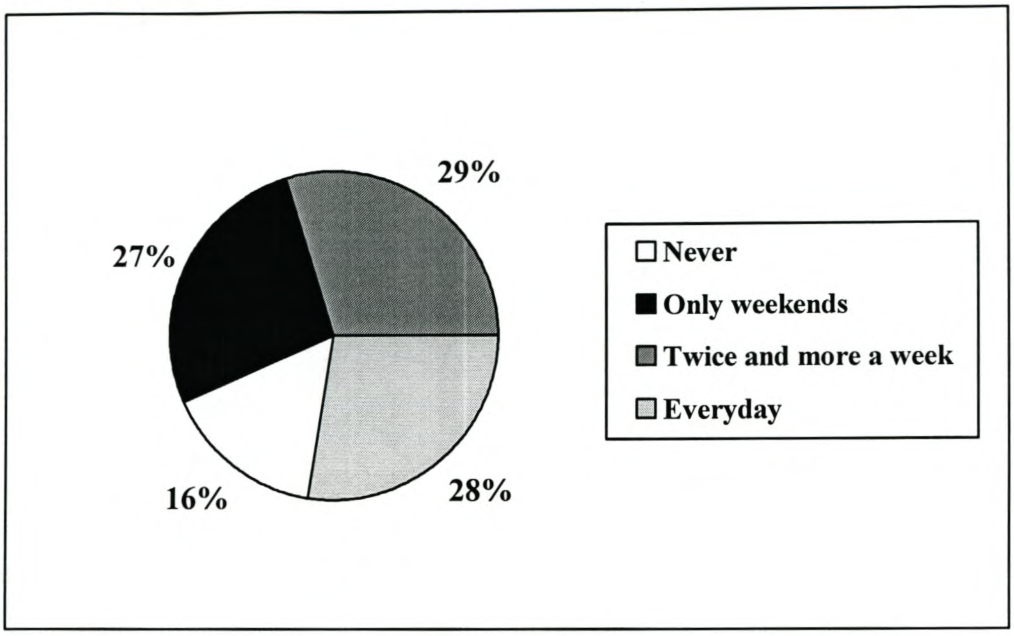
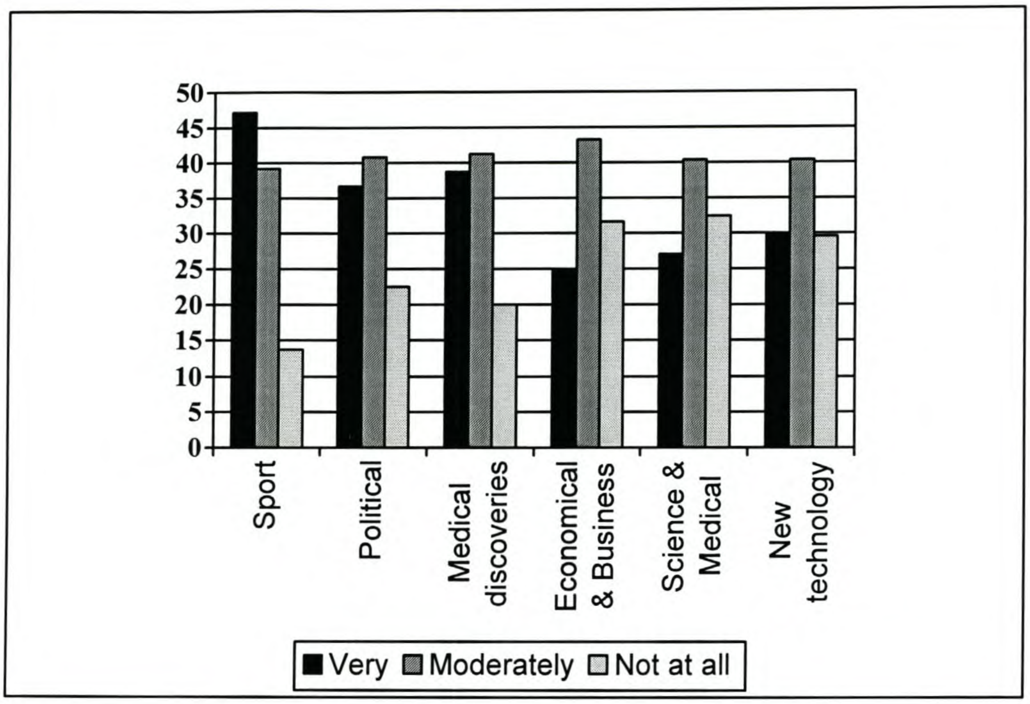


Figure 9: Read newspapers



Respondents were also asked to indicate their levels of interest in a number of issues. About 40% of respondents revealed a moderate interest in each of the six selected news issues (Figure 10). Three issues that the respondents appear to be very interested in are news relating to sport (47.1%), new medical discoveries and events (38.8%) and political news (36.7%). The three issues with relatively high percentages of "not at all interested" responses are news about science and medical issues (32.5%), economic and business news (31.7%) and news about new technology (29.6%).

Figure 10: Degrees of Interest in selected news issues



The gender, age and SES breakdowns of interest in these news issues are displayed in Tables 2, 3 and 4 respectively. Only statistically significant results are reported.

Table 2: Gender x Degree of interest in news issues (row %)

COMPARISON		NOT AT ALL	MODE-RATELY	VERY	STATISTICS
Sport	Male	5.0	30.3	64.7	Chi-square = 33.374
	Female	22.3	47.9	29.8	p = 0.000 Cramer's V = 0.373
Political	Male	15.1	32.8	52.1	Chi-square = 24.794
	Female	29.8	48.8	21.5	p = 0.000 Cramer's V = 0.321
Econ & Buss	Male	23.5	42.0	34.5	Chi-square = 13.468
	Female	39.7	44.6	15.7	p = 0.001 Cramer's V = 0.237

Table 3: Age x Degree of interest in news issues (row %)

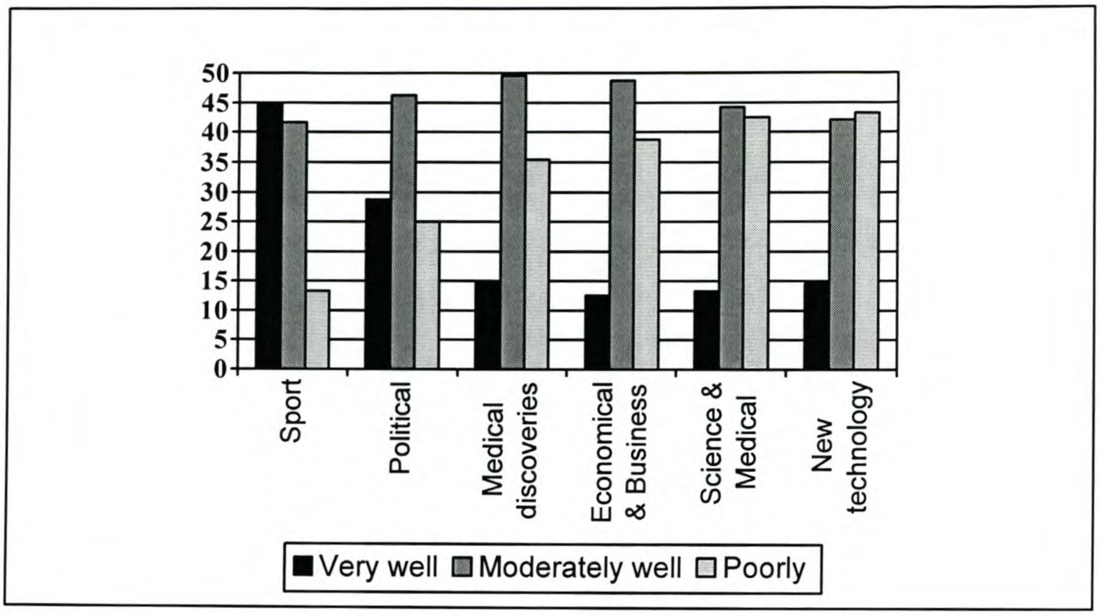
Comparison		Not at all	Moderately	Very	Statistics
Sport	18-24	9.1	36.4	54.5	Chi-square = 15.492
	25-34	8.1	43.5	48.4	p = 0.017
	35-44	10.3	39.7	50.0	Cramer's V = 0.180
	45+	29.1	36.4	34.5	

Table 4: SES x Degree of interest in news issues (row %)

Comparison		Not at all	Moderately	Very	Statistics
Political	Low	28.8	41.3	30.0	Chi-square = 23.470
	Medial	20.0	51.8	28.2	p = 0.000
	High	13.1	24.6	62.3	Cramer's V = 0.228
Medical	Low	26.3	38.8	35.0	Chi-square = 10.239
discoveries	Medial	20.0	45.9	34.1	p = 0.037
	High	8.2	39.3	52.5	Cramer's V = 0.151
Economic	Low	36.3	50.0	13.8	Chi-square = 26.301
& business	Medial	32.9	48.2	18.8	p = 0.000
	High	18.0	32.9	49.2	Cramer's V = 0.241
New	Low	37.5	35.0	27.5	Chi-square = 10.416
technology	Medial	25.9	48.2	25.9	p = 0.034
	High	18.0	39.3	42.6	Cramer's V = 0.152

It is clear from Table 2, that no statistically significant gender differences exist for the three S&T related news issues (new medical discoveries and events; science and medical issues; and new technology). The same applies to Table 3. In Table 2 males – perhaps not surprisingly – showed more interested both in news related to sport, political, economic and business issues. Table 4 includes two of the three S&T related news issues. Here respondents with high SES scores (i.e. good education and high total monthly household income) appear to be the ones with significantly greater interest in the four issues concerned.

