Chapter 2
The development of science communication

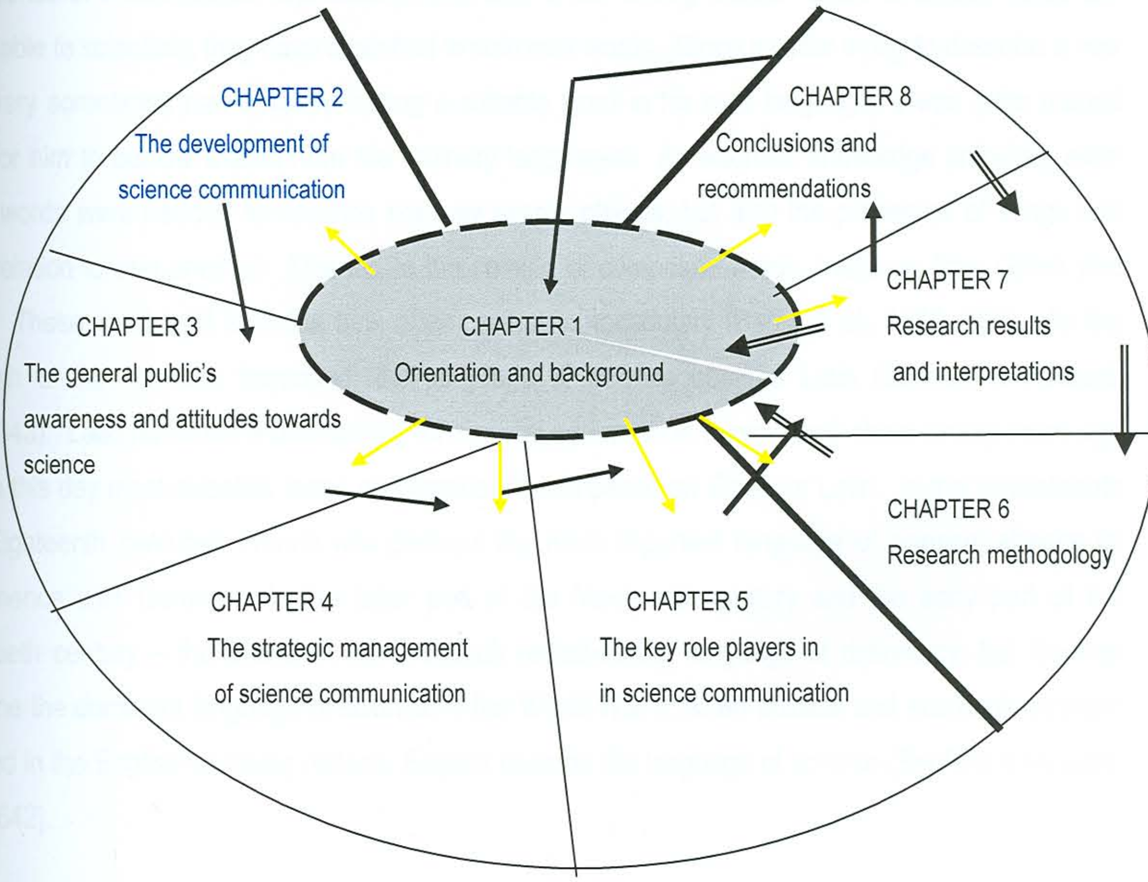
2.1 INTRODUCTION

Effective communication is not easy to achieve. According to Bittner (1988) it would be impossible to act as a truly human community, without approximating an understanding of one another, however imperfectly. The pursuit of science is a very special human activity. It is concerned with describing the universe in which man lives, and it has two main purposes. One is to disentangle nature's mysteries, for no other purpose than to satisfy man's curiosity about the world of nature and his place in it. The other is to discover to what extent man can make use of the facts of nature in order to increase his interest in and mastery over his surroundings, whether it be in order to increase his standard of living, to prolong human life, or to make better use of his raw material resources (Stempra, 2001).

Science has a language of its own, as well as many non-verbal ways of conveying information in a precise and condensed form. It is perhaps for this reason that scientists are often accused of being cold and unemotional people, withdrawn from ordinary human joys and sorrows, and living in a remote world of their own (Barry, Bronowski, Fisher & Huxley, 1965: 174).

To communicate science to non-scientists is therefore not an easy task. In this regard, communication specialists at HEI are essential to assist scientists in their communication with the media and general public in South Africa. Theoretical perspectives are discussed to elucidate the term science communication. Tools and vehicles to convey the message of science are included and finally communication to a mass audience is discussed. Chapter 2 establishes the connection between Chapter 3 (which addresses the awareness of science, engineering and technology) and Chapter 4 (where strategic communication planning is explained). Chapter 1 however remains the pivot of the study throughout. The structure of the study is illustrated in the following figure for ease of reference.

Figure 2.1: Chapter 2 in relation to other theoretical chapters



2.2 UNDERSTANDING SCIENCE COMMUNICATION

Because science concentrates on facts and figures, its language contains no shade of meaning, no humour, no excitement and no lyrical passages of the kind that is found in novels (Rowe, 2000:435). The language of science is in fact dull and even boring to the layman, and it makes no appeal to people who love literature for its own sake. However, its precision gives it one very valuable property, since it can be translated from one language to another without loss of information. This means that the results of scientific research in one country can be made available in any other country. Since scientific research is international, the free exchange of accurate information across national boundaries makes for economy of effort and prevents the same work from being done twice over (Barry *et al.*, 1965:174). Therefore, scientists, for all their restrictive use of words, actually have an advantage over novelists and poets.

Mathematics is an essential part of the language of science. In fact, much research can be reported as a series of mathematical expressions, with only a few linking words. Since everyday words are unsuitable to scientists, they have often had to coin new words. Since a writer trying to describe a new discovery sometimes had difficulty finding a suitable word in his own language, it was quite natural then for him to borrow a term from the ordinary languages. As scientific knowledge unfolded, even more words were needed to describe not only simple objects, but also the properties of things and their relation to one another. This led to the coining of composite words, made up from Greek and Latin. These words still form the bulk of our scientific vocabulary (Barry *et al.*, 1965: 185). As the strength of the Romans increased, the language of science became Latin (Benfield & Howard, 2000:643). Latin remained a prerequisite for medical education in Europe until about twenty years ago and to this day most scientific terms and names are still based on Greek or Latin. In the Seventeenth and Eighteenth centuries French was perhaps the most important language of science, sharing its prominence with German. In the latter part of the Nineteenth century and the early part of the Twentieth century – the Bismarck era – French remained the language of diplomacy, but German became the dominant language of science. After World War II, when political and economic strength centred in the English-speaking nations, English became the language of science (Benfield & Howard, 2000:642).

