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THE EFFECTS OF AN OUTREACH PROGRAMME ON THE PUBLIC UNDERSTANDING OF SCIENCE, ENGINEERING AND TECHNOLOGY

by

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ABSTRACT

The main purpose of this study was to evaluate the effects of a Technology Outreach Programme on Public Understanding of Science, Engineering and Technology (PUSET). The study further intended to give feedback to the management of the Tsebo Koloing Technology Outreach Programme, to assist them to make an informed decision with regard to the continuation, termination or revision of the existing programme, which represent a major investment of resources. It was also foreseen that the findings of this study could contribute towards the design and successful implementation of similar PUSET programmes elsewhere.

To facilitate the understanding of the problem statement of this study, an evaluation framework based on the Context-Input-Process-Product (CIPP) model of Stufflebeam, Madaus & Kellaghan, (2000) was applied. The research was carried out at four secondary schools that were considered disadvantaged situated in townships near Pretoria, South Africa. Secondary school learners and science and technology teachers, who visited the Tsebo Koloing programme, as well as members of the executive committee of the programme, participated in the study. This study provided valuable insight into the understanding of the effects of the TK programme on learners and teachers in schools (particularly in a developing nation context) who visited the programme and how the extent to which the programme created and promoted PUSET furthermore this study emphasized the importance of programme evaluation and proper planning of S&T outreach programmes with regard to needs assessment; identification of target groups; programme design; programme development and content; as well as programme implementation and evaluation. Although valuable information was obtained from this research, there is still scope for further research on how to evaluate the effects of S&T programmes on PUSET as well as research on the effectiveness of mobile S&T programmes.

Key words:

Promoting public understanding of science, engineering and technology; Mobile science and technology outreach programmes; Hands-on exhibits; Science, engineering and technology related careers; Input; Process; Output

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DEDICATION

Dedicated to my Father, God Almighty,
my best Friend, Jesus Christ and
my Teacher, the Holy Spirit.

May this degree contribute towards the restoration and
transformation of people and communities to glorify God.

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LIST OF ACRONYMS

PASET	Public Awareness of Science, Engineering and Technology
PUSET	Public Understanding of Science, Engineering and Technology
SAASTA	South African Association for Science and Technology Advancement
SET	Science, Engineering and Technology
S&T	Science and Technology
TUT	Tshwane University of Technology
TK	Tsebo Koloing
HS	High School
THS	Technical High School
UP	University of Pretoria

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The purpose of this study was to evaluate the effects of a specific education mobile science and technology (S&T) facility namely the Tsebo Koloing Technology Outreach Programme (TK programme) on the Public Understanding of Science, Engineering and Technology (PUSET) in secondary schools that are considered to be disadvantaged.

The TK programme was designed and implemented in 2000 as an initiative of the faculties of engineering at the University of Pretoria and Tshwane University of Technology to reach out to teachers and learners in secondary schools that are considered to be disadvantaged in townships surrounding Pretoria to promote PUSET.

This study intended to: (a) provide insight into and understanding of the effects of a mobile S&T facility; (b) contribute towards the knowledge of the evaluation of the effects; design, planning and successful implementation of similar PUSET programmes elsewhere; and (c) assist and inform the management of the TK programme to make an informed decision with regard to the continuation, termination or revision of the existing programme.

In section 1.2 the problem statement of this study is discussed; section 1.3 deals with the objectives of the study; the rationale for the study is discussed in section 1.4; and section 1.5 gives an overview of the dissertation.

1.2 PROBLEM STATEMENT

The TK programme was running since 2000 but the effects of the programme on PUSET were unknown. There are very few mobile S&T programmes in South Africa and the impact of these programmes is unknown. Therefore it has been decided to conduct this study to determine the effects of the TK programme on PUSET.

Furthermore, the executive management committee of the TK programme had to make a strategic decision with regard to the continuation or termination of the programme due to financial constraints because the programme was heavily dependent on donor funding for its survival. The running costs of the programme increased annually; it has been extremely difficult to find sufficient funding, as funders insist on proof of evaluation of the effects of, as well as a guarantee of the sustainability of the programme. Therefore the management of the programme decided to evaluate the effects of the programme to comply with these prerequisites and to improve their chances to obtain funding if they could prove that the programme has a positive effect. They also wanted to determine whether the programme was successful in reaching the intended overall objective, to promote PUSET, and whether it is worth the significant financial input.

Financial constraints are not unique to South Africa. Taylor (2003) of Science Alive!, The New Zealand Science Centre, commented in his article *Survival of science centres in New Zealand: What we can learn,* that although science and technology centres have made great strides in recent years in terms of increased visitor numbers, improved range of offerings and recognition of their role as purveyors of science and technology, they generally face a financial squeeze, even though most may not want to admit to this. Taylor (2003, pp. 490-500) continued by indicating that paucity of funds can have a debilitating effect on the operation of these centres, and this in turn can affect the promotion of their mission objectives. The repercussions on the public understanding of science and technology then take on graver overtones. There is thus a pronounced need for these centres to have a diversified portfolio of financial support - gate takings rarely, if ever, cover the administrative, operational and maintenance costs of these institutions.

The TK programme was facing the same challenge regarding funding to cover their running expenses. There is just not enough funding available for such programmes in South Africa and there is increasing competition for the limited funding pool.

To evaluate the effects of the TK programme the following three research questions were formulated:

(a) How do the intended outcomes of the TK programme compare with the actual outcomes?

(b) How does the intended process of the TK programme compare with the implemented process?