Figure 11: Level of informedness about selected news issues



As can be seen from Figure 11, at least 40% of respondents rated themselves moderately well informed across the six news issues, with the highest percentage of "moderately well informed" responses recorded for new medical discoveries and events (49.6%). As far as the percentage of "very well informed" responses is concerned, it only exceeds the 40% mark (i.e. 45%) for news relating to sport. If one looks at the distribution of "poorly informed" responses, this is predominantly for news about new technology (43.3%) and science and medical issues (42.5%).

A breakdown for gender, age, education and SES follows in Tables 5 to 8. Again only statistically significant results are displayed.

Table 5: Gender x Level of information about news issues (row %)

Comparison		Poorly	Moderately	Very well	Statistics
Sport	Male	5.9	31.1	63.0	Chi-square = 33.204 p = 0.000 Cramer's V = 0.372
	Female	20.7	52.1	27.3	
Political	Male	18.5	40.3	41.2	Chi-square = 18.467 p = 0.000 Cramer's V = 0.277
	Female	31.7	52.1	16.5	

One can infer from Table 5 that men and women do not differ significantly in their levels of information about the three S&T related news issues. Differences only occur for news relating to sport and politics, with men being better informed than women in these areas.

Table 6: Age x Level of information about news issues (row %)

Comparison		Poorly	Moderately	Very well	Statistics
Sport	18-24	5.5	45.5	49.1	Chi-square = 13.909 p = 0.031 Cramer's V = 0.170
	25-34	6.5	45.2	48.4	
	35-44	17.6	33.8	48.5	
	45+	23.6	43.6	32.7	
Medical discoveries	18-24	32.7	58.2	9.1	Chi-square = 13.543 p = 0.035 Cramer's V = 0.168
	25-34	46.8	46.8	6.5	
	35-44	27.9	51.5	20.6	
	45+	34.5	41.8	3.6	
New technology	18-24	38.2	50.9	10.9	Chi-square = 15.783 p = 0.015 Cramer's V = 0.181
	25-34	50.0	41.9	8.1	
	35-44	30.9	44.1	25.0	
	45+	56.4	30.9	12.7	

Inspection of Table 6 shows substantive percentages of both "moderately well" and "very well" responses for all age groups with regard to sports news (with the younger age groups being slightly better informed). The significant results for medical discoveries and new technology in relation to age are more difficult to interpret. There nevertheless appears to be a tendency for the age group 35-44 to be somewhat better informed about S&T related news issues. It is also of interest that the percentage of "very well informed" responses for sports news is markedly higher than those for the S&T related news issues.

Table 7: Education x Level of information about news issues (row %)

Comparison	Poorly	Moderately	Very Well	Statistics
Sport				
Some Primary	32.4	27	40.5	Chi-square = 20.653
Some Secondary	13.5	40.5	45.9	P = 0.002
Matric/Diploma	6.3	48.1	45.6	Cramer's V = 0.213
Degree	2.7	48.6	48.6	
Medical discoveries				
Some Primary	54.1	37.8	8.1	Chi-square = 13.734
Some Secondary	35.1	54.1	16.8	P = 0.033
Matric/Diploma	34.2	49.4	16.8	Cramer's V = 0.174
Degree	18.9	54.1	27	
Economic & Business				
Some Primary	56.8	35.1	8.1	Chi-square = 15.958
Some Secondary	36.5	52.7	10.8	P = 0.014
Matric/Diploma	38	52.9	10.1	Cramer's V = 0.187
Degree	16.2	59.5	24.3	
Science and medical issues				
Some Primary	51.4	37.8	10.8	Chi-square = 13.501
Some Secondary	44.6	45.9	9.5	P = 0.036
Matric/Diploma	46.8	40.5	12.7	Cramer's V = 0.172
Degree	18.9	54.1	27	
New technology				
Some Primary	67.6	24.3	8.1	Chi-square = 28.838
Some Secondary	41.9	43.2	14.9	P = 0.000
Matric/Diploma	41.8	49.4	8.9	Cramer's V = 0.252
Degree	16.2	48.6	35.1	

Most of the respondents are moderately informed relating to sport. But it is clear from Table 7 that respondents with degrees rated themselves to be better informed about the four S&T related news issues (medical discoveries, economic and business news, science and medical issues and new technology).

Table 8: SES x Level of information about news issues (row %)

Comparison		Poorly	Moderately	Very well	Statistics
Sport	Low	22.5	33.8	43.8	Chi-square = 16.001
	Medial	10.6	42.4	47.1	p = 0.003
	High	1.6	54.1	44.3	Cramer's V = 0.188
Political	Low	31.3	42.5	26.3	Chi-square = 9.863
	Medial	28.2	43.5	28.2	p = 0.043
	High	9.8	57.4	32.8	Cramer's V = 0.148
Economic & business	Low	48.8	38.8	12.5	Chi-square = 11.198
	Medial	34.1	57.6	8.2	p = 0.024
	High	26.2	55.7	18.0	Cramer's V = 0.157
New technology	Low	55.0	32.5	12.5	Chi-square = 16.028
	Medial	42.4	47.1	10.6	p = 0.003
	High	24.6	50.8	24.6	Cramer's V = 0.188

In Table 8 the percentages of "poorly informed" responses for news relating to sport and politics are distinctively lower than similar responses for economic and business news and news about new technology. This is the case across all three levels of SES. Also of interest are the substantive percentages of "moderately well informed" responses across the news issues, although lower rates are reported throughout for respondents within the low SES group. With the exception of sports news, the largest percentages of "very well informed" responses are associated with the high SES group.

The respondents also indicated whether or not they watch TV programmes on S&T or read any scientific magazines. The overall responses appear in Figure 12.

Figure 12: Exposure to TV programs on S&T and scientific magazines

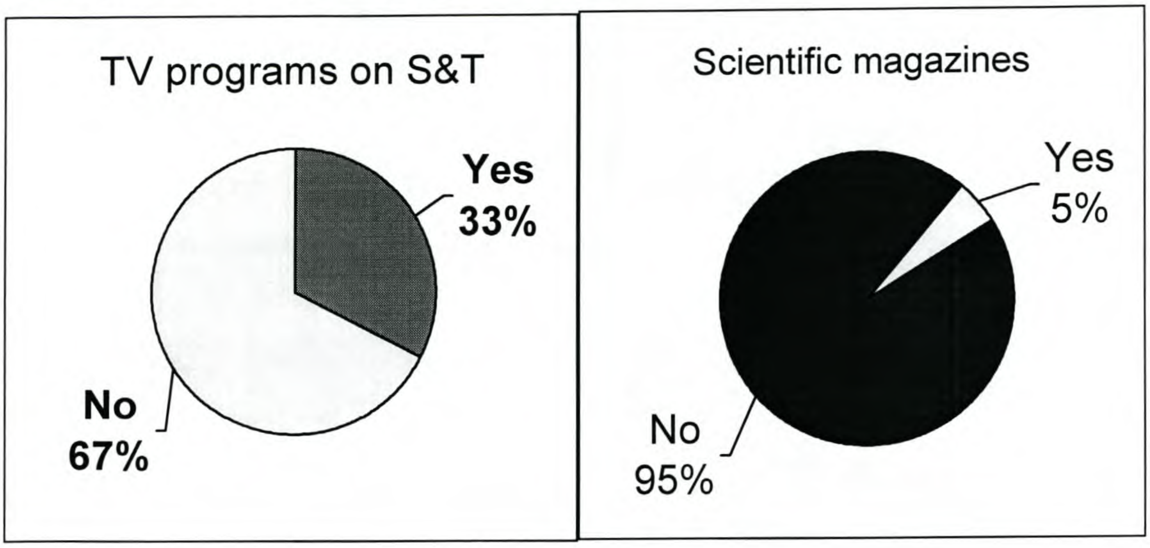


Figure 12 reveals that two-thirds of the respondents (67%) do not watch S&T related programmes on television and that the overwhelming majority (95%) does not read scientific magazines. The two TV programmes most frequently mentioned by the 33% with affirmative responses are *50/50* (48.1%) and *Beyond 2000* (26.6%).

Statistically significant associations were found for TV programmes on S&T and both gender and SES, as well as for scientific magazines and age and SES. However, in the cross-tabulations for scientific magazines more than 25% of the cells have the expected counts of less than 5, making the interpretation of Chi-square invalid. For this reason significant results are reported only for TV programmes (Table 9).