According to Barry *et al.* (1965:185), a great achievement of the Greeks in science development was that they discovered and proved certain relationships that were true in any situation. For instance, they proved that the three angles of any triangle add up to 180 degrees. This and other relationships make up the science of triangles, or trigonometry, which is still applicable to science and mathematics education today. This science has helped enormously to construct accurate and informative "pictures" of the world, of which the map is the most familiar example. Such pictures are more economical and informative than words or figures.

Over time these relationship illustrations developed further and scientists invented the graph, which illustrates that in any situation one thing varies in relation to another. Graphs help scientists to convey a mass of information to others. It also makes it easier for the scientist to depict his results in a way that makes it easier for him to look at them as a whole and to see whether his experiments reveal a consistent relationship between the quantities that he is measuring (Barry *et al.*, 1965:186).

These developments are still used in science and mathematics teaching at school and HEI. The applications of these scientific languages can be seen in almost all manufactured products used by all levels of society. To maintain and further the development of these products, science has to be communicated to the general public. An understanding of science will certainly decrease the fear of risks in new scientific products and technologies.

2.3 COMMUNICATING THE LANGUAGE OF SCIENCE

People use mainly two ways in their daily lives to communicate, speak and write. Verbal spoken communication is accompanied by a continuous flow of non-verbal communication, which involves not only the voice (the pitch, tone, speed and quality of speech) but also the face (gaze, facial expression) and the body (the distance one stands from others, spatial orientation of people, posture, gesture, touch, etc.) (Gallois & Callan, 1997:7). In written communication it is much more difficult to detect feelings, emotions and expressions. Unfortunately communication is the topic of much speculation and debate. Broadly speaking, communicational scepticism might be defined as the idea that meaning is to some extent private to each individual, since language is an inadequate instrument for conveying thoughts from one mind to another. Human beings, the sceptic believes, are isolated from one another by the very medium that might be supposed to unite them: language (Farrow, 1996:108).

According to the logician, Gottlob Frege, language "is not governed by logical laws in such a way that mere adherence to grammar would guarantee the formal correctness of thought-transitions"' (Farrow, 1996:108). Successful communication may be threatened by the inability of language to correspond perfectly with thought.

Signals and meanings are two components of communication of which signals are the most fully analysed and understood, compared to meanings which are the least known and the least analysed. Coding is used to analyse meanings. It is decision making, choosing between a figure and ground in a gestalt and these choices involve evaluations and values. According to Smith (1966:406), much of everyday communication is not a simple and direct coding of meanings, but is metacommunication in which the meaning that is coded is just communication going on. Bernstein, (in Smith, 1966:406), pointed out that meaning is embedded in a social system and social systems can generate different codes of meaning. According to Bernstein (in Smith, 1966:406), meanings do not have to be made explicit if a social system is based on intimacy and little social distance, because in such systems there are little noise and little need for redundancy. In a social system where greater social distance exists, meanings have to be made more explicit. Bernstein's "Elaborated and Restricted Codes" demonstrates the situation-behaviour matrix of these codes of meaning and indicates how the meaning is always related to the situation (in Smith, 1996:406). However, these codes are not defined in terms of vocabulary. The speech system is called elaborated code when it is difficult to predict the syntactic options speakers use to organise their meanings over a representative range of speech. In the case of an elaborated code, the speaker has to select from a wide range of syntactic alternatives, which make it more difficult to make an accurate assessment of the organising elements used at a specific time. With the restricted code on the other hand, the range of syntactic alternatives is considerably reduced and prediction is much more possible. Although the vocabulary is drawn from a narrow range, it is no indication that the code is a restricted one (Smith, 1996:430). In communicating science, Bernstein's restricted codes might be applicable when scientists are communicating with one another, because through the planning procedures the code might not facilitate the verbal expansion of the scientist's discrete intent. When scientists have to communicate with the general public, the code through its planning procedures might facilitate scientists in their attempt to put into words in their purposes, discrete intent and their unique experience in a verbally explicit form (Smith, 1966:430).

Therefore, the scientist has a difficult task in communicating with non-scientists, since she/he must also place his findings on record, and for this purpose she/he uses written communication. This is yet another reason why scientific language and the scientists who use it, appear to the layman to be stilted, pompous and remote from the affairs of everyday life.

Like the stenographer, the scientist has his shorthand – a code that can condense a lot of information into short symbols. Each of the many branches of science has its own code. For example, a reaction between marble and sulphuric acid contains about 400 words, but by using a code in the equation it allows scientists to write all the necessary information in one line. It would be difficult to imagine a more compact way of recording and transmitting information, once the code is known (Barry *et al.*, 1965:189).

During the past four hundred years scientific inquiry has brought to light a huge number of facts. Scientists have described about a million species of animals, over 300 000 species of plants, and several hundred thousand chemical compounds. How can so much information be handled without getting lost in a mass of detail? For this reason scientists have brought millions of isolated facts into shape that makes them understandable and useful by classifying them. Not only has classification of all the known facts about a certain species shown more clearly the similarities and differences in organisms, but a progression from simple forms to more complex ones has also been revealed as the pattern of relationships between organisms has become clearer. It is because the facts of natural history were classified that the discovery of evolution became possible. Thus, the act of arranging data methodically does more than merely keep the facts tidy. Classification is a way of clarifying what one knows, and it is therefore an essential part of the language of science (Barry *et al.*, 1965:191).

Although science language is a very old language that developed over hundreds of years, the communication thereof to every society all over the world is today even more important than before. The role of communication specialists in the mediation process is equally important to facilitate the communication process between scientists and the general public. Communication specialists should be trained as facilitators between scientists and journalists, which imply communication specialists should receive a basic education in science to enable communication specialists to translate the complex facts of science in simpler formats understandable for stakeholders of HEI.