(c) To what extent was it anticipated that the actual input would result in the actual process?

1.3 OBJECTIVES OF THE STUDY

The *main objective* of this study was to evaluate the effects of the TK Technology Outreach Programme on teachers and learners in secondary schools considered to be disadvantaged and to determine to what extent this programme promoted PUSET.

The *specific objectives* for the study were derived from Stake's layout of statements of data to be collected by the evaluator of an educational program Stake, 1967, pp. 523-540 discussed in chapter 4 of this study. The specific objectives of this study were to:

(a) Identify and compare the intended outcomes of the programme with the actual outcomes to determine whether the programme achieved what it intended to achieve,

(b) Evaluate the intended (planned) process and the implemented process of the programme and to compare them, and

(c) Determine what the actual input was and to what extent it was anticipated that it would result in the actual process.

The research conducted by Guskey (2000) and Weiss (1995) regarding programme evaluation contributed towards the formulation of the objectives for this study. Guskey (2000, p 41) defined evaluation as the systematic investigation of merit and worth. The term *systematic* implies that evaluation in this context is a thoughtful intentional and purposeful process. Therefore, systematic evaluation refers to determining if the goal of an activity or in the case of this study the objectives, are met or if progress toward the goals or objectives is made*. Investigation* in the definition refers to the collection and analysis of appropriate and pertinent information. *Merit* and *worth* in the definition refer to appraisal and judgment. According to Guskey (2000, p. 42) evaluations are designed to determine the value of something. Evaluations help to answer questions such as: Is this programme leading to the results that were intended? Is it better than what was done in the past? Is it better than another, competing activity? Is it worth the costs? Weiss (1995, p. 4) defined evaluation as follows: "Evaluation is the systematic assessment of the operation and/or the outcomes of a programme or policy, compared to a set of explicit or implicit standards, as a means of contributing to the improvement of the programme or policy."

1.4 RATIONALE FOR THE STUDY

The importance of programme evaluation was emphasized by Stufflebeam, Madaus and Kellaghan, 2000, p. 279 stating that policymakers, programme and project staff, and individual service providers can conduct or contract for evaluations to help initiate, develop, and install sound programmes, projects, or other services; to strengthen existing programmes or services; to meet the accountability requirements of oversight groups, sponsors, and constituents; to disseminate effective practices; and to contribute to knowledge in the area of service by employing the following four interrelated types of evaluation: context evaluations; input evaluations; process evaluations; and product evaluations.

Why is it necessary to evaluate programmes such as the TK programme? Delacôte (1998, pp. 617-618) from the Exploratorium, United States of America, confirmed the importance of continuous revision of science programmes in his article *Apoptosis: the way for science centres to thrive,* that the message is clear that it is important for science and technology centres to undergo frequent metamorphosis within the framework circumscribed by their mission objectives in order to be resilient and be better able to cope with the new challenges of promoting science and technology. As mentioned earlier, the TK programme was running since 2000 but the effects of the programme were not known. The question is: is the TK programme still relevant and is it coping with the challenges of promoting PUSET?

Scriven (1971, cited in Guskey, 2000, p. 43) took the necessity of programme evaluation one step further by adding that the evaluation of *worth* questions the extent to which the programme is essential to the organization's mission, its perceived value to various constituents, its payoffs in terms of recognition and public goodwill, and so on. *Worth* might also be considered in terms of the benefits to a single individual or a specific group of people as in the case of the TK programme reaching out to learners and teachers in communities that are considered to be disadvantaged to expose them to SET. *Merit* on the other hand is a property of the programme, judged by comparing its performance against established standards of excellence in the profession.

It became necessary to evaluate the operation and outcomes of the TK programme to contribute towards the improvement of the programme and/or to assist management to make an informed decision whether to redesign or terminate the programme.

The executive management committee of the TK programme decided to have the effects of the programme evaluated empirically for the following reasons:

(a) To determine the actual effects of the programme on PUSET.

(b) The programme needed to be evaluated to determine whether it is viable to continue with it, whether it is necessary to re-design it to be more effective and efficient or to terminate it.

(c) A prerequisite for interested individuals and firms to donate funds and the participating institutions to allocate resources to support the programme is that the actual effects of the programme should be positive, which implies that the effects should be evaluated.

(d) The running costs of the programme increased annually and it became necessary to compare the costs and increasing input with the actual outcomes.

According to Worthen, Sanders and Fitzpatric (1997, p. 98) the management-orientated evaluation approach serves decision-makers and that its rationale is that evaluative information is an essential part of good decision-making. It is the intention of this study to provide the management of the TK programme with information to enable them to make an informed decision.

With regard to the TK programme it was determined during interviews with the management team that apart from statistical information compiled of visitors, the number of schools visited annually, and questionnaires completed by visitors, no other evaluation has been done to determine whether they achieved their objectives or whether the programme made a difference or contributed towards the promotion of PUSET. According to the executive management committee such in-depth evaluation of the actual effects of the TK programme has not been done previously. (P. C. du Plessis, personal communication, February 14, 2003).

It is important to note that although this research focused on a specific programme, it is believed that the findings of the study will be relevant and of interest to other parties focusing on the promotion of PUSET in South Africa and internationally, such as the national department of education, tertiary education institutions involved with such programmes, funders, and non-governmental and non-profit organizations and those involved in research on non-formal education in science and technology.