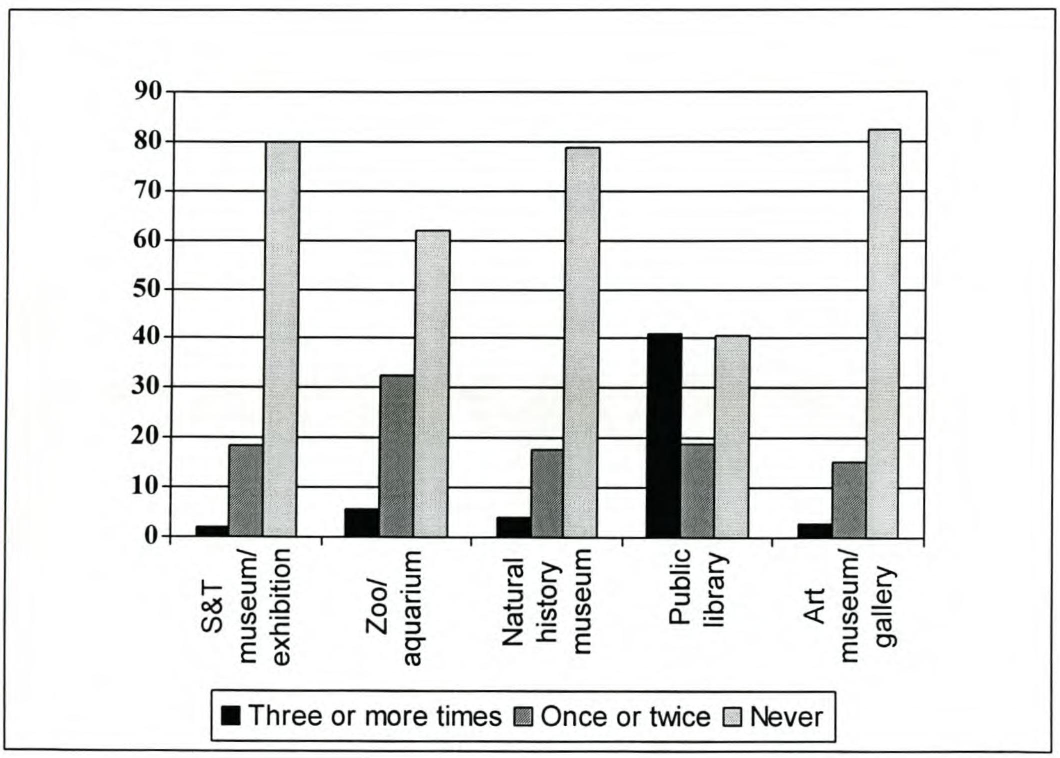
Table 9: TV programs on S&T x Gender and SES (row %)

Comparison	Yes	No	Statistics
Gender			
Male	46.2	53.8	Chi-square = 20.240/ p = 0.000
Female	19.0	81.0	Cramer's V = 0.290
SES			
Low	16.3	83.8	Chi-square = 17.609/ p = 0.000
Medial	34.1	65.9	Cramer's V = 0.279
High	49.2	50.8	

There are two patterns emerging from Table 9 worth mentioning: Men watch significantly more TV programmes on S&T than women, and respondents in the high SES group are also more inclined to do so than respondents in the low SES group.

Exposure to and interest in S&T related issues were also assessed by the frequency with which the respondents have visited places of artistic, cultural or scientific and technological interest in the last two years. An overview of the responses for the total sample appears in Figure 13.

Figure 13: Visits to places of artistics, cultural, scientific and technological interest over the past two years (5)



The most salient finding of Figure 13 is that, with the exception of the public library, large percentages of respondents (62.1% to 82.5%) have never visited any of the venues during the preceding two years. In the case of the public library, equal percentages of respondents selected the two scale-end responses (40.8% vs. 40.4%).

The response patterns in Figure 13 can be further articulated through a breakdown for gender, age and SES. These appear in Tables 10 to 12 and again the emphasis is on statistically significant differences.

Table 10: Gender x Visits to places of artistic, cultural, scientific and technological interest (row %)

Comparison		Never	Once or twice	Three times +	Statistics
Public library	Male	47.1	21.0	31.9	Chi-square = 7.798 p = 0.020 Cramer's V = 0.180
	Female	33.9	16.5	49.6	

Table 10 shows that female respondents are more likely to have frequented public libraries over the past two years than their male counterparts.

Table 11: Age x Visits to places of artistic, cultural, scientific and technological interest (row %)

Comparison		Never	Once or twice	Three times +	Statistics
S&T museum/ exhibition	18-24	61.8	30.9	7.3	Chi-square = 23.437 p = 0.001 Cramer's V = 0.221
	25-34	88.7	11.3	0.0	
	35-44	82.4	17.6	0.0	
	45+	85.5	14.5	0.0	
Zoo/ aquarium	18-24	50.9	45.5	3.6	Chi-square = 12.882 p = 0.045 Cramer's V = 0.164
	25-34	66.1	30.6	3.2	
	35-44	55.9	36.8	7.4	
	45+	76.4	16.4	7.3	
Natural history museum	18-24	60.0	36.4	3.6	Chi-square = 21.538 p = 0.001 Cramer's V = 0.212
	25-34	82.3	14.5	3.2	
	35-44	85.3	13.2	1.5	
	45+	85.5	7.3	7.3	
Public library	18-24	20.0	27.3	52.7	Chi-square = 21.256 p = 0.002 Cramer's V = 0.210
	25-34	50.0	21.0	29.0	
	35-44	35.3	17.6	47.1	
	45+	56.4	9.1	34.5	

There seems to be a tendency for 18-24 year old respondents to have visited these four venues at least once in the last two years. The frequent visits to these venues by this specific age group can be attributed to the fact that many of them are still in school. Thus, meaning that it is part of their school curriculum to visit these venues

Table 12: SES x Visits to places of artistic, cultural, scientific and technological interest (row %)

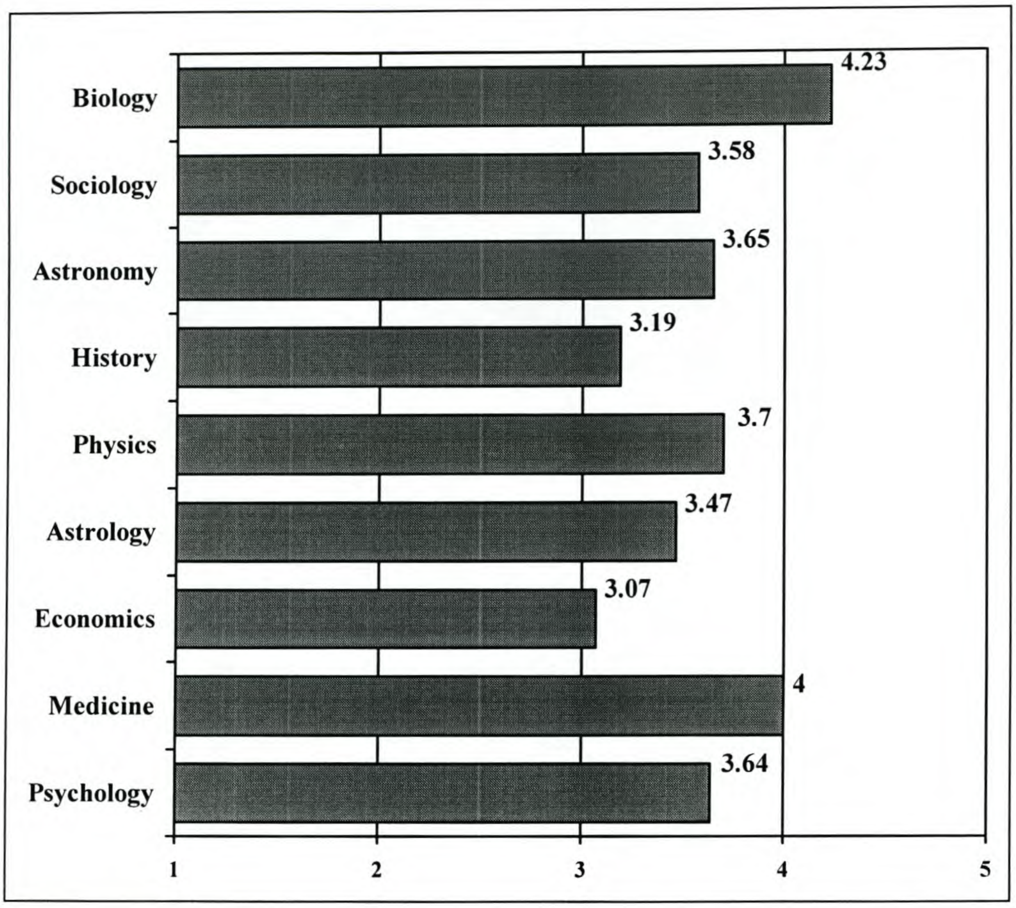
Comparison		Never	Once or twice	Three times +	Statistics
S&T museum/ exhibition	Low	91.3	8.8	0.0	Chi-square = 17.132
	Medial	74.1	21.2	4.7	p = 0.002
	High	70.5	29.5	0.0	Cramer's V = 0.195
Public library	Low	56.3	18.8	25.0	Chi-square = 20.112
	Medial	29.4	23.5	47.1	p = 0.000
	High	32.8	11.5	55.7	Cramer's V = 0.211
Art museum/ gallery	Low	91.3	7.5	1.3	Chi-square = 16.902
	Medial	85.9	11.8	2.4	p = 0.002
	High	65.6	29.5	4.9	Cramer's V = 0.193

Table 12 demonstrates that respondents of higher SES (i.e. higher education and total monthly household income) are also more likely to frequent S&T museums or exhibitions, zoos or aquariums, and art museums or galleries.

3.5 Attitudes about the nature and value of S&T

The respondents were given a list of nine science fields (not labelled as such in the questionnaire) and asked to rate these in terms of "scientificity" (5 = very scientific and 1 = not scientific at all). A "don't know/ no opinion" option was also provided for. The mean ratings of the total group per science field are given in Figure 14.

Figure 14: Mean ratings per scientific field



The size of the samples on which Figure 14 is based range from 186 (Astrology) to 226 (Biology). This implies a "don't know/ no opinion" response rate of between 5.8% and 22.5%. Biology and Medicine fall closest to the "very scientific" end of the scale with ratings of 4.23 and 4 respectively. None of the nine fields, however, was viewed as "not scientific at all" because the lowest mean rating is 3.07 (Economics), which lies to the middle of the scale.

A series of t-tests and one-way ANOVAs was also performed, with gender, age and SES as independent variables and the ratings as dependent variables. Significant differences are presented in Tables 13, 14 and 15.