2.4 HISTORY AND DEVELOPMENT OF SCIENCE LANGUAGE

Language is arguably the most important characteristic of all species. The evolution of language is one of the most intriguing events in the history of life on earth. Until recently, the evolution of language has remained a marginalised topic in both biology and linguistics, seeming to many scientists more fitting for after-dinner speculation than scholarly study. However, remarkable empirical advances in biology, neuroscience and linguistics have led to a rebirth of research on language evolution in the past decade (Fitch, 2002:278).

With the onset of civilisation ten thousand years ago, the generation and application of knowledge began to flourish. Access to knowledge remained the privilege of small elites however. Knowledge has always been interwoven with politics and was strictly controlled by the powerful because scientifically sound ideas had the potential to be explosive. The science community wrote and spoke Latin so no layperson could understand it.

However, from 1667 onwards things began to change when the London Royal Society published a guide to writing scientific papers. It suggested a direct and precise style, no bombastic or foggy sentences, and the use of the language of farmers, craftsmen and tradesmen instead of the jargon of scholars. Twenty years later the first lecture was held in plain German at the University of Leipzig (Goede, 2001:3). The specific German natural scientist became famous because of an extensive tour he made of South America at the beginning of the 19th century – but his message still did not reach everyone. In 1827 Humboldt presented the findings of his studies in Berlin in addition to an absolutely clear and fascinating rundown of almost the entire knowledge of mankind at that time.

Then came the Industrial Revolution. It catapulted people into a new world with a flood of technological innovations, ever increasing speed and profound cultural changes. Trains, automobiles, airplanes, dreams of mobility came true and lured people into becoming frenetic proponents of progress. For more than a century nobody dared to touch science's truth monopoly, that is, until 1945 when two atomic detonations in Japan shocked the world. In the aftermath people began realising that indefinite growth was not possible. Growing poverty, misery and hunger had split the world into a developed and developing world. Man started to realise that the earth's natural resources and energy supplies would only last for another hundred years, and that the deterioration of the environment and the climate was becoming inescapable (Goede, 2001:3).

The reactions to this realisation varied. Goede (2001:4,5) refers to the fact that, on the political level, the Green Party, activist movements like Robin Wood, Green Peace and most recently the globalisation adversaries emerged. The experts at universities suddenly had to abandon their ivory towers and present their research in the market place in order to rebuild public confidence. As a result of this distrust, the news media discovered science and found a new huge platform in newspapers, magazines, radio, television and in the Internet.

However, associated with this discovery there were certain problems. Since scientific language is not common knowledge to the general public, an inevitable barrier arose between science and the public, and this will be discussed in the next section.

2.5 BARRIERS BETWEEN SCIENCE AND THE GENERAL PUBLIC

Although society currently depends on science as never before (also on science activities and assistance of new technology), what scientists do remains an enigma to most people. The language of science is virtually incomprehensible to the layman. To maintain public (stakeholder) appreciation and support, the benefits and grandeur of science have to be translated into the language of everyday people.

The need for accuracy, conciseness and precision has compelled scientists to build up a structure of special languages and codes. There is no doubt that such languages have provided a very efficient means of communication among scientists themselves, but between the scientist and the man in the street, there is a wide gap (Barry *et al.*, 1965:191). In short, there is a failure of communication between the two segments of society.

Barry *et al.* (1965:191) stated the following reasons for the failure of communication between scientists and the public:

- Scientists are usually too absorbed in their work to pause and tell the public what they are doing and why they are doing it. Sometimes, because they are working at problems that have never been solved before, they are somewhat inclined to be superior about their professions and to look down on those who do not understand their kind of work.
- Probably the main reason for lack of communication is that even if scientists are willing to explain themselves, their specialised training often makes it impossible for them to express themselves in simple language.

The man in the street, however, has neither the time nor the specialised training that would enable him to read scientific papers. Instead, he gets his news of scientific developments through newspapers, magazines and television. In this regard the role of communication specialists becomes important to assist scientists translating scientific facts in a comprehendable language that stakeholders can understand. Furthermore, to ensure that the mass media understands the message that scientists want to distribute, communication specialists at HEI are important in their role as facilitators between scientists and the media (Joubert, 2001). Communication specialists, therefore, play an important role to ensure that what scientists are saying is correctly reflected in the media.

2.6 THE BEGINNING OF THE POPULARISATION OF SCIENCE

The historians of science have debated at large both the intellectual problems of establishing the new basis for knowledge and the practical efforts necessary to build an experimental array of instruments and machines. But there is one thing the historians of science persistently ignore or minimise: the immediate use of the technologies discovered by scientists to create a large number of devices for popular entertainment. However, this trend is not part of the history of science itself, and the historians (following in fact the opinion of the distinguished scientists of the time) consider most of the actors of this derivation with some contempt. Two examples of development of the popularisation of science are discussed next.

According to Caro (1997:112,113), Athanasius Kircher (1602-1680) was the most famous scientist of his time. As a Jesuit priest in the service of the Pope in Rome, he received lavish grants from several patrons, especially German princes. Starting in 1660, he had an exclusive agreement with a publisher in Holland for the right to print his best sellers. He is one of the few scientists in history who eventually made a living selling his books. Kircher was not only one of the first scientists, but also a perfect prototype of a figure well known today in the more established field of science popularisation.

Science was popularised by entertainment shows, books and other forms of entertainment, such as spectacular shows that were set up with profitable commercial intent to reach emotionally innocent and ignorant people with science. From the beginning, the contribution of scientific and technical knowledge to the staging of shows was essential, in fact seminal. The development of an entertainment-oriented society cannot be separated from the progresses of science itself (Caro, 1997:113).

Kircher used his knowledge to stage a variety of optical shows for the Cardinals in Rome. He was not taken seriously by most of his colleagues across Europe because he made extravagant claims (such as the decipherment of hieroglyphs). But besides being one of the first writers of science popularisation books, and a kind of inventor of the principle of using devices derived from scientific apparatus to provide entertainment as in modern science-based theme parks, he was also the founder of the first science museum. The museum housed, in the gallery of the Collegio Romano, a collection of stuffed animals and birds from the New World, which the distinguished European visitors to Rome were eager to see.