Apart from the fact that this research intended to assist the management of the TK programme in strategic decision-making, it also could be of specific value to other institutions and organizations who are involved in the promotion of PUSET to assist them with regard to the design, planning, implementation and evaluation of science, engineering and technology (SET) programmes.

1.5 OVERVIEW OF THE DISSERTATION

Chapter 2 of this dissertation elaborates on the background of the TK programme. In chapter 3 the literature review focuses on the definitions of terms used in this research; research conducted on PUSET programmes internationally and in South Africa; and research conducted on the evaluation of science and technology (S&T) programmes internationally and in South Africa. The conceptual framework is discussed in this chapter and the adapted conceptual framework for this study is described. The research design and methods are discussed in chapter 4. In chapter 5 the findings of the study are elaborated in accordance with the research questions. The main conclusions and overall recommendations are presented in chapter 6.

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CHAPTER TWO

BACKGROUND OF THE TSEBO KOLOING PROGRAMME

2.1 INTRODUCTION

As mentioned in chapter 1 the TK programme was designed and implemented in 2000 as an initiative of the faculties of engineering at the University of Pretoria and Tshwane University of Technology to reach out to teachers and learners in secondary schools that are considered to be disadvantaged in townships surrounding Pretoria to promote PUSET.

In this chapter, the background and context of the TK programme will be covered in section 2.2; in section 2.3 rationale for the existence of PUSET programmes are explained; in section 2.4 the mission and objectives of the TK programme are presented; in section 2.5 the management and funding of the programme is clarified; the operation of the programme is explained in section 2.6; and a summary is provided in section 2.7.

2.2 BACKGROUND AND CONTEXT OF THE PROGRAMME

The background of the programme and the context within which it operates are described in this section. The background of the programme is dealt with under 2.2.1 and the context of the TK programme is discussed under 2.2.2.

2.2.1 Background

The name *Tsebo Koloing* literally means a “moving vehicle”. The name was chosen to draw the attention of the target group consisting of learners speaking different African languages. The slogan of the programme is: *Engineering your future.*

2.2.2 Context

The faculties of engineering at the University of Pretoria and the Tshwane University of Technology have identified the need to bring science, engineering and technology to those communities who have not been exposed to it previously. To address this need a mobile unit, consisting of a trailer drawn by a mechanical horse, was equipped with hands-on exhibits and demonstrations with an emphasis on learner involvement. The unit, based on the successful science exploratorium principle applied in the Exploratorium, the museum of science, art and human perception, in San Francisco, United States of America, which is an experimental, hands-on museum where visitors can explore S&T hands-on (Exploratorium: the museum of science, art and human perception. Retrieved December 4, 2006, from http://www.exploratorium.edu/) went out to schools to reach learners and teachers with the aim of enhancing their interest in and awareness of science, engineering and technology since the beginning of 2000.

The designers of the TK programme believe that for South Africa to prosper it is imperative that future higher education entrants realize the important role that engineers, scientists, technicians, artisans, and other engineering and science-related careers play in the urgent economic development that South Africa needs and to improve its position on the world's competitiveness list. At the same time the need for proficiency in science, mathematics and technical subjects must be emphasized to encourage learners to matriculate with high marks which will allow them to study at tertiary education institutions (TK business plan, 2003, p. 1).

2.3 RATIONALE FOR THE EXISTENCE OF PUSET PROGRAMMES

The rationale for the existence of PUSET programmes and the strategic positioning of the TK programme are discussed in this section.

According to the South African Agency for Science and Technology Advancement (SAASTA) the promotion of PUSET is nationally and internationally recognized as a high priority of governments: "The United States National Science Board Strategic Plan (NSB-98-215) identified public understanding and appreciation of science and technology and public outreach by the science and engineering communities as essential for successful science and technology policy that will benefit society" (SAASTA. [n.d.] Retrieved June 30, 2003, from http://www.saasta.ac.za/puset /international html).

Research by the National Science Board of the United States has shown that in the United States of America, the general level of understanding of basic scientific concepts and of the nature of scientific inquiry may be insufficient for the average citizen to be able to make informed decisions (National Science Board, 2002).

The important role that science and technology plays in wealth creation, and sustainable development was emphasized at the world conference on science in Budapest (1999) during which the key role played by the use of scientific knowledge in alleviating poverty was identified. The meeting produced a "Declaration on Science" in which participants noted that greater use of scientific knowledge is essential in creating a better quality of life and a sustainable and healthy environment for present and future generations (SAASTA. [n.d.] Retrieved May 4, 2003, from http://www .saasta ac.za/puset/index/html).

The Human Development Report of the United Nations Development Programme (n.d.) further emphasizes the role that science and technology plays in the development of the individual, and of countries on the whole. The report states that: "Technology is like education - it enables people to lift themselves out of poverty. Thus technology is a tool for, not just a reward of, growth and development" (SAASTA. [n.d.] Retrieved, May 4, 2003, from http://www.saasta.ac.za/puset/index /html).

Stocklmayer (2003, pp. 405-412) of the National Centre for Public Awareness of Science, Australia, said in an article *What makes a successful outreach program? An outline of the Shell Questacon Science Circus,* argued that a science circus is a natural extension of a science centre: it is a science centre on wheels. She also stated that whilst institution-based science centres generally cater for the needs of people and students in the general vicinity, people in rural areas often lack opportunities to savour the multi-faceted splendours of science and technology.