Table 13: Gender x Mean scientific ratings per science field

Comparison		N	Mean	Std Dev	Statistics
Sociology	Male	107	3.41	1.33	t = -2.071
	Female	105	3.75	1.05	p = 0.040
History	Male	104	2.98	1.54	t = -2.000
	Female	106	3.40	1.47	p = 0.047

Table 14: Age x Mean scientific ratings per science field

Comparison		N	Mean	Std Dev	Statistics
Economics	18-24	48	2.65	1.41	F = 3.630
	25-34	53	2.85	1.45	p = 0.014
	35-44	61	3.30	1.54	Eta squared =
	45+	41	3.07	1.42	0.052

Table 15: SES x Mean scientific ratings per science field

Comparison		N	Mean	Std Dev	Statistics
Botany	Low	71	3.92	1.30	F = 5.938
	Medial	83	4.30	1.09	p = 0.003
	High	59	4.58	0.83	Eta squared = 0.054
Astronomy	Low	62	3.35	1.32	F = 7.973
	Medial	76	3.47	1.32	p = 0.000
	High	56	4.21	1.12	Eta squared = 0.077
Physics	Low	64	3.44	1.21	F = 10.640
	Medial	77	3.52	1.35	p = 0.000
	High	57	4.37	1.06	Eta squared = 0.098
Astrology	Low	56	3.11	1.37	F = 5.710
	Medial	69	3.42	1.40	p = 0.004
	High	52	3.96	1.17	Eta squared = 0.062
Economics	Low	62	2.89	1.53	F = 4.910
	Medial	74	2.82	1.47	p = 0.008
	High	56	3.57	1.33	Eta squared = 0.049
Medicine	Low	61	3.82	1.27	F = 6.232
	Medial	76	3.78	1.31	p = 0.002
	High	59	4.46	0.97	Eta squared = 0.061

Table 13 shows that women are significantly more inclined to rate Sociology and History as scientific, and respondents in the age group 35-44 more likely to do so for Economics (Table 14). Respondents in the high SES group are more likely to rate Biology, Astronomy, Physics, Astrology, Economics and Medicine as scientific (Table 15). The respondents in the high SES group are also more positive about science

Apart from rating the "scientificity" of selected science fields, the respondents were also instructed to indicate the extent of their agreement or disagreement with 13 statements about the value of S&T (1 = strongly disagree; 3 = neutral; and 5 = strongly agree). These statements, together with the mean attitude scores, are given in Table 16.

Table 16: Mean attitude scores to S&T value statements

Statement	Mean	Std Dev
(1) Science and technology make our lives healthier	4.38	0.84
(2) Scientific research can play an important role in protecting the environment and repairing it	4.31	0.89
(3) We depend too much on science and not enough on faith	4.21	1.11
(4) Scientific and technological progress will help to cure illnesses such as Aids, cancer etc.	4.18	0.99
(5) Social science and psychology help people deal with stress	4.02	1.03
(6) Thanks to scientific knowledge, the earth's natural resources will never be exhausted	4.00	1.00
(7) Only by applying the most modern technology can our economy become more competitive	3.88	1.04
(8) Computers have made the use of bank services more complicated	3.84	1.18
(9) The benefits of science are greater than any harmful effects it may have	3.79	0.97
(10) Scientists should be allowed to do research that causes pain and injury to animals (dogs) if it can produce new information about serious health problems	3.74	1.26
(11) Scientific research does not make industrial products cheaper	3.48	1.14
(12) On balance, computers and factory automation will result in decrease of work opportunities	3.15	1.51
(13) Technology and science make our lives more difficult and create more problems	3.10	1.30

As can be seen in Table 16, six attitude statements all received ratings in the "agree" (score of 4) to "strongly agree" (score of 5) range. The rest of the statements vary to different degrees between "agree" (score of 4) and "neutral" (score of 3). No statements were disagreed with (i.e. there were no scores of 2 or less).

The 13 S&T value statements were also subjected to a factor analysis, in order to identify the underlying dimensions or components. A principal component analysis was performed, with a varimax rotation. If the latent root criterion (eigen values greater than 1) is specified as stopping criterion, altogether 5 factors are extracted, explaining about 60% of the variance in the statement responses. If, however, *a priori* criteria of 4 and 3 are specified, then the percentage of explained variance drops to 53% and 43%, respectively. This is summarised in Table 17.

Table 17: Results of three factor solutions to the value statements

Statement	5 Factors					4 Factors				3 Factors		
	F1	F2	F3	F4	F5	F1	F2	F3	F4	F1	F2	F3
(4) Scientific and technological progress will help to cure illnesses such as Aids, cancer etc.	.782					.757				.779		
(9) The benefits of science are greater than any harmful effects it may have.	.616					.646				.653		
(7) Only by applying the most modern technology can our economy become more competitive.	.646					.640				.645		
(2) Scientific research can play an important role in protecting the environment and repairing it.	.515							.409		.438		
(13) Technology and science make our lives more difficult and create more problems.	.440			.659		.553	.534			.504	.660	
(10) Scientists should be allowed to do research that causes pain and injury to animals (dogs) if it can produce new information about serious health problems.		.557						.531			.622	
(11) Scientific research does not make industrial products cheaper.				.820			.530				.548	
(8) Computers have made the use of bank services more complicated.					.761		.657				.493	
(5) Social science and psychology help people deal with stress.								.583			.451	
(3) We depend too much on science and not enough on faith.		.594						.529			.419	
(1) Science and technology make our lives healthier.			.602						.808			.795
(6) Thanks to scientific knowledge, the earth's natural resources will never be exhausted.		.697							.636			.635
(12) On balance, computers and factory automation will result in decrease of work opportunities.			.836				.506	.458	.550			.579
Total variance explained			60.399				52.529				43.335	

In Table 17 factor loadings of 0.40 and higher were considered significant. This is based on a guideline by Hair et al. (1998:112), which takes into account the sample size. As can be seen in Table 16, the 3-factor solution is the easiest to interpret but accounts for the least of the variability in the statement responses. Given however that the purpose of the factor analysis was to explore meaningful dimensions (rather than simply reducing the statements to a number of factors that explain optimal variance), the 3-factor solution has been maintained.

Inspection of the pattern of loading as well as the statement content, resulted in the following labels being assigned to the factors:

Factor 1: S&T as ultimate problem-solver

Factor 2: Scepticism towards S&T

Factor 3: S&T for enhanced quality of life

Factor scores were calculated for each respondent according to the regression-method and used in a series of comparison procedures (t-test and one-way ANOVAs), with gender, age, SES and education as the independent variables.

It evident from the factor analysis that no difference in gender and age appear. However, there are clear differences pertaining to scepticism towards science and technology. People with a low socio-economic status are more sceptical towards science and technology than people with middle to high socio-economic status. This trend is also evident at the level of education; people with low educational qualifications are more sceptical to science and technology than people with middle and high level educational qualifications. The rest of the results are summarised in Table 18.

Table 18: Factor scores x Gender, Age, SES & Education

Comparison		N	Mean	Std Dev	Statistics
Gender					
S&T as ultimate problem-solver	Male	119	-0.02	1.05	t = - 0.319
	Female	121	0.02	0.95	p = 0.075
Scepticism towards S&T	Male	119	-0.11	1.07	t = -1.677
	Female	121	0.11	0.92	p = 0.095
S&T for enhanced quality of life	Male	119	-0.07	1.06	t = -1.068
	Female	121	0.07	0.94	p = 0.286
Age					
S&T as ultimate problem-solver	18-24 yrs	55	-0.20	0.94	F = 1.073
	25-34 yrs	62	0.02	1.09	p = 0. 361
	35-44 yrs	68	0.04	0.90	Eta squared = 0.013
	45+ yrs	55	0.13	1.07	
Scepticism towards S&T	18-24 yrs	55	-0.04	0.89	F = 0.792
	25-34 yrs	62	-0.14	1.01	p = 0.499
	35-44 yrs	68	0.13	1.03	Eta squared = 0.010
	45+ yrs	55	0.04	1.06	
S&T for enhanced quality of life	18-24 yrs	55	0.20	0.94	F = 1.345
	25-34 yrs	62	-0.07	0.92	p = 0.260
	35-44 yrs	68	0.04	1.08	Eta squared = 0.017
	45+ yrs	55	-0.16	1.04	
SES					
S&T as ultimate problem-solver	Low	80	-0.10	1.09	F = 2.320
	Medium	85	-0.03	0.98	p = 0.101
	High	61	0.25	0.87	Eta squared = 0.020
Scepticism towards S&T	Low	80	0.42	0.91	F = 16.165
	Medium	85	-0.08	1.01	p = 0.000
	High	61	-0.49	0.91	Eta squared = 0.127
S&T for enhanced quality of life	Low	80	-0.13	0.95	F = 0.877
	Medium	85	0.03	1.06	p = 0.418
	High	61	0.08	1.04	Eta squared = 0.008

Comparison		N	Mean	Std Dev	Statistics
Education					
S&T as ultimate problem-solver	Primary	37	-0.18	1.10	F = 0.884
	Secondary	74	-0.04	1.05	p = 0.450
	Matric/Dipl	79	0.10	0.94	Eta squared = 0.012
	Degree	37	0.13	0.95	
Scepticism towards S&T	Primary	37	0.47	0.89	F = 9.369
	Secondary	74	0.25	0.95	p = 0.000
	Matric/Dipl	79	-0.35	0.90	Eta squared = 0.112
	Degree	37	-0.29	1.13	
S&T for enhanced quality of life	Primary	37	-0.33	0.93	F = 2.340
	Secondary	74	-0.06	1.03	p = 0.074
	Matric/Dipl	79	0.02	0.98	Eta squared = 0.031
	Degree	37	0.28	1.09	

3.6 Knowledge of basic scientific facts

The respondents' knowledge of basic scientific facts was assessed by means of two sets of questions. The first set involved two problem statements, for which the respondents had to select the correct response. These are given in Tables 19 and 20.