Another prominent scientist during the same time was Christiaan Huyghens (1629-1695). He designed the first magic lantern, which he used to project the image from an animated plate through which a skeleton played ball with its head, a scene inspired from a drawing by Holbein. Since the images did not depend on the strength of the sun as a source of light any more, they could be shown anywhere, at any time, in any place. At first the images, painted on glass plates, were designed to produce fear. These images could be animated (the devil could roll his eyes). But the potential of this new "media" for education was quickly realised and was to grow until the end of the 19th century and the advent of the cinematograph (Caro, 1997:114).

As can be seen from the abovementioned developments, professors of science and technical writing have struggled for many years to find new ways to help students learn to organise and present technical information so that lay audiences can understand it. However, effective dissemination is not simply a matter of finding a way to explain complex issues in plain language or using audio-visual technologies to present them. In the following section other tools and vehicles that have developed over time to promote science to the non-scientific public are discussed. The information theory and the mass communication theory, which provide the base for the use of technological developments to convey the message of science to the mass of non-scientists, are also described.

2.7 THE ROLE OF INFORMATION THEORY IN SCIENCE COMMUNICATION

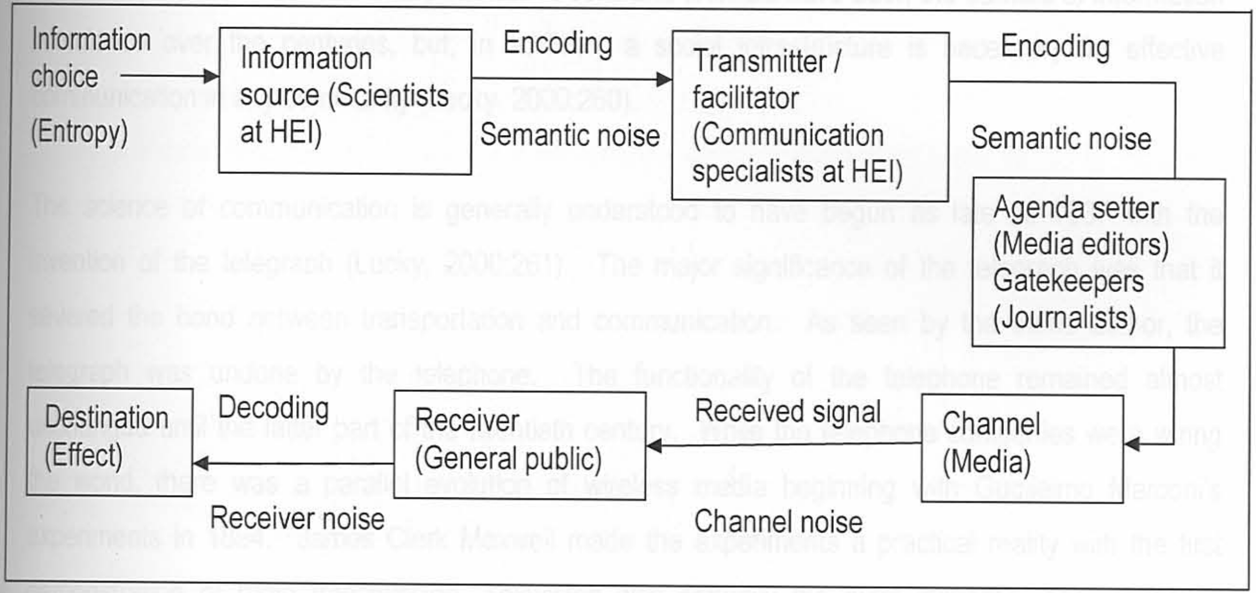
Science communication is based on the concept of information about science being conveyed from the sender to the receiver of the message. The information theory contributes to the investigation of the various characteristics of physical, biological, social and behavioural phenomena. It is not only a communication theory, but also has important implications for communication and other socio-cultural happenings (Littlejohn, 1992: 34). Although the concept of information has proved difficult to define since it can be viewed in different ways, the central element is probably the capacity to 'reduce uncertainty'. Information is therefore defined by its opposite – randomness or chaos (McQuail, 1994:248).

Tichenor, Donohue and Olien (in Jansen van Vuuren, 2002:27) defined information theory as follows: "As the infusion of mass media information into a social system increases, segments of the population with higher socioeconomic status tend to acquire this information at a faster rate than the lower status segments, so that the gap in knowledge between these segments tends to increase rather than decrease."

The insight that led to the development of information theory was the realisation that all the processes, which might be said to convey information, are basically selection processes. The mathematical theory of communication provided an objective approach to the analysis of communication texts. As stated by McQuail (1994:248), the basis for objectivity (quantification) is the binary (yes/no) coding system, which constitutes the basis for digital computing. The information theory is general enough that it can be applied to written languages, musical notes, music, spoken words, pictures and many other communication signals (Severin & Tankard, 1984:43).

The roots of the information theory are intermingled with the basic transmission model, which conceives communication as essentially the intentional transfer of information from sender to receiver, by way of (physical) channels, which are subject to noise and interference. According to this model, communication is judged by the efficiency and effectiveness in achieving the planned 'transfer' (McQuail, 1994:248). It is therefore also applicable in science communication where various channels are used to convey the message of science. In communicating the science message, it is suggested that communication specialists should act as facilitaors to ensure that information is conveyed correctly, which is not prejudial to HEI and in a way that stakeholders, including the media and general public can understand the intention of the message (Mersham & Skinner, 2001: 24). In Figure 2.2 the communication model adapted from Shannon and Weaver (Tan, 1981:60) demonstrates the relationship between the information theory and the basic transmission model.

Figure 2.2: A mathematical model of communication



Source: Adapted from: Tan (1981:60)

Tan's (1981:60) model was applied to illustrate the flow of communication in science communication. Scientists at HEI who produces the science are the source of information and communication specialists are the facilitators who mediate between scientists and journalists to ensure that scientific facts are correctly interpreted by media editors and journalists. Media editors are the agenda setters who determine which articles should be published, while the journalists act as gatekeepers in deciding if the messages received from scientists and communication specialists are newsworthy enough to write articles about. The media is the channel through which science messages are distributed to the receiver or general public. The destination of the message or the effect of the message on the receivers is determined by the facts of science that reaches the receivers or general public. The agenda setting and gatekeeper theories are discussed in Chapter 5 in more detail.