According to Mir (2003) from Sci-Tech Hands-on Museum, United States of America and Fermi National Accelerator Laboratory, United States of America, science and technology centres facing spatial limitations in the fulfilment of their mission objectives or those reaching a critical mass in visitation rates in their indoor settings may have to consider expanding their reach through the opening of an outdoor annex. The concept of an outdoor science centre is also a particularly economical and cost-effective option for nations in the developing world to popularize science and technology among their people. It could be said that the TK programme is following this trend because it reaches out to communities in a developing world through a mobile unit.

In South Africa the importance of SET for the development of the country is emphasized by the fact that the South African government is actively involved in creating an understanding of SET amongst the general public through the development and implementation of S&T programmes.

SAASTA for example stated that PUSET is seen as the critical interface between science, wealth creation, and sustainable development (SAASTA. [n.d.] Retrieved May 4, 2003, from http://www.saasta.ac.za/puset/index/html).

It is a concern of the South African government specifically regarding the role that science and technology can play in wealth creation and the improvement of the quality of life in the society. According to the White Paper on Science and Technology (1996), science and technology are considered to be central to creating wealth and improving the quality of life in contemporary society (Department of Science and Technology. Retrieved July 23, 2003, from http://www.dst.gov.za).

In conclusion it could be said that the TK programme is in line with what is happening nationally and internationally and that it plays an important role with regard to the promotion of PUSET.

2.4 MISSION AND OBJECTIVES OF THE PROGRAMME

The mission and objectives of the TK programme are discussed under point 2.4.1 and 2.4.2 in this section.

2.4.1 Mission

The TK business plan (2003, p. 2) defines the mission of the programme as follows: “The main result of the programme is increasing awareness in the community and amongst learners of the important role that engineers and scientists play in society, as well as a desire in learners to enter the engineering, science and technology-related professions.”

According to the management of the programme and other documents example funding proposals, the mission of the programme is to promote PUSET. It was decided to use this as the mission statement of the programme for the purpose of this study with the consent of the management.

2.4.2 Objectives

The TK business plan (2003, p. 2) describes the main objective as follows: "To stimulate an interest in engineering and science-related careers, and encourage learners to prepare themselves for technological careers." They divide the specific objectives of the programme into three groups:

Specific objectives for learners are to:

(a) expose them to technology in a user-friendly environment,

(b) provide them with the opportunity to experience some of the wonders of science and technology at first-hand,

(c) stimulate their interest in science, mathematics and engineering,

(d) create an understanding of the importance of science and mathematics education, and

(e) ensure that engineering and science are positive career choices in their minds.

Specific objectives for teachers are to:

(a) ensure that teachers will understand the need for qualified engineers and scientists for sustained economic growth in South Africa,

(b) stimulate and develop their interest in technology,

(c) provide them with the opportunity to conduct experiments on the tertiary level,

(d) ensure that they realize the importance of science and mathematics education, and

(e) enable them to provide the relevant information regarding engineering and science related careers to their learners.

Specific objectives for the community are to ensure that:

(a) they will grasp the importance of science and engineering related professions in improving their daily lives,

(b) they will have a positive attitude towards science engineering and technology,

(c) they will perceive the profession to be accessible to their children if they are adequately prepared in science and mathematics, and

(d) their own understanding of some aspects of science and technology will have been improved.

During interviews with the executive committee and the operational manager of the programme and studying of the business plan, it became clear that there is some confusion and inconsistency amongst the management staff with regard to the specific objectives of the programme. To solve this problem it was decided to focus on the following as the specific objectives of the programme for the purpose of this study namely to:

(a) expose teachers and learners to the basic concepts of SET,

(b) create and promote awareness amongst teachers and learners of the importance of S&T education at school level,

(c) create an interest amongst learners in SET-related careers, and

(d) provide learners with career information with regard to SET-related careers.

2.5 MANAGEMENT AND FUNDING

The TK programme is managed by an executive committee and an operational manager and it receives funding from different funders from the private (corporate) sector including motor manufacturers; banks; oil companies; and foundations. The management structure and funding details of the TK programme is discussed under 2.5.1 and 2.5.2 in this section.

2.5.1 Management

An executive committee consisting of 10 representatives of the faculties of engineering of Tshwane University of Technology and the University of Pretoria as well as representatives from the two foundations (responsible for fund-raising at the two institutions) are responsible for strategic planning and overall management of the programme.

An operational manager is responsible for the day-to-day running of the programme. He reports back to the executive committee on a quarterly basis during board meetings.

The executive committee reports back to the funders via the two foundations with regard to the achievements of the programme.

2.5.2 Funding

Several funders (example businesses and large corporations) provide funds to cover the operational costs of the programme via the foundations of the two institutions. The operational cost of the programme amounts up to approximately R550 000.00 per annum in 2005 (TK business plan, 2003, p. 7). The faculties of engineering at the two universities provide some resources including infrastructure, maintenance of equipment and some funding required for this initiative. The programme is supported through expertise of registered professional engineers and engineering technologists, as well as infrastructure (including office facilities) and administrative assistance made available by the two universities.

2.6 OPERATION OF THE TK PROGRAMME

The operation of TK the programme that is the way the programme is implemented and what it comprises is discussed in this section.

The programme consists of a mobile unit (truck) equipped with hands-on science, engineering and technology exhibits, challenging games (example puzzles), and colourful posters displaying science concepts. Each exhibit has written instructions (instruction cards) to explain how to operate it.