<u>Table 19: Problem statement 1</u>

<u>Problem A</u>: Suppose a machine is breaking down repeatedly. It is suspected that the material from which a particular part is made is responsible for the breakdown. There are different ways of investigating this problem. Which of the following do you think scientists would most likely use?	
	% response
(1) Talk to the machine operators and get their opinion?	30.8
(2) Use their own scientific knowledge to decide how good the material is?	45.8
(3) Make the same part from different materials, put them in the machine and then compare what happens in each case? (C)	23.3

As shown in Table 19, 23.3% of respondents chose the third response, which the item developer regarded as the correct answer. However, it is important to note that a plurality of 45.8% selected the second response. Although the third is technically probably the correct response, one could not argue against the fact that so many respondents indicated that scientific knowledge is appropriate. A case could be made, therefore, that both 2 and 3 are legitimate and evenly credible options for scientists. On this basis, it means that 69.1% respondents answered the question "correctly".

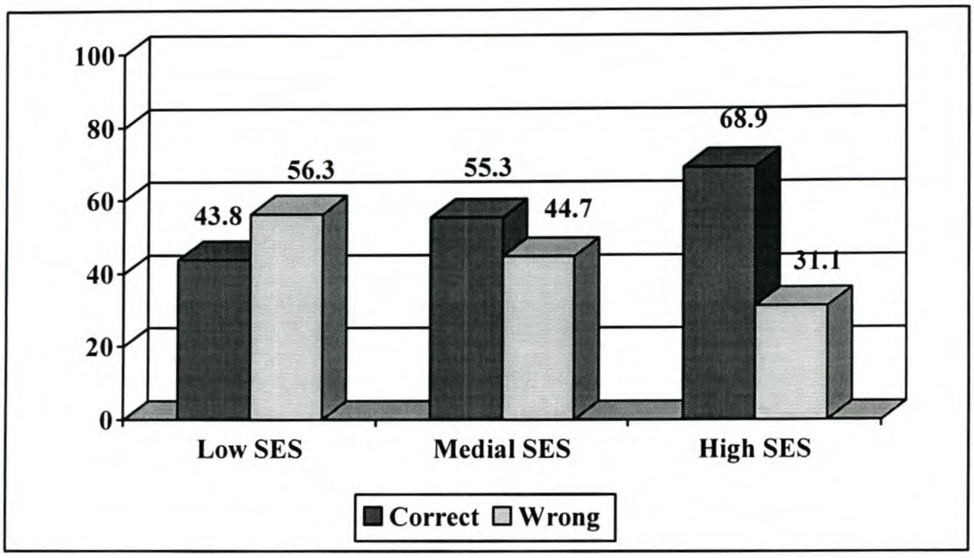
Table 20: Problem statement 2

Problem B: Suppose a doctor tells a couple that their genetic make-up means that they've got a one in four chance of having a child with an inherited illness. Does this mean that...

	% response
(1) If they have only three children, none will have the illness?	9.2
(2) If their first child has the illness, the next three will not?	18.3
(3) Each of the couple's children has the same risk of suffering from the disease? (C)	53.8
(4) If their first three children are healthy, the fourth will have the disease?	18.8

Table 20 shows that a plurality (nearly 54%) selected the correct option to Problem statement 2. A cross-tabulation of these responses with socio-economic status is presented in Figure 15. The results show a clear correlation between correct answers and SES, with 68.9% of high SES respondents answered the problem statement correctly, only 43.8% of low SES respondents managed to do so. Moreover, 56.3% of respondents in the low SES category got the answer incorrect, compared to 31.1% of high SES respondents [Chi-square = 8.817; p = 0.012; Cramer's V = 0.198].

Figure 15: Socio-economic status by responses to Problem b(%)



The second set of questions that relate to basic scientific facts consisted of two statements[1]. The respondents needed to say which were true or false. Summary results are presented in Table 21.

Table 20: Two more statements to assess knowledge of scientific facts

Statement	% Response	
	True	False
(1) The greenhouse effect may raise the sea level	42.5 (C)	57.5
(2) Acid rain may cause damage to the forests	75.8 (C)	24.2

Only the second statement was selected correctly by more than half of the respondents (76%), with most respondents select the wrong answer regarding staement 1.

[1] Originally five statements were used to assess the respondents' knowledge of basic scientific facts. However, three of these statements ("The hole in the ozone layer may cause cancer", "The greenhouse effect may reduce the desert" and "Car exhausts have to do with acid rain") generated conflicting responses from experts, resulting in these statements being dropped. The variation in expert opinion could primarily be ascribed to vagueness in wording (for instance, it is not the hole in the ozone layer that may cause cancer but what filters through the hole).

The correct response of each respondent was added up across statements to yield a total score on a 2-item scientific knowledge scale, ranging from 0 (none correct) to 2 (all correct). This scale was subsequently used as dependent variable in four sets of analyses with gender, age and SES as the independent variables. Differences for SES (Figure 16) and education (Figure 17) were noted.

Figure 16: Socio-economic status by mean scores on 2-item scale

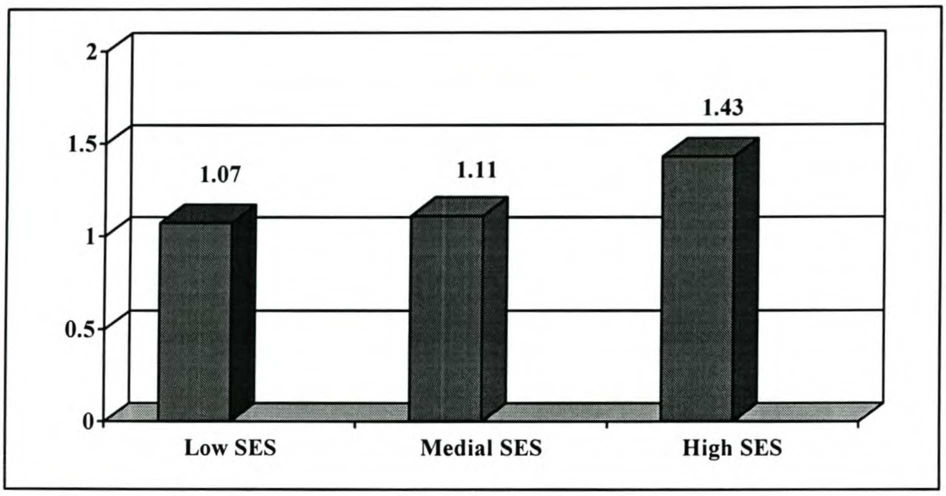
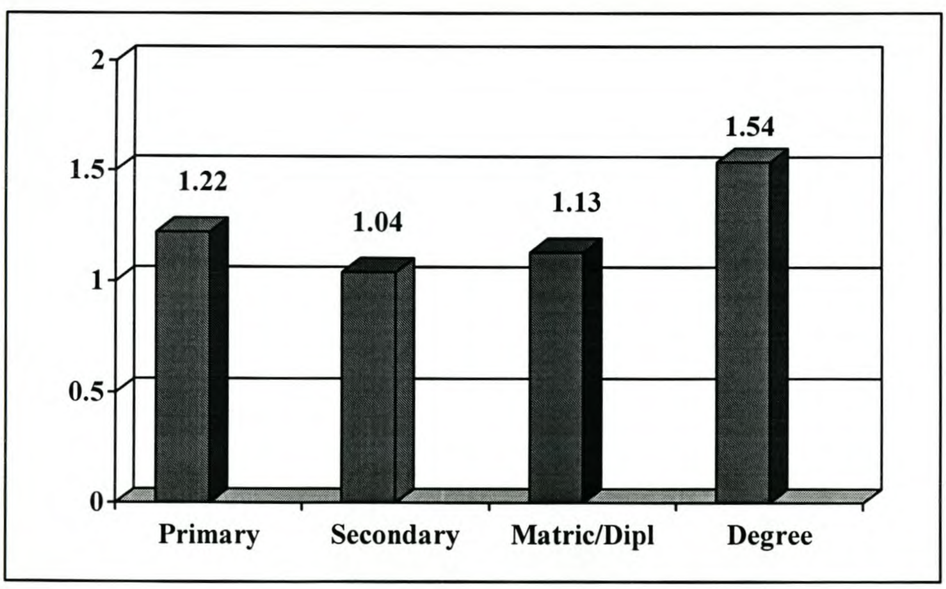


Figure 17: Educational level by mean total score on 2-item scale



The results in Figure 16 are consistent with general expectations. High SES respondents scored significantly higher on the 2-item scientific knowledge scale, relative to respondents within the medial and low SES categories [F = 4.830; p = 0.009; Eta-square = 0.042]. The results of Table 20 reveal no fundamental difference in understanding between people with primary education and those with higher education. Respondents with higher education scored the highest, followed by those with primary education on the 2-item scientific knowledge scale. This could be a function of the fact that the sample was pretty much split in their responses to question 2.

3.7 SUMMARY

The main findings of the study can be summarised as follows:

3.7.1 DEMOGRAPHICS

The gender distribution of the sample was roughly 50/50 (49.6% male and 50.4% female). Almost 50% of the respondents were younger than 35. The age category with the highest frequency was 35 to 44 years (28%).

It was also apparent from the survey that close to half of the respondents (48%) never completed formal school education (of which 16% only attended primary school). Moreover, significantly low percentages of 13% and 4%, respectively, have a first bachelor's degree (university or Technikon) and a higher degree (postgraduate).

As far as total monthly household income is concerned, just more than half of the respondents (51.5%) have a total monthly household income of less than R3 000.

This results in a sample that is relatively poorly educated and not very affluent. The gender and age distributions are perhaps as expected.