2.8 THE DEVELOPMENT OF TECHNOLOGY TO COMMUNICATE SCIENCE

In the sixteenth century, science progressed at the pace of the postal system. Often it would take six months for one scientist to learn of the latest results of another. It took even more time for scientists to build on one another's accomplishments (Lucky, 2000:259). After the development of written language, the next stage of communication was the emergence of postal systems, which could transport that recorded language farther than the loudest voice. Although a postal system provides the rudiments of individual communication, it does not enable broadcast or widespread knowledge dispersal. For that purpose, according to Lucky (2000:260), books have been remarkable social instruments, and they have remained unchanged in concept from nearly the time written language arose until today. The printing media made possible the widespread dissemination of books, which had previously been the exclusive property of the rich and powerful. Books and journals have been the carriers of information in science over the centuries, but, in addition, a social infrastructure is necessary for effective communication in any community (Lucky, 2000:260).

The science of communication is generally understood to have begun as late as 1837 with the invention of the telegraph (Lucky, 2000:261). The major significance of the telegraph was that it severed the bond between transportation and communication. As seen by the same author, the telegraph was undone by the telephone. The functionality of the telephone remained almost unchanged until the latter part of the twentieth century. While the telephone companies were wiring the world, there was a parallel evolution of wireless media beginning with Guglielmo Marconi's experiments in 1894. James Clerk Maxwell made the experiments a practical reality with the first demonstration of radio transmission. Television was certainly the most influential communication medium of the last century. There came to be more television receivers in the world than telephones, and television broadcasts have purveyed culture to the farthest corners of the earth. The popularity and politics of science were affected by this new medium (Lucky, 2000:261).

However, until recently, access to knowledge was the privilege of an elite group and there was little transparency and public accountability. Magazines, radio, television, etc., have helped to democratise knowledge, to disseminate it so that everybody can participate in and get on top of the information flow. With this type of knowledge empowerment, it is possible to build a civil society in which citizens can gain access to major developments. Citizens can decide for themselves whether these developments suit them or not, make their voice heard and pursue an active role in public life. However, many people find today's communication environment intimidating, fast-paced and chaotic. Often they feel personally and professionally assaulted by today's electronic environment and many regard technology as a necessary irritation. Among these people, the mass media are perceived as manipulative, monolithic, and too obsessed with strategy and tactics than with issues and understanding. The role of communication specialists can add value to this perception by ensuring that the media convey correct messages to the public. However, this can only be achieved if there is a relationship of trust and mutual understanding between communication specialists and journalists.

2.9 THE ARRIVAL OF THE MASS MEDIA AND THE APPLICATION OF MASS COMMUNICATION THEORY ON MASS AUDIENCES

Today's society has more radio stations, television channels, magazines, newsletters, telephones, computers and fax machines than ever. People have instant access to news, information, and entertainment. Despite all this growth, communication seems to have less meaning. Technology has altered everything – from people's personal perception of the world and their relationship to it, to how people buy groceries, how banking is done and how people entertain, educate and inform themselves. With instant news from around the world at one's fingertips, the sense that one is living in a global community grows every day. Yet, people lack the sense of common cause, community, and the public interest (Radtke, 1998:47). Mass communication aiming at mass audiences endeavours to create a sense of common cause amongst the general public.

According to Tan (1981:3), "... mass communication involves the scientific study of the mass media, the messages they generate, the audiences they attempt to reach, and their effects on these audiences". Mass communication involves basically the same process as one-to-one communication. Three interacting components (sender, facilitator and receiver) are involved; messages are encoded, filtered, sent through a channel, and decoded; responses in the receiver are observed; feedback allows interaction to continue between sender and receiver. However, there are some special characteristics of mass communication that distinguish it from interpersonal communication. The first characteristic is the receiver in mass communication. Early definitions of mass communication focused on 'mass society' as the audience of communication. Mass society was seen as the milieu within which mass communication functions. Blumer (in Tan, 1981:72), using concepts derived from theories of mass society, characterised mass audiences as follows:

- Heterogeneous in composition, its members coming from different groups in society;
- Composed of individuals who do not know each other, who are spatially separated from one another and who cannot interact with one another; and
- Having no leadership or formal organisation.

The audience was an aggregate of individuals, which could best be classified not on the basis of group memberships, but according to demographic characteristics such as age, sex, socio-economic status and education. The important questions were how members of the mass audience selected their communication and how the media affected the mass. The prevailing idea was that the mass audience was passive, unstable and easily influenced (Tan, 1981:72). More recently researchers have discarded the view of 'mass audience' as a passive aggregate of disconnected individuals and have emphasised, instead, social structures or group affiliations among members of the audience, the social nature of most of the contact with the mass media and the reciprocal nature of media-audience relationships.

As in person-to-person communication, the interaction in mass communication is goal directed, transactional and influenced by the participant's ongoing culture. The main difference is that in mass communication the receiver is considered as "a vast number of people receiving simultaneously but independently the communication of a very few" (Tan, 1981:73). However, defining mass communication solely on the basis of a mass audience seems inadequate, since 'a vast number' can have several implications.

A more useful approach is to consider also the original communicator and the method by which the message is transmitted to the receiver. In mass communication the communicator is a social organisation capable of reproducing the message and sending it simultaneously to large numbers of people who are spatially separated. In this definition, the number of people reached is of secondary importance. The communicator in mass communication is often a mass medium – a newspaper, television station or network, magazine or book publisher. It is a social organisation because it is made up of many individual communicators with well-defined role responsibilities (Tan, 1981:73). In science communication, however, this is not the case, since the originator of the message is the scientist who conveys the message to stakeholders via the communication specialist (facilitator).

Another characteristic of mass communication that distinguishes it from interpersonal communication is that the messages are sent to the receivers indirectly, using some form of mechanical device. According to De Beer (1998:14) and Tan (1981:73), the sender and receiver are not physically in the same place, therefore, face-to-face or direct interaction is not possible, and since the message is sent through a mechanical device, the message can be reproduced and distributed to many receivers at the same time. In science communication, this interaction involves scientists (originators or senders) who use the channels (the media, such as Internet, science shows, newspapers, television and radio) to communicate the message of science to the various receivers (stakeholders, such as the general public). However, there is another link in this process, which refers to the facilitator (communication specialist) who has to ensure that the agenda setters (editors) and the gatekeepers (journalists) interpret the message correctly to reach the final destination (effect) of the message.