The hands-on exhibits inside the unit represent science, engineering and technology topics. The following list (Table 2.1 below) indicates the SET topics represented by the exhibits:

Table 2.1 *SET topics represented by the exhibits*

EXHIBIT	**TOPIC**
1. Hand battery	Electrical current flow (science)
2. Corner reflector	Reflection of images in mirrors (science)
3. Plasma ball and tubes	Electromagnetic waves (science)
4. Interactive pick-up cones	No specific concept (technology)
5. Flame engine	Combustion engine (science)
6. Gearbox model	Mechanical engineering (technology)

Table 2.1 *SET topics represented by the exhibits (continued)*

EXHIBIT	**TOPIC**
7. Differential gear model	Mechanical engineering (technology)
8. Steering mechanism model	Mechanical engineering (technology)
9. Tunnel light	Reflection of light (science)
10. Winding radio	Conversion of energy (science)
11. Zoetrope	Persistence of vision (technology)
12. Uphill roller	Gravity (science)
13. Floating spindle	Magnetism (science)
14. Bernoulli blower	Air pressure (science)
15. Non-round wheels	Effect of different shapes on rolling action (technology)
16. Computers	Information technology.

There are a number of games outside the unit. These include wooden puzzles, untangling of ropes, and hand-eye coordination activities. The emphasis here is on fun-filled games (entertainment) that provide interesting challenges to the visitors.

The unit is pulled by a mechanical horse and parked at a school for a minimum of two consecutive days during which teachers and learners visit the unit during school periods and after school. The unit could stay longer if requested by the school. The learners and teachers visit the unit for 30 to 45 minutes during which they have the opportunity to handle the exhibits, look at demonstrations and ask questions.

The staff component of the TK programme consists of a full-time operational manager (who is also a facilitator) and an assistant facilitator. They provide information, perform demonstrations and answer questions on an individual basis during visits.

They are responsible for the following tasks:

(a) identify and contact schools and arrange visits,

(b) determine when and where SET shows and career shows will be held and arrange to participate,

(c) prepare equipment for demonstrations, and

(d) check quality of exhibits and arrange for repairs and maintenance.

There are follow-up visits to schools during which:

(a) the effects of the unit are determined, and

(b) career guidance lectures regarding science, engineering and technology related careers are presented to groups of learners in grades 11 and 12.

These career guidance lectures include information with regard to subject choices; admission requirements for further study in science, engineering and technology related careers as well as application procedures at the two universities.

The unit visits open days at the two universities, career shows and science expos where the general public, including prospective students, teachers and learners, visit it.

2.7 SUMMARY

In this chapter the rationale for the existence of PUSET programmes was explained and the background, strategic positioning and the content of the TK programme were discussed focusing on the mission and objectives; management and funding; and operation of the programme.

CHAPTER THREE

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

As discussed in chapter 1 the aim of this study is to evaluate the effects of the TK programme on PUSET in secondary schools that are considered to be disadvantaged. The purpose of the literature review therefore was to analyse previous research with regard to PUSET internationally and in South Africa and to ascertain what research has been done with regard to the evaluation of the effects of PUSET programmes internationally and in South Africa.

The literature review is discussed in section 3.2; in section 3.3 the literature is synthesised and conclusions drawn; in section 3.4 the conceptual framework for this study is discussed; and a summary of the chapter is provided in section 3.5.

3.2 LITERATURE REVIEW

This literature review was informed by the following research questions:

(a) How do the intended outcomes of the TK programme compare with the actual outcomes?

(b) How does the intended process of the programme compare with the implemented process?

(c) To what extent was it anticipated that the actual input would result in the actual process?

In this section the literature review is discussed under the following three sub-sections: 3.2.1 definitions of terms; 3.2.2 previous studies conducted on PUSET; and 3.2.3 research conducted on S&T programmes and the evaluation thereof internationally and in South Africa.

The following databases were used to trace bibliographic or full text references of journal articles, and chapters from books on research done on PUSET and the evaluation of the effect of PUSET programmes:

- SABINET: SA platform for databases, amongst others – ISAP: SA journal articles, current and completed research; SA ePublications: full text of SA.
- TYDS@TUKS: A platform for a large selection of international full text journals in all subject fields, as well as full text databases.
- UPEXPLORE: A computerized catalogue of books and journal titles.
- Academic Search Premier; EBSCO host research databases.
- ERIC: Educational Resource Information Centre.
- Google and Google Scholar.
- SACat.

The key terms used in the search were: *evaluation* of and *research* on PUSET; Public *Awareness* of Science, Engineering and Technology (PASET), SET; S&T programmes; science centres; science museums; S&T outreach programmes.

3.2.1 Definitions of Terms

It became clear during the initial interviews with the management of the TK programme to gain insight and obtain background information about the programme to be evaluated, that confusion and even vagueness exists with regard to the terminology used in the programme (P. C. du Plessis, personal communication, February 14, 2003). This was confirmed during the analysis of the programme documentation in which terminology is used randomly and inconsistently (TK business plan, 2003). It was important to determine the meaning of a number of terms used in the documentation; by management; operational staff; in articles; and in research reports about PUSET and S&T programmes. The first objective of the literature review for this study therefore, was to clarify the terminology used by the TK programme and to ensure that the terminology is applied correctly in this study.

Public *Understanding* of Science, Engineering and Technology (PUSET)

The first concept was that of Public *Understanding* of Science, Engineering and Technology (referred to as PUSET). The concept houses a complex of terminological problems. There are five aspects: (a) that of *understanding* as such; (b) then the idea of *public* understanding; (c) *science;* (d) *technology;* and finally (e) the idea of understanding *engineering* that specifically relates to this study because the programme was initiated by the two faculties of engineering of the two universities to recruit more students for engineering studies.