3.7.2 EXPOSURE TO AND INTEREST IN S&T RELATED ISSUES AND EVENTS

The results revealed that a significant proportion of respondents has moderate to high exposure to current news events. Three of the issues that the respondents appear to be very interested in are news relating to sport (47.1%), medical discoveries and events (38.8%) and political news (36.7%). However, a high percentage respondents are not interested in news about science and medical issues (32.5%), economic and business news (31.7%) and news about new technology (29.6%).

It is also noteworthy to mention that no statistically significant gender differences exist for the three S&T related news issues. It is, however, evident that respondents with high SES scores appear to be the ones with significantly greater interest in S&T related news issues.

In relation to the visits to scientific and cultural interest places, there seems to be the tendency for 18 -24 year old respondents to have visited these venues at least once in the last two years. Respondents with high SES frequently visited S&T museums or exhibitions, zoos or aquariums, and art museums or galleries in last two years.

3.7.3. ATTITUDES ABOUT THE NATURE AND VALUE OF S&T

The respondents were given a list of science fields and asked to rate these in terms of "scientificity". Biology and Medicine was rated as very scientific with ratings of 4.23 and 4 respectively. None of the fields, however, was viewed as "not scientific at all" because the lowest mean rating is 3.07 (Economics) which lies to the middle of the scale.

Women were significantly more inclined to rate Sociology and History as scientific, and respondents in the age group 35 - 44 more likely to do so for Economics. Respondents in the high SES group rated Biology, Astronomy, Economics and Medicine as scientific. The respondents in the high SES group were also more positive about science.

It was significant to note that no difference in gender and age appeared. There was, however, differences pertaining to scepticism towards science and technology. People with low SES were more sceptical towards science and technology than people with middle to high SES.

The trend of scepticism was also evident in the educational level. People with low educational qualifications were more sceptical to science and technology than people with middle to high educational qualifications.

3.7.4. KNOWLEDGE OF BASIC SCIENTIFIC FACTS

The respondent's knowledge of basic scientific facts was assessed by means of two sets of questions. The first set involved two problem statements. In this particular set of questions 23.3% answered the question correctly according the items developers perceptions. The second set of questions dealt with basic scientific fact. The respondents needed to say which were true or false.

In the first set of questions no significant associations with gender, age, and SES were found pertaining to problem statements. However, the results in the second set of questions complimented the general expectation. Respondents with high SES scored significantly higher, relative to respondents within the medial and low SES categories. It was

The question that remains: What implications do these survey results have for adult education and what do results like this say about the educational system? These questions will be addressed in the following two chapters.

CHAPTER 4
IMPLICATIONS OF THE SURVEY

4.1 INTRODUCTION

If public interest in science and technology are to be improved, the main effort must be made in the area of education. It is, therefore, important to review the implications that the findings of the survey could have for science education. Although the survey was primarily concerned with an adult sample and carried specific messages for the science education of adults, it may also have implications for the science education of children in schools. The following issues are addressed in this chapter:

- How science is represented and perceived to be represented by the public
- Public understanding of science
- Users of science
- Science and the media
- Forums for dialogue

4.2 REPRESENTING SCIENCE

Surveys that were conducted in the past clearly demonstrated that interest in science and technology essentially develops at the primary and secondary level of education. Secondary learning is important, but it is very difficult to fill the gaps that are left from the early years. The problem that arises is how to teach these subjects to adults and students to awaken an interest in them? The lack of interest for science and technology from the public is revealed in Figure 10 in the previous chapter. The respondents appear to be very interested in news relating to sport (47.1%), new medical discoveries and events (38.8%) and political news (36.7%). The three issues with relatively high percentages of "not at all interested" are news about science and medical issues (32.5%), economic and business news (31.7%) and news about new technology (29.6%). This lack of interest in scientific and technological matters could possibly be attributed to the fact that they see science as irrelevant to real life. They also expressed the notion that science is difficult to understand.

The lack of or decline in technical or science programmes within schools may also have contributed to the lack of interest from the public. The lack of interest may also be due to the fact that the public and teachers find scientific language difficult to understand. Some teachers have to teach these difficult theories to the students without really comprehending the theories themselves.

Furthermore, while the computer-age is on our doorsteps, children in South Africa are still being taught with old methods. Most children complete school without being really computer literate. It is also clear from the survey that access to computers in South African households is low and clearly related to SES. Only 2.5% of low SES respondents have a computer, as compared to 16.7% and 45.9% of medial and high SES respondents, respectively. Therefore, the lack of computer literacy, especially by low SES respondents, makes it difficult for them to compete in a highly competitive world.

In the age of science and technology, our educational system has to be transformed and updated to cope with the new and challenging environment of the world. The current educational system, where the teachers mainly carry the weight of the learning process, must change so that the learners can take more initiative in the learning process.

To change the current educational system superficially is not satisfactory. A new educational philosophy in line with developments in science and technology worldwide is needed. The emphasis in the educational system was and still is, on developing exam skills and information techniques. Thus, learners became passive and simple memorised the patterns needed to answer the questions. The demands of today's labour market require much more than that.

If South Africa continues with the current educational system it will have a major effect on today's teenagers when they enter the labour market. I foresee with our current educational system, that South Africa's biggest problem will not be the illiteracy rate, but the people's inability to compete economically with rest of the world. For example, in our sample we have an economic inactivity rate of about 53% (i.e. unemployed, retired, students and housewives). The two groups of economically active respondents with the highest frequencies are unskilled labourers (15.8%) and semi-professionals (12.9%). The latter primarily comprises teachers and nurses. This may also be a contributing factor to the respondent's inability to take initiative and to apply analytical skills.

Ziman (1991: 102) made a pertinent contribution to the education of science by stating:

i. "Science is not a well-bounded coherent thing, capable of being more or less understood.
ii. Science is not a sharply-defined and special type of knowledge which only starts to be misrepresented and misunderstood outside well-defined boundaries by people who simply do not know any better."

Ziman (1991) further indicates that "he has seen many everyday questions that cannot be addressed properly, let alone answered, simply in terms of a shortfall in potential understanding."

Thus, there remain two options:

i. Allow the future generation to become victims of a poor educational system; or

ii. Change the educational system so that today's teenagers will be more competitive in the labour market.

Either way, our educational system has reached the crossroads and some hard decisions need to be made. "There needs to be a move to one in which, inescapably, hard decisions have to be made on the basis of a scientific input, which is irremediably soft" (Ravetz, 1990: 38). Furthermore, in order to change the educational system, consideration also needs to be given to ideas like the plurality of science.

4.3 UNDERSTANDING SCIENCE

The survey demonstrated that the respondents lack a comprehensive understanding of science. For example, 40% of respondents rated themselves moderately well informed across the six news issues, with the highest percentage of "moderately well informed" responses for new medical discoveries and events (49.6%). As far as the percentage of "very well informed" responses is concerned, it only exceeds the 40% mark. (i.e. 45%) for news relating to sport. If one looks at the distribution of "poorly informed" responses, this is predominantly for news about new technology (43.3%) and science and medical issues (42.5%).

The lack of understanding of science by the public may be a direct result of deficiency in knowledge, which can only be repaired by an improved supply of knowledge. The ignorance which some of the respondents displayed during the interviews may also have a direct influence on the deficiency in knowledge. Nevertheless, "a better understanding of scientific knowledge will be achieved by a more efficient, unidirectional flow of knowledge from science to citizens, from active producers to passive consumers" (Durant et al, 1989).

Recent innovations are directed to make science and technology more relevant to the public at large. For example, in a report the American

Association for the Advancement of Science (AAAS, 1993) stated the following:

> "The common core of learning in science and technology should be centred on science literacy, not on an understanding of each of the separate disciplines. Moreover, science and technology should make connection with areas such as arts and humanities."

However, at school level, neither science nor technology, achieve recognition at this level of education. Thus, in order to cultivate a spirit and unidirectional flow of knowledge and creativity, it is necessary to inquire about the activities in our educational system. As we stated above, the goal should be to develop people and students creativity through appropriately planned and well-organised scientific events.

If you consider the farmers' responses to radiation risks from a nuclear fuel reprocessing plant (chapter 2), it demonstrates that lay people are both creative and analytical when science is available to them. Furthermore, it indicates that lay persons have the ability to conceptualise knowledge that is important for their use. Seen in this light, the creativity that was stimulated within the farmers gave them the ability to develop specific scientific knowledge outside of formal educational settings.

The results of the survey demonstrate that the public with a high SES do have the ability to fully integrate scientific facts into specific knowledge. As presented in the previous chapter (Figure 15) 69% of the respondents in the high SES-category answered the problem statement correctly whereas only 44% of low SES respondents managed to do so. Moreover, 56% of respondents in the low SES category got the answer incorrect, compared to 31% of high SES respondents. We conclude from these results that respondents in the lower SES-categories find it difficult to related and integrate scientific knowledge to their own personal situations. This lack of scientific appreciation by the public with a low SES may be attributed to the fact that in the past when you reached secondary education, it was seen as sufficient preparation for adult life, especially in the Coloured community because there was no inspiration to proceed further on to tertiary education.

Clearly, this traditional view of secondary school is being challenged by the increased enrolment of adults in tertiary education. It is our perception that the increased enrolment of adult learners means that the public is moving towards a less passive mode when it comes to science. But they have a long way to go before science can be tested against personal experience.

The question surrounding the conceptualisation of scientific knowledge is significant. Does science flow freely and is it overcome by social and institutional connections? It is our view that the answer to this question is central to the truth and reliability of knowledge. Furthermore, the answer plays an important role in the interaction between experts and the public. When the respondents were interviewed to test their knowledge of scientific facts, it became clear that there was not explicit appreciation of the value of science in society. I also observed that the respondents were mainly concerned with social, economic and political consequences. It is clear that the lack of interconnectedness between the public and scientists has a direct influence on the intellectual understanding of these highly sophisticated concepts.