In the last decades, as a consequence of the growing interest in science communication activities, studies have been aimed at the use and possible impact of wider tools associated with mass communication. The discoveries and applications of science have appeared in literature and the mass media, therefore contributing to the creation of a collective image of science and scientists (Massarani, 2002:25). The next section addresses the Internet and World Wide Web as tools of mass communication to communicate science.

2.10 THE INTERNET AND WORLD WIDE WEB AS MEDIA CHANNELS TO COMMUNICATE SCIENCE

The electronic revolution fostered the development of computers, the rise of computer networks, and the digitisation of information and media. Together they created the present digital networked economy. Today's World Wide Web has been cited as a counterexample of the well-known thesis that all major technological developments require 25 years for widespread availability, as was the case with radio, television and the telephone. The Web, by contrast, has become overwhelmingly popular in only a few years (Lucky, 2000:262).

The Internet, a complex network of networks, removes the geographical and time limitations of operating in a global economy. According to Dhillon (2002:14), there is an underlying assumption in the popular belief that the Internet may be the saviour of the developing countries of the world. Such thinking is dependent on a single premise: the belief that access to the global marketplace leads to economic growth. Information is power; knowledge is wealth. In their effect on the way in which science is transacted, the Internet and World Wide Web have had the greatest impact of any communication medium since possibly the printing media (Lucky, 2000:263).

The beauty and power of these media are that they allow the formation of spontaneous communities of unacquainted users. Their topology is neither one to one nor one to many, but rather many to many. They allow the sharing of information in textual, graphic, and multimedia formats across these communities, and they empower users within these communities to build their own applications. This function is particularly beneficial to the distribution of science messages.

Internet and the World Wide Web are being increasingly used as a medium for producing and delivering news. Many magazines and newspapers nowadays have an online version and sell access to their content. The Web is regarded as a 'new space', where authors can 'guide' readers through diverse information sources and types. Either as a news-making or as a dissemination tool, the Web is changing the practice of science writers and making new stories possible. There are, however, some concerns about source reliability and information quality (Trumbo, Sprecker, Dumlao, Yun & Duke, 2001:347), as the Web is unfortunately also loaded with jargon and questionable material. Science has also yet to evolve a satisfactory economic model that defines and protects the rights of intellectual property owners.

Another serious obstacle applicable to science communication has been the tenure committees at universities and their reluctance to give full credit to online publication. However, reasons exist to believe that the Web will be adopted as an important medium for publishing science news in the future. The Internet is also increasingly important for continuing education, the lifeblood of the scientific profession. Numerous courses are put up on the Web, and both universities and commercial enterprises are getting in the business of packaging educational material for distance learning.

Although communication technology will certainly contribute to easier access of information and faster communication, no such technology has yet preserved the important nuances of a face-to-face interaction.

2.11 SCIENCE POPULARISATION ON THE WORLD WIDE WEB

Even though some science popularisation websites are already visited frequently, not much data is available on how users actually read, understand and make use of their content. It is therefore not clear whether the Web allows the communication of science as effectively as, or perhaps better than, the traditional printed media (Macedo-Rouet, 2002:13).

On the one hand, authors can use electronic media to provide contextual material, increase the number of information sources, include multimedia contents and establish new forms of communication with the public. These potentialities are interesting and attractive. However, on the other hand, results from experimental research have shown that multimedia technology is not easy to handle. Issues of disorientation, high cognitive prerequisites and lack of experience with technology constitute barriers for users (Macedo-Rouet, 2002:13).

In the context of science popularisation, both print and electronic media deal essentially with written language. There are large differences in the way textual elements are displayed and interconnected. Technological developments in the 1990's have had a negative impact on the presentation of text on computer screens (Macedo-Rouet, 2002:13). As a consequence, reading on a computer screen takes about 20% slower than reading on paper, according to Nielsen (2000:14). Computer presentation requires the use of a greater contrast, less information density and bigger characters to be able to provide a satisfactory level of legibility. Although screen legibility can be improved through the use of high definition screens, this technology is still not available to most users.

Attitudes toward a technology such as the Internet can predict the degree of its adoption in a given population. Although studies have indicated a positive attitude towards the Internet (Trumbo *et al.*, 2001:352), a positive attitude or even large-scale use does not mean absolute faith in the medium. In fact, many professionals tend to see the Web and e-mail as great tools for news making, but they are also sceptical, because the Web may easily lead to dispersion, waste of time and non-reliable information or illegitimate sources (Macedo-Rouet, 2002: 13).

Magazines, newspapers, radio and television were previously mentioned as mass media channels that are used to distribute science messages to the general public. The Internet and World Wide Web are also mass media channels that are used more frequently in today's society to distribute science. The advantage of these media, except radio, are the fact that visual images of scientific facts can be observed by users of any of these channels, which enhances the comprehension of the science messages to the general public. However, despite all the developments of technology and mass media to distribute messages to mass audiences, these developments do not always contribute to enhance the distribution of science to the general public. There are still too many people in South Africa who do not have access to all the new technologies and mass media channels to receive science messages effectively. Therefore, science communication activities were established at various institutions to contribute to the South African government's goal to create an informed public. Some of these activities are described in the next section.

2.12 SCIENCE COMMUNICATION ACTIVITIES IN SOUTH AFRICA

In South Africa there are a number of opportunities for promoting science and several science communication activities are taking place to communicate science to stakeholders. These activities that are used as vehicles for communicating science include the Government's annual National Science, Engineering and Technology week, the annual Sasol SciFest in Grahamstown and Sasol TechnoX in Sasolburg, various science centres, for example in Pretoria, Cape Town, Durban and elsewhere, planetariums in Cape Town and Johannesburg, and mobile science centres such as the Starbus of the South African Astronomical Observatory and the Tsebo Koloing truck of the University of Pretoria. At many HEI communication specialists are often tasked to organise or participate in and manage a variety of these science activities. The science activities mentioned above are explained briefly below:

- **The Gateway Discovery Centre Trust, better known as the Discovery Centre**

According to Mvalo (2002), the aim of the Discovery Centre is to raise awareness and enthuse learners about the practical applications of science and technology. This is done in an informal but fun way through interactive exhibits where learners and educators are encouraged to discover for themselves by pulling, touching, pressing and observing science phenomena, thereby becoming discoverers in the scientific process. It is anticipated that these learners will continue to take mathematics and science subjects at high school and enrol for science, engineering and technology (SET) courses at HEI once they matriculated from school. In the final analysis a larger number of students in science, engineering and technology may lead to an increased human resource base in SET and improve national economic growth as well as the level of international competitiveness.