Public *Awareness* of Science, Engineering and Technology (PASET)

In the search for a definition of PUSET the term Public *Awareness* of Science, Engineering and Technology (PASET) was identified. It became clear that both terms PASET and PUSET are used with regard to programmes such as the TK programme and that they are often used randomly although there is a fundamental difference between *understanding* and *awareness.*

The meaning of the terms *understanding* and *awareness* in this context needs clarification because the TK programme's stated main objective or overall goal is to promote PUSET. However, according to the Oxford Advanced Learner's Dictionary (2002, p. 1302) *understanding* means the knowledge that someone has about a particular subject; to know or realize why something happens; and how it works or why it is important. *Understanding* in this sense then implies *learning* about or getting to *know* something. The question arose during the initial discussions and interviews with the TK management whether the programme creates an *understanding* of SET and what exactly does that entail or does it create an *awareness* of SET instead? It was clear that uncertainty existed amongst the role-players involved in the programme about this issue.

The Internet was also searched for *definitions* to provide clarification. One of the definitions found, describes *understanding* as the ability to apply *broad knowledge* to situations likely to be encountered, to recognize significant deviations, and to be able to carry out the research necessary to arrive at reasonable solutions (Indiana University Internal Audit. [2004]. Retrieved August 25, 2003, from http://www.indiana .edu/~iuaudit/glossary.html).

According to the above definitions the emphasis is on *knowledge*. The question was then asked whether the knowledge of the visitors to the TK programme increases during a visit and if not, what they gain from their visit.

The other term often used by role-players is the term *awareness.* According to the Oxford Advanced Learner's Dictionary (2002, p. 67) the term *awareness* refers to being *affected* by or *interested* in something. *Awareness* also means knowing of and realizing that something exists and that it might be important.

It is important to note that *awareness* does not necessarily imply *understanding* something, although it is a necessary condition for understanding: one cannot understand X without being aware of X, to eventually create an understanding of X. Looking at the TK programme and the definitions of understanding and awareness, it initially seemed that the programme is actually creating *awareness* rather than an *understanding* of SET.

The term PUSET also includes the term *public*. What is meant by *public* understanding? The following definition of *public* was found during the search for clarification: open to or concerning the people as a whole; a body of people sharing some common interest; and affecting the people or community as a whole (Wordnet®. A lexical database for the English language Cognitive Science Laboratory, Princeton University. [n.d.]. Retrieved August 25, 2003, from http: //wordnet.princeton.edu).

It could be said that the term *public* could either refer to people in general or to a specific group of people, for example the learners and teachers in secondary schools as in the case of the TK programme.

Science and technology

In defining *science* and *technology* the terms, technology and science, are often confused. Technology is said to be 'applied science'. Science deals with the natural world. Technology is the study of the natural laws, which govern the universe. Science tells us that objects will fall to the earth (law of gravity). Science explains why only certain plants are found on the Mojave Desert (plant ecology). Science tells us that steel exposed to oxygen will rust (chemistry). Science tells us that cross-pollinating plants will produce predictable results (biology). Science tells us that oil is most likely found near certain rock formation (geology). On the other hand, technology deals with the human-made world. It is the study of ways people develop and use technical means - tools and machines. It tells us how to control the natural and human-made world. This is not to say science and technology are unrelated. Science deals with 'understanding' while technology deals with 'doing'. Science helps us know how to do something efficiently (*Technology.* [n.d.]. Retrieved August 25, 2003, from http://www.bergen.org/technology/defin.html).

As mentioned earlier the TK programme puts a high premium on the promotion of engineering as a field of study and this study includes the evaluation of the effects on public understanding of e*ngineering* as such and not only science and technology.

Engineering

In the search for a definition of engineering the following definitions and explanations were found:

(a) Engineering involves the *knowledge* of *mathematical and natural sciences* (biological and physical) gained by study, experience, and practice, applied with judgment and creativity to develop ways to utilize the materials and forces of nature for the benefit of mankind (Massachusetts Department of Education. *SET Curriculum Framework.* [n.d.]. Retrieved August 25, 2003, from http://www.doe.mass.edu /frameworks /scitech/2001/resources /glossary.html).

(b) Engineering is a general term, which refers to the systematic analysis, and development of measurable physical data, using applied *mathematical, scientific, and technical principles,* to yield tangible end products, which can be made, produced, and constructed (Maine Department of Transportation. [2002]. Retrieved August 25, 2003, from http://www.state.me.us/mdot/homepage.html).

According to the above definitions it is clear that engineering is the application of science and technology principles. Could it then be assumed that learners will gain an understanding of engineering or make the link between the exhibits and engineering during their visit to the programme?

It is important to determine how other researchers and role-players use (or understand) the terms PUSET and PASET. *The Science and Technology Report* (2000) of the Select Committee on Science and Technology in the UK refers to PUSET as the *understanding* of scientific matters by non-experts. They further stated that this couldn't of course mean a comprehensive knowledge of all branches of science. It may however, include understanding of the nature of scientific methods, including the testing of hypotheses by experiment. It may also include *awareness* of current scientific advances and their implications.

The Select Committee on Science and Technology (2000) concluded that *Public Understanding of Science* has become a shorthand term for all forms of outreach by the scientific community, or by others on their behalf (example science writers, museums, event organizers), to the public at large, aimed at improving that understanding. It is sometimes expressed more comprehensively as 'public understanding of science, engineering and technology' (Select Committee on Science and Technology. [2002]. Retrieved August 25, 2003, from http://www.publications.parliament.uk/).