Brain Wynne (1991) addressed the interconnectedness between the public and experts from a different standpoint by stating that "the public's conceptualisation of science is not based upon intellectual capabilities as much as socio-institutional factors having to do with social access, trust and negotiation as opposed to imposed authority". It is evident that the socio-institutional factors, which Wynne mentioned, played an important role in the respondent's interest and concerns when they answered the statements in the survey. They demonstrated resourceful insight into these areas by translating science and other knowledge into forms to support their practical actions. It would be unrealistic to think that the average amount of translating science displayed by the respondents, would be sufficient to challenge the prevailing scientific expertise, through understanding and identifying gaps in the research agendas of the scientific community.

For us to adequately contribute to science, a change in the philosophical approach to education is required. Connell (1996) stated that the change could only take place if the following would occur:

i. The scientific and technological fields are updated and upgraded in faculties and departments through quantitative and qualitative restructuring;
ii. Reform the university curricula by introducing a mini-thesis early in undergraduate education, seminar-type classes, tutorials, multi-disciplinary supervision, laboratories where students do experiments, and a broader curriculum that gives science and technology students a sound foundation in other disciplines;
iii. Improve the environment for research and teaching at graduate schools by increasing the number of fellowships, scholarships and student loans and having graduate students work with teaching staff on research and supervision of students;
iv. Improve university premises and facilities by providing space for research, setting up university museums and creative work studios, which would also be open to non-students;
v. Provide opportunities for people to study science and technology subjects."

It is clear that the requirements of understanding science in scientific terms, as implied by the slogan '*public understanding of science*', can only be challenged by the public when they develop a factual understanding of science. Furthermore, the process of trying to make science central to everyday-life practices needs the adaptation of a contextual approach. I am not saying that scientific knowledge is unimportant in the realm of practical action, but to underline the necessity of reworking or translating it, if it is to become instrumental.

4.4 USERS OF SCIENCE

It is clear from the survey that the public sees their relationship to science as merely that of a user. This is evident in the fact that the overall perception of science, particular in South Africa is generally positive. When you analyse the perception of people internationally, there is a largely negative attitude towards science. For example, the recent ability of scientists in almost successfully cloning a human being drew a major discussion from the international public but there was virtually no response from the South African public. Although this invention coincides with major breakthroughs for the medical profession, the international public argued on moral grounds that it was improper.

This leaves us with the question - do the South African public see themselves as scientifically inadequate in raising their voices on such important moral issues? It is my view that they are not inadequate, but that they are ignorant of the real moral implications of such a development. Furthermore, the lack of interest in science and technology by particularly the young people, as seen in the survey, may also reflect the disinterest of public in South Africa in general. For example, the young people in the country were the ones who raised their voices against the injustice of the country in the apartheid area. But has the fight for democracy left South Africa with young adults, particular the Coloured and Africans, who are not interested in science and technology?

Recognising the dangers that such an disinterest in science and technology pose, the government passed the White Paper on Science and Technology, which provides a framework for future science and technology policies in South Africa:

i. To provide opportunities for young people to become more familiar with science and technology;

ii. To increase the general public's understanding and interest in science and technology.

In general, progress in science and technology will have wider implications for the country. The fact that South Africa is Africa's leading economy, means that it has a major role to play in the global aspirations of the continent. This is evident in the notion that South Africa must help develop its neighbouring by means of the African Renaissance, to which I have already alluded. The African Renaissance basically implies that:

> "Africans need to rediscover and understand their rich pre-colonial, colonial and postcolonial heritage and appreciate the value of indigenous knowledge. The ability to find solutions for African problems, whilst developing a pride in African culture " (The Star, 1998: 16).

It is important to realise that South Africa should not be caught up in the idea of an African Renaissance, and fall further behind the developments in science and technology. Furthermore, the rapid changes in science and technology could mean that the knowledge acquired by many African countries is outdated. Thus, it is important that South Africa makes opportunities available to young people to keep abreast of new developments. By providing opportunities like this, the public's interest in science and technology is stimulated.

Most of the research performed in this country is publicly funded. For this reason, the impact of science on the activities of the public needs to be assessed. Furthermore, political decisions are increasingly based on research and the boundaries between scientific and political considerations are becoming blurred. It is thus important to have a reasonable level of understanding of scientific concepts and facts, as well as scientific processes and methodology, in order to participate in an informed manner on different scientific issues.

In addition, pursuing a wide variety of occupations and professions requires a reasonable level of scientific literacy. Thus, formal and informal education in science and technology is important for coping with problems of under-employment and unemployment that South Africa is experiencing.

Jenkins (1992) highlights the importance of science and technology by stating that "people should be aware that science and technology are intimately related to global challenges such as the need for sustainable development, alternative production of energy, ecologically sound food production and cleaner technologies". Consequently initiatives are being undertaken on a number of fronts to make the general public more aware of and more competent in science and technology related issues. For example, the recent Scifech exhibitions in Grahamstown were directed towards accomplishing this goal. It was supported by non-governmental organisations, the scientific and educational communities, business enterprises and the media, and had an attendance of almost 40 000 people for the week. The aim was to communicate science and technology to the public, to involve people who are not traditionally associated with science and technology and to provide the public with an opportunity to learn more about their own country's science and technology.

4.5 SCIENCE AND THE MEDIA

The media (newspapers, magazines, radio and television) play a very important role in the dissemination of scientific and technological information to the general public. For example, our results show that a significant portion of the sample has moderate to high exposure to current news events. This is clear from the fact that, 73% of respondents watch TV news, 58% listen to the news on radio and 84% read the newspapers at least once per week.

While the media is a powerful force for disseminating information to the general public, the art of stimulating the imagination often remains elusive. It is therefore, important to use television, radio, newspapers and magazines in ways that actively engage the viewers. By taking a narrative approach and beginning from concrete everyday elements and gradually introducing more and more complex and abstract concepts, all the possibilities offered by the media can be exploited to make scientific concepts clearer.

Layton (1991) made reference to the use of the media at an international scientific audio-visual conference sponsored by UNESCO and France's Centre Nationale de la Recherché, called 'Image and Science':

> "Layton stressed that the key to success is to take full advantage of the most popular television formats (news, dramatic presentations) and to adopt an effective means of communication. The suggestion has been made of creating an international/ national education and training television channel or to make joint use of certain niches on thematic and cultural channels and attaching an internet server in order to allow for dialogue among viewers, and the creators of the programmes, among whom it is important to include scientists and educators".

Layton is thus implying that when representing scientific discoveries, it is important for the media to show the mystery and the drama of scientific discoveries, as well as the end results. The approach of Layton leaves me somewhat in the dark when I consider the results of survey. If the media is an important vehicle for communicating science to the public, why are people, especially in South Africa, not interested in watching scientific programmes? The results demonstrate that most of the respondents are interested in sport (47.1%) new medical discoveries and events (38.8%) and political news (36.7%). Our impression is that if the balance between interest levels of the public can't be obtained, then it will be impossible to divorce this from the current economic situation in the country.

Furthermore, the survey revealed that only those respondents with a high socio-economic status seemed to be interested in news pertaining to science and medical issues (33%), economic and business news (32%) and news about new technology (30%). It is therefore obvious that the task of making science more visible by means of the media is difficult.

However, there are possibilities available for raising the public's interest in science and technology. For example (OECD, 1996):

i. "Japan has decided to create a television channel with programmes around the clock on science and technology, to extend broadcasting nation-wide and to exploit all media possibilities, including multimedia.

ii. Mexican National Council of Science and Technology (CONACYT) edits and prints three different magazines to increase the visibility of science and technology: **Ciencia y Desarrollo**, a bimonthly publication targeted to business enterprise sector, the scientific community and the specialised public; **Informacion Cientifica y Tecnologica**, a monthly magazine that focus on new technological developments and is addressed to a very limited public; and **Tecno-Industria**, a bimonthly publication oriented to business and industry, etc".

Nonetheless, the problem of making science and technology available to the public remains. This problem can only be successfully addressed when attention is given to illiteracy rate of the country.

4.6 FORUMS FOR DIALOGUE

Science and technology often confront society with possibilities that require democratic reflection on the ethical and social consequences. Ethics apply to all fields as recent attention to the credibility of scientific advice and information under public debate (e.g. oil spill at the Cape coast and mad cow disease) has highlighted. These debates again emphasised the need for the highest standards in areas such as health care and the environment. Given the substantial influence science and technology has on political decisions the line between the world of science and the world of politics is becoming harder to draw.

If the public is to believe that science can contribute to a better society, better interaction between scientist and the public and better dissemination of research results is essential. Scientists will also have to make a serious effort to predict the possible risks that their findings could present to society and the environment.

More generally, efforts should be made to improve public understanding and awareness of scientific and technical issues. Scientists should be made aware of their responsibilities as experts and politicians should make more use of scientific advice and information.

The country needs to foster the development of forums for dialogue between government authorities, scientists and the public or its representative on issues of scientific and technological matters. Such institutions can take many forms, depending on the country's structures and institutions.

> "They may foster discussions to be made, in terms of research and development, as in Denmark, for example, where the government had decided to draft a national research strategy through an open process in which scientists, industrialists, organisations, politicians and ordinary people discuss needs and possibilities. The choices made are, therefore, envisaged as a social contract between the political system and the science community and reflect the view that Science and Technology policy should not be decided by bureaucrats and experts alone" (OECD, 1996a).

Many have recognised the need to involve the public in questions concerning the ethics of scientific research and its applications. The Netherlands undertook a pilot project for a national platform for science and ethics, where experiments with different types of the public debate and discussions have been held with scientific and professional organisations concerning ways to make their members more sensitive to the social and ethical dimensions of their work.