- **National SET weeks**

National SET weeks were introduced by the South African Government in 1998, and they have continued since then. Since its inception, the National SET Week took place annually in May. Several activities take place during that week, for example workshops, interactive displays, participative activities, etc., all of which are focused on simplifying scientific facts into comprehensible experiences for the target audience. All the science activities are targeted at children of all ages to enhance their awareness of the importance of science.

- **Sasol TechnoX and SciFest**

South Africa's weeklong National Festival of Science, Engineering and Technology (known as SciFest) is held annually in Grahamstown in the Eastern Cape during March/April. Since the first festival in 1997, it has attracted some forty thousand visitors a year, drawing prominent scientists from around the globe as key speakers, and securing participation and support from abroad, especially from Imperial College, London. Because HEI in the northern half of South Africa were not prepared to travel to Grahamstown every year, the Sasol TechnoX was initiated in Sasolburg in 2001. This festival has the same aims as SciFest, but more institutions and organisations based in the Gauteng area are involved in providing hands-on science activities for school children. The Sasol TechnoX takes place annually in August and the number of visitors reached 45 000 in 2004.

- **Science Centres and museums**

A handful of science centres and science museums in South Africa personalise science communication for their target market. Committed staff at the centres and museums accommodate and interest thousands of school children every year. The Discovery Centre and Camera Obscura at the University of Pretoria are among the few centres that accommodate children from preprimary school to adults in order to provide an opportunity of hands-on playing and experience of science applications. Other centres, which include the aquariums in these two cities, are situated in Cape Town and Durban. Science museums are situated in Cape Town, Johannesburg and Pretoria.

- **Planetariums**

Planetariums in South Africa (especially the Johannesburg Planetarium and the Planetarium at Cape Town's South African Museum) have particularly long track records for promoting science communication to the general public in South Africa.

- **Mobile science centres**

The Southern African Association of Science and Technology Centres (SAASTEC), which were established to promote communication and networking between science centres, encourage their members to join forces for travelling displays and sponsorships. Two of the established and successful mobile centres are the Starbus and Tsebo Koloing Truck.

The Starbus is the colourfully decorated minibus outreach vehicle of the South African Astronomical Observatory. It enables science communicators to take workshops and astronomy viewing sessions to rural communities and schools in remote areas. The Starbus carries high-tech equipment (e.g. telescopes) and low technical resource material (e.g. cardboard, plastic, glass and other everyday household items) for use in practical sessions. The University of Pretoria's Faculty of Engineering, Built Environment and Information Technology has equipped a large truck as a mobile technology laboratory. The Tsebo Koloing (meaning "technology in motion") truck has been visiting schools in and around rural areas in Gauteng and the Limpopo province since 1999.