In conclusion it could be said that the terms PUSET and PASET can be used interchangeably, but when the effect of a particular programme is evaluated it is important to distinguish between the two terms to determine what the programme achieved. The term PUSET was used in this study.

The following definitions and terms were chosen for the purpose of this study: *Public* to a specific group of people; *Understanding* implies learning about or getting to know something; *Technology* deals with the human-made world and how to control the natural and human-made world; *Science* helps to know how to do something efficiently and that *science* and *technology* are related; and engineering is the application of science and technology principles.

3.2.2 Previous Studies done on PUSET Programmes and their Effects

A search was done for previous studies done on PUSET internationally which resulted in a number of references such as Brossard, Liewenstein and Bonney (2005); Salmi (2003) Stocklmayer (2001); Rennie and McClafferty (1996); Edwards (2002); Rix and Mcsorley (1999) and Bowker (2002).

However, these studies tended to focus on what the programmes offer and why they were important. No reference was found with regard to the evaluation of the *effects* of such programmes.

The subsequent search for previous research focusing on PUSET in South Africa resulted in a number of references to PUSET programmes referring to what the programmes offer and their importance such as Hughes (2002); Howie (1999); Mvalo

(2001); and Myburgh (n.d.). No reference was found regarding the evaluation of the *effects* of such programmes.

3.2.3 Research Conducted on PUSET Programmes and the Evaluation thereof Internationally and in South Africa

In this section research done on PUSET programmes and the evaluation thereof internationally and in South Africa is discussed starting with the research done internationally.

Research Conducted on PUSET Programmes and the Evaluation thereof internationally

The search started with looking for research on the *evaluation* of the *effects* of *PUSET* programmes, but due to the lack of information the search was broadened to research on the effects of *S&T* programmes (excluding engineering). In general the search for previous research conducted on the *evaluation* of S&T programmes internationally also resulted in very few references and most of the research was conducted in the 1990s. For example Boddington and Coe (1996) Perry (1993); Rennie and McClafferty (1996); and Rix and Mcsorley (1999). The search was once again broadened to *science* programmes more generally (excluding technology), for example science centres, museums, shows, and outreach programmes.

It was determined during the search that there is a lack of relevant research on the evaluation of the *effects* of S&T programmes in general and that the research focused more on science museums. This lack of relevant research was mentioned by

Brossard, Liewenstein and Bonney (2005, p. 1100) from the University of Wisconsin-Madison, Wisconsin, United States of America; and Cornell University, New York, United States of America, who reported that although various evaluations of the effects of informal science projects on scientific knowledge and attitudes toward science have been published by researchers like Crane, Nicholson, Chen and Bitgood (1994); and George and Kaplan, (1998) most literature is devoted to learning in the context of science museums. Brossard et al (2005) reported that although citizen science projects are rapidly increasing in number the *effect* of such projects on participants' knowledge and attitudes toward science are yet to be documented.

Salmi (2003) from the Finnish Science Centre in Finland, reported in his article *Science centres as learning laboratories: experiences of Heureka, the Finnish Science Centre,* that although science centres have made great strides in popularizing science and technology among the general public, case studies of the *effectiveness* of their programs are rather sparse in the primary science literature and generally limited to the well established science and technology centres in the United States of America and UK.

Stocklmayer (2001) from the National Centre for Public Awareness of Science, Australia, reported that until recently very little research into what people take away from science centres had been carried out.

Edwards (2002, p. 5) of The Open University, reviewed the literature on the evaluating of European Public Awareness of Science Initiatives and his first observation was that although there really are very many Public Awareness of Science Initiatives (PASIs) taking place across Europe, only a tiny proportion are involved in any form of systematic *evaluation* and reporting on it. Edwards (2002) continues by saying that very few initiatives actually undertake any formal form of evaluation and those that do, tend to opt for a questionnaire, interview or data analysis technique that gives an immediate indication of success.

According to the above literature, it seems as if very little research with regard to the evaluation of the effects of mobile PUSET programmes specifically, has been conducted and that very few formal evaluations are done internationally. Although the search resulted in very few references there was some research that contributed towards the design of this study providing some guidelines with regard to the evaluation of the effects of mobile PUSET programmes on visitors.

The following topics were identified from previous research as important in evaluating the effects of S&T programmes:

The interactive nature of exhibits, the ambience of the centre and questions provoked by exhibits

Rennie and McClafferty (1996, p. 58) from the Science and Mathematics Education Centre, Curtin University of Technology, Australia, have done research with regard to science centres and science learning. The purpose of their research was to examine the role of science centres and their *interactive exhibits* in learning about and understanding science. They began by defining what *interactive exhibits* mean and considered their *attractiveness* to visitors and their potential for learning. They examined the outcomes of the visit experience and problems relating to research in science centres by studying previous research done by other researchers with regard to the outcomes of a *successful visit* to a science centre.

Rennie and McClafferty (1996, p. 85) concluded that:

(a) although science centres are popular and their educational potential is recognized, there is criticism that education is sacrificed for entertainment,

(b) science centres must become more involved in their own research to become more effective and achieve their mission,

(c) *the nature of the exhibits* presented, the *questions they provoke* in the visitor, the *ambience of the centre*, all present an image of science to the public, and

(d) the success of exhibits, in terms of the kinds of *engagement they provoke,* is a critical aspect of the effectiveness of a science centre in promoting learning about science.