Denmark has also addressed the need for better interaction between politicians, scientists and the public by establishing the Danish Council of Ethics and a Committee System on Scientific Ethics. The former informs the public and advises the government on questions of ethics and biomedicine in general, while the latter, which includes both laymen and researchers, must approve all Danish biomedical research projects involving experiments with human beings.

Recognising the importance of finding qualified interpreters able to present such information to these different groups, the Japanese government has decided to launch a broad effort to use scientists, educators and journalist as 'interpreters of science', in order to foster better communication with science and society.

The programme for the 'interpreters of science' includes:

i. "Expanding opportunities for interpreters' activities, including greater use of mass media, such as TV, radio, newspapers and magazines. Also under consideration is the establishment of a science and technology television channel and a plan to send more scientists and engineers to schools, to open research institutes more often to the public, to expand science camps for high-school students at research institutes, and to increase activities at science museums.

ii. Training interpreters of science so that scientists are better able to communicate to non-specialists and organising lecture programmes where scientists present recent advances to journalists and school science teachers.

iii. Establishing a commendation system so that distinguished interpreters will receive recognition for their achievements from the Minister of Science and Technology.

iv. Promoting interactive communication over the information network, by developing an interactive database for answering questions commonly asked by people, a database with information on research topics in various institutes and virtual science museums that be accessed from the home." (OECD, 1996 b).

Those who are able to 'interpret' science and technology to the public starting with the scientists themselves should have incentives to do so and their efforts should be publicly rewarded. For example, "in Australia, the Daley awards for journalism are national awards for excellence in communicating science, technology and engineering issues to the public via print, radio and TV, features and news, and photography; and there are special awards for journalists under 26 years of age" (OECD, 1997). In the case of scientists, it is essential that their efforts be taken into account for reasons of professional advancement.

Continuing involvement and dialogue about science- and technology-related issues are indispensable not only for the continuing vigour of the scientific enterprise itself, but also for the social and economic vitality of economies and societies throughout South Africa.

CHAPTER 5
CONCLUDING REMARKS

5.1 INTRODUCTION

The focus of this study was the public's attitude towards science and technology and the level of interest and understanding in it, with special emphasis on the adult population of the selected sample. I considered various factors that are related to the public's attitude to and awareness of science, and identified the importance of primary and secondary education in laying the basis for life-long interest in and adequate awareness of science and technology.

Several types of programmes and possible future efforts to increase public awareness of, and involvement in science and technology-related activities were also compared. These programmes were considered in terms of best practices that might be replicated in South Africa. The need for continual studies and surveys relating to public attitudes and awareness of science and technology was discussed, together with the need for active communication among concerned individuals and groups on relevant trends and on the effectiveness of programmes aimed at increasing the public's interest and awareness.

But the question need to be asked what more needs to be done? What needs to be done to improve our education and dialogue? These are not only my concerns, but they are also the concerns of politicians, community leaders, scientists and policy makers. Against this background I want to make a few recommendations for improving scientific literacy and better integrating science and technology into the knowledge-based society in South Africa.

5.2 DIALOGUE AND ENGAGEMENT

The task of increasing public awareness of science and technology must involve government, business enterprises, the media, and the scientific and educational communities. But the task should not be approached in terms of attempting to convince the public of their need to understand and accept perspectives of the science and technology community on research and innovation and their implications. Rather, what is needed is continuing involvement and dialogue among scientists and various sectors of the public about science-and technology-related issues. Involvement and dialogue should be regarded as essential not only for the continuing vigour of the scientific enterprise itself, but also to the social and economic vitality and well being of economies and societies throughout South Africa. Establishing and maintaining public dialogue requires, as a minimum, that scientists themselves become actively engaged in reaching out to the wider public, to engage in what has been referred to as 'civic science'.

5.3 POLICY DIRECTIONS

Increasing public awareness of science with the objective of integrating science and technology more fully into modern, knowledge-based societies will require that national governments consider policy actions at several complementary levels. Since primary education is fundamental to increasing scientific literacy, consideration must be given to improving teacher involvement, student motivation, and to methodologies based on concrete, hands-on learning. Opportunities for life-long learning; for example, through interactive science museums, science centres in collaboration with university teaching centres, and national initiatives need to be developed. Furthermore, the effectiveness of the mass media, particularly television, in increasing awareness of science needs to be assessed, with a view to developing attractive, useful materials with genuine scientific content. The potential of the Internet should also be examined in this respect. Appropriate institutional arrangements for enhancing public dialogue on science-and technology-related issues, including ethical questions, need to be established.

5.4 SCIENTISTS AND ENGINEERS

Scientists and engineers have a responsibility to engage actively in public debates about their professional work, both directly and indirectly by contributing to the activities of professional interpreters and educators. They should be willing to discuss their work and its possible social implications in easy-to-understand language and with a minimum of scientific terminology. An essential element of successful public debate should be recognition, by scientists and engineers, of the validity of informed public attitudes towards specific aspects of science and technology that may not be in complete accord with prevailing scientific consensus or industrial preferences.

Scientists and engineers must endeavour, both through formal teaching and informal outreach activities, to stimulate young people to explore the frontiers of knowledge, recognising that, despite the achievements of their own and earlier generations, there still remains much to be done. For the professional legitimacy of effective, self sustaining public outreach activities by scientists and engineers to be recognised by their peers, the value of such endeavours should be explicitly reflected in the appreciation of their careers and in related promotion procedures.

Although the involvement of scientists and engineers in public outreach activities is essential, it should be recognised that many may not be well versed in communication skills. The necessary training should, therefore, be made available to enable scientists and engineers to participate effectively in public awareness efforts. Furthermore, it is essential that individuals who are professionally involved with science and technology be well informed about the possible ethical and social impacts of scientific research and of new technologies growing out of current research. They should be sensitive to public concerns and be prepared to debate the ethical issues both in academic and public institutions.

There are several past and current examples of effective international initiatives taken by scientists to address critical global problems arising out of their work. Similar endeavours might usefully be initiated to address new and emerging science-and technology-related issues.

5.5. THE PUBLIC

Science and technology contribute to social development and stability and are the common assets of humankind. It is important that society as a whole become aware of the need to nurture skilled human resources in these areas. Throughout history, technology has been passed down directly from parent to child. It is important that we pass on appropriate attitudes towards science and technology to new generations.

It will become increasingly important for a wide variety of people to be involved in addressing social issues related to scientific research and technological innovation. Instead of simply accepting or rejecting new developments in science and technology, individual citizens have an obligation to gain sufficient knowledge and understanding to express and discuss their concerns rationally. They have the right, and the responsibility, to express and discuss their concerns openly, even when they appear to conflict with accepted scientific points of view.

5.6 THE MEDIA

The media may increasingly be expected to act as interpreter, conveying specialist knowledge to the public in an easily digested form. While such information must of necessity be cast in accessible, non-scientific language, particular care must be taken to assure that it is accurate and to point out scientific and technical uncertainties and points of contention clearly as and when they arise.

Both the media and the scientific community have the responsibility not to limit the dissemination of science to scientific knowledge alone. They must also disseminate methods of scientific thinking based on critical analysis and continual questioning. This will improve understanding of research, as well as what can be expected from scientific research, including both its hopes and limitations.

Beyond providing appropriate information in response to public uncertainties and concerns associated with science and technology, the media have a responsibility to encourage and facilitate public debate and to assist scientists and engineers to understand the origins and character of public concerns. The media provide a forum for the discussion of science and technology. In our increasingly global society, the media can serve as an international forum for widespread discussion about science and technology and their broader implications.

5.7 GOVERNMENT

Government should support effective strategies for the dissemination of information on science and technology, for instance by building and networking interactive science centres and museums, establishing structural links between these institutions, schools and universities, and supporting volunteers working in the field of science popularisation. Other important activities that could be encouraged by government include the interchange of quality science and technology television and video programmes, and the dissemination of high quality scientific and technical information over the Internet. One significant aspect should be to promote international co-operation in line with the ongoing globalisation of information.

In addition to the necessity for government to support the effective dissemination of public information about science and technology, political leaders themselves, in addition to technical and administrative managers, need to understand what is at stake in decision making that requires scientific expertise. Decision-makers need to understand not only scientific fact, but also scientific method: i.e. hypothesis, testing, experimentation, and validation.

The process involved in science and technology policy formulation must be transparent, for instance through disclosure of relevant information. Mission oriented research that involves large groups of scientists or engineers and requires substantial public funding should be carried out in a strategic fashion, based on public consensus, and suitable evaluation techniques for public research and development activities should be developed.

Education should provide the youth with opportunities to appreciate the intrinsic value of science and technology and the scientific way of thinking through practical experiences and experimentation. It is vital that young people with the potential to become productive scientists recognise the joys of knowledge and creativity. Special attention should be paid to the important role of teachers and curricula, together with parents and local government, so that students will maintain the interest in science and technology that they develop during their formative years. Supporting teachers in developing new approaches to teaching and learning at both the primary and secondary levels is crucial.

The evolution of social criteria for addressing problems generated by developments in science and technology will become increasingly important in the future. As ethical issues associated with scientific developments become more complex and more evident, particularly in the biomedical sciences, greater efforts to promote rational public dialogue will be required, to deal appropriately with legitimate social disquiet in face of some developments of the science and technology enterprise.

Finally, there is no doubt that motivation is the primary factor in increasing interest in science and technology. It is obvious that people of all ages learn more easily about any topic, even a very complex one, when they are directly and personally involved. For example, in the face of illness, they quickly learn, and understand, even extremely subtle physiological mechanisms and relevant scientific information.

In seeking to help improve scientific literacy, it is, therefore, necessary to address not only the intelligence but also the imagination and the emotions, in order to make science and technology understandable. Only when one has understood that, can one make a valid contribution to discussions of science and technology.

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