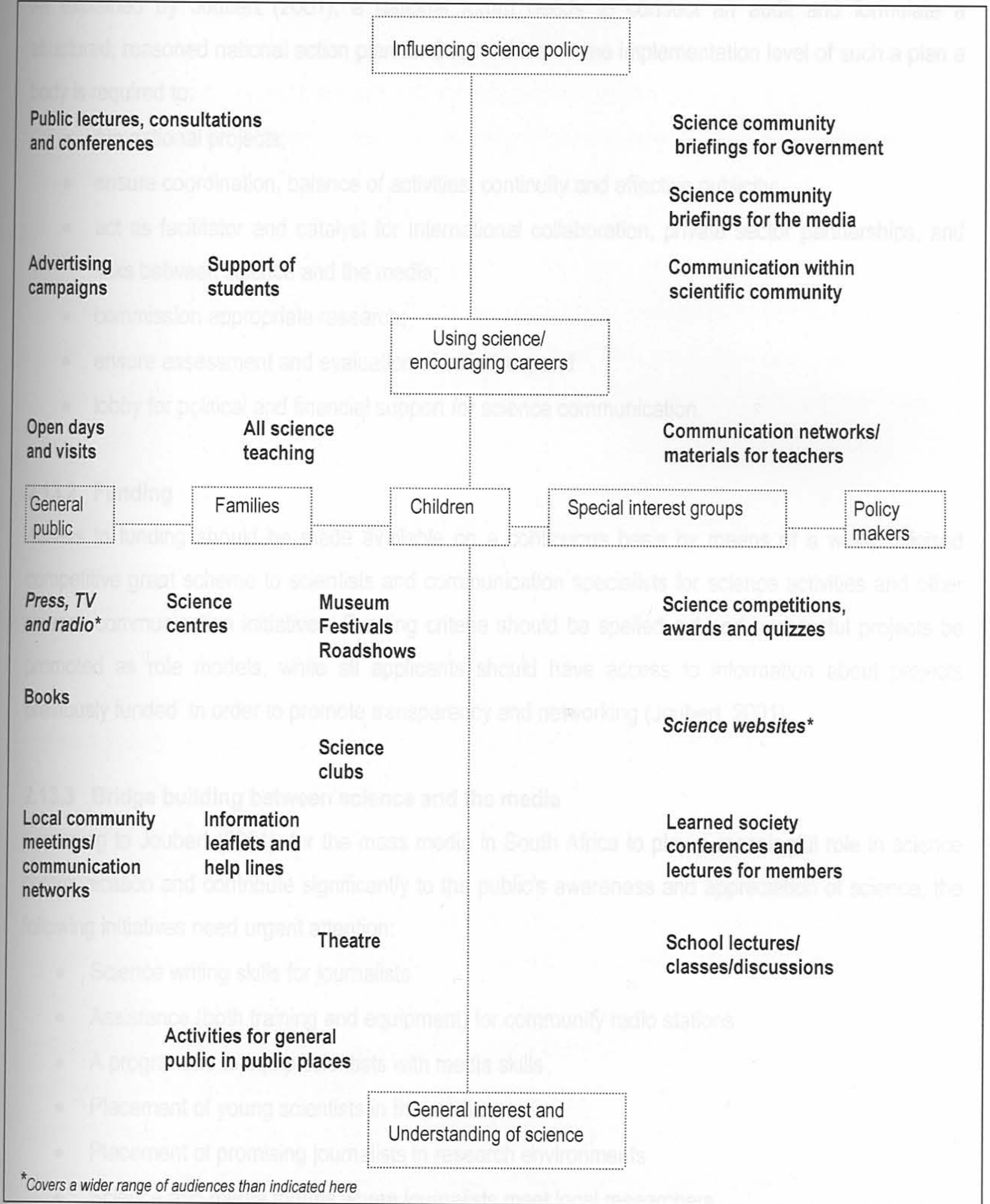
2.13 ASSESSMENT OF THE EFFECTIVENESS OF SCIENCE COMMUNICATION ACTIVITIES

Science communication activities are a fairly recent phenomenon in South Africa. These activities and the role they are playing in raising awareness about science still need to be evaluated, but some problems have already been identified. Funding is a pressing challenge that faces the future of science activities in South Africa. According to Joubert (2001), in an environment where formal science education struggles to achieve acceptable standards, teachers are often underqualified, demotivated and disillusioned; and many schools do not even have electricity. South Africa needs many more mobile outreach activities to promote science. New technology is certainly contributing to a better and easier way to communicate, but in rural areas this new technology will virtually be a waste of time and money. Therefore, despite all the new technologies available to distribute science to all segments of society, it seems as if not enough effort is applied to enhance science communication in South Africa.

Figure 2.3 displays a map, prepared by Research International (2000:9), to assist HEI in defining various types of activities according to different target audiences and the context or aims of the specific activity, which could be applied in South Africa to enhance science communication.

The horizontal axis represents the target audience (stakeholders), from 'general public' to 'policy makers', while the vertical axis portrays the context from 'influencing science policy' to 'general interest and understanding of science'. ('Influencing science policy' refers to activities undertaken in the context of aiding government policy development.)

Figure 2.3: Mapping of science activities



Source: Research International (2000:9)

The mapping of science activities points out certain priorities for future action, which can be divided into the following six categories as identified by Joubert (2001):

2.13.1 Leadership and coordination

As explained by Joubert (2001), a national forum needs to conduct an audit and formulate a structured, reasoned national action plan for South Africa. At the implementation level of such a plan a body is required to:

- run national projects;
- ensure coordination, balance of activities, continuity and effective publicity;
- act as facilitator and catalyst for international collaboration, private sector partnerships, and links between science and the media;
- commission appropriate research;
- ensure assessment and evaluation of initiatives; and
- lobby for political and financial support for science communication.

2.13.2 Funding

Access to funding should be made available on a continuous basis by means of a well-publicised competitive grant scheme to scientists and communication specialists for science activities and other science communication initiatives. Funding criteria should be spelled out and successful projects be promoted as role models, while all applicants should have access to information about projects previously funded in order to promote transparency and networking (Joubert, 2001).

2.13.3 Bridge building between science and the media

According to Joubert (2001), for the mass media in South Africa to play a meaningful role in science communication and contribute significantly to the public's awareness and appreciation of science, the following initiatives need urgent attention:

- Science writing skills for journalists
- Assistance (both training and equipment) for community radio stations
- A programme to equip scientists with media skills
- Placement of young scientists in the media
- Placement of promising journalists in research environments
- Science and media forums where journalists meet local researchers
- A programme to market science to editors and media leaders, and to secure their commitment
- Research into science in the South African media
- Effective networking among science communicators
- Promotion of South African science on the Internet

2.13.4 Science on local radio and television

South Africa needs strategies, high-level commitment and support to improve the quality and quantity of science in local broadcasts. Science needs to be integrated into popular, peak-time programmes, such as local dramas, historical and other documentaries, talk shows, and even soap operas. There is also a need for regular science inserts on news broadcasts and science fillers between programmes (Joubert, 2001).

2.13.5 International networking and exchange

Science communication in South Africa would be stimulated if science communicators could meet regularly and exchange ideas with science communicators from other countries. This could also provide a meeting ground for Western ways of understanding and indigenous or non-Western ones.

2.13.6 Main players

According to Joubert (2001), the government of South Africa must formulate policy and guide and promote interdepartmental collaboration in the field of science communication. In many cases, science councils are prepared and committed at the grassroots level, but they often function without resources or the backing of their leaders. The councils must take responsibility for science communication, which should perhaps be included in their Acts, as is the case in the United Kingdom. The same applies to universities and other statutory research institutions. Ultimately, scientists themselves must embrace their role in science communication, for without them science communicators and science journalists have nothing to say.

Although Joubert (2001) addressed relevant issues in the science communication environment, a very important aspect had not been addressed, i.e. the role of communication specialists in science communication. In addition to tasks generally devoted to communication specialists at HEI, participation in science activities is crucial. Communication specialists, as marketers of their institutions, are the people visiting schools, communities, etc., and in the role of marketers should also assist scientists to communicate science to all levels of society. The omission of these imperative role players is a concern for the researcher and result in questioning Joubert's interpretation of science communication in South Africa.

2.14 CONCLUSION

The phenomenon of science communication and the theories used as framework for the development of science communication were described in this chapter. The information theory, as discussed under

Section 2.7 and the mass communication theory are two of the theories that can be applied to science communication. These theories form an integral part with the rest of this study, referring to the importance of science communication (Objective 1), since science communication is information (information theory) that has to be distributed to all segments of society (mass communication theory).

It is true that the Internet and its associated developments, such as the World Wide Web, are a developed global phenomenon. It is also true that the gap between the economically advantaged and disadvantaged communities continues to increase in both developed and developing economies. Together with these phenomena, science and its communication become more and more crucial to sustain the development of society at large.

Despite the new technological developments too many people in South Africa still do not have access to these developments and although science communication activities contribute to distribute the messages of science, a variety of problems need to be addressed to enhance the effective application of science communication activities, as suggested in Section 2.13.

The development of science communication was clarified in this chapter, but unless the perception of the general public (as an important stakeholder group of HEI) towards the phenomenon of science and the communication thereof is known, all efforts to enhance the importance of science communication would be in vain. In Chapter 3 the theory of stakeholders of HEI (receivers of science messages) is discussed. Chapter 3 also not only provides answers to the question on how the public perceives science communication, but also contains a discussion on the results of studies aimed at determining the public's attitudes towards science.