The significance of the research conducted by Rennie and McClafferty (1996) lies in the fact that they identified the following factors that contribute towards a successful visit to a science centre: *the interactive nature of the exhibits* presented; the *questions they provoke* in the visitor; and the *ambience of the centre*. Although they did not specifically evaluate the effects of the visits on visitors with regard to understanding or awareness of S&T, they identified the above factors which play a vital role in the success of a visit.

Interaction with exhibits and positive attitudes of visitors

An investigation into the role that school-based interactive science centres may play in the education of primary-aged children was done by Rix and Mcsorley (1999) of the department of education, De Montfort University, Bedford in the UK. The research investigated the children's *interactions with exhibits* and each other in such a "centre".

The researchers applied action research, setting up in a school classroom a range of exhibits designed to imitate those found in a science centre. Data were collected by direct responses, group discussions and written responses and direct observation of the children's interactions. They found that although children did appear to make some gains in their learning of scientific knowledge and scientific skills and processes, the largest gains were made in the development of *positive attitudes* towards science. Their survey highlighted the success of the mini-museum in terms of the children's *enjoyment* of their visits. This enjoyment appears to have produced a *positive attitude* towards science although not necessarily the understanding of science. Their findings contributed towards the design of this study in the sense that learners' attitudes and what they enjoyed (about their visit) were evaluated. It was not one of the main questions asked because it could be misleading to see enjoyment as success as indicated by Edwards (2002, p. 8) who warned that it is possible to equate success with popularity, and perhaps, the *excitement* generated. Caution should be taken when giving people a good time (entertaining them) does not mean that their awareness or appreciation of things scientific or technological has been raised. The important role of popularity and the excitement generated by a programme was also one of the findings of Rix and Mcsorley (1999, p. 590) whose survey highlighted the success of the mini-museum in terms of the children's enjoyment of their visits. This enjoyment appears to have produced a positive attitude towards science and not necessarily the understanding of science.

Stocklmayer (2003, p. 232) reported that teachers who visited the Shell Questacon Science Circus in Australia were asked during an interview how they prepared for the visits, what kinds of perceptions of science they thought the visit encouraged, and how useful, generally, the visit – and the accompanying teacher materials – were for them and their students. The teachers thought that the visit to the Circus *'inspires and motivates students* to think about science', that it 'is a fun way to learn about science concepts' and that it *'encourages and motivates teachers'*. They also indicated that the image of science was 'fun, interesting, not just about text books but practical and hands-on' and 'it communicated that science is part of everyday life and relevant'. This research confirmed the importance of including teachers in the evaluation of a programme to obtain their point of view and it assisted with the formulation of some of the questions asked in the questionnaires but it also emphasised the positive influence a programme could have on the attitudes of visitors.

Salmi (2003) from The Finnish Science Centre, Finland, focused on four case studies relating to the motivation of school groups when visiting Heureka, the Finnish Science Centre. Research findings suggest that well organized programs linking schools to the informal open learning environments of science centres are helpful in enhancing the motivation of students towards science and technology. In this study learners who visited the TK programme were asked in open-ended questions for their opinion with regard to the importance of S&T education at school to determine what the effects of the visit was on their attitudes.

Facilitator involvement, interactive learning and time spent

The research conducted by Bowker (2002, p. 123) from the School of Education and Lifelong Learning, University of Exeter, UK, on the Eden Project *Evaluating teaching and learning strategies at the Eden Project,* shed some light on the evaluation of the effects of a programme on learners and teachers. The Eden Project aims to raise children's *interest and awareness* of plants, their symbiotic relationship with people and the importance of world trade in plants and plant products, leading to better and sustainable futures for all people around the globe. One of the key aspects about the Eden Project is that it gives children the *real* experience of being in a tropical rainforest with all the humidity, sounds and a visual feast of exotic plants. The purpose of the research was to focus on *teacher-led* primary school visits to the Eden Project. It considered the objectives of the school visits and the aims of the project. The strategies used by the project to convey their messages, through observation and interviews with children were also investigated and evaluated. It was found that there is no doubt that the project captures the imagination of the children. It has the "wow" factor and certainly improves the children's *attitude* to and interest in science (Bowker, 2002, p. 131).

The following key strategies that lead to effective teaching and learning were identified by Bowker (2002, p 133):

(a) an *adult-child ratio of 1:2,*

(b) the length of *time spent* in the project is crucial because primary school children can only work effectively for 40 minutes,

(c) children need to be prepared for the visit well in advance at school,

(d) *prior knowledge* - a successful visit depends on the prior knowledge and attitudes the children bring with them,

(e) mediation - adults should accompany children,

(f) *unstructured time* - children should be allowed to spend time exploring first, and

(g *hands-on* and *interactive* learning was highlighted by researchers for pedagogical effectiveness.

This study by Bowker (2002) suggested that it is important for schools to link the visit to their curriculum and prepare children for the visit and that the teachers play an important role in successful inter-active learning. In short, the programme should be actively integrated into the school experience and a visit to the programme should be structured. Another important aspect emphasized by this research is the role that the "wow" factor plays in creating interest amongst learners. This is an important aspect that should be built into a programme to ensure success. This contributed towards the design of this study during which the facilitator involvement, interactive learning and time spend in the TK programme were evaluated.

Audience and programme design

Edwards (2002); Rennie and McClafferty (1996); Rix and Mcsorley (1999) described a successful visit to a science museum as one in which *the visitor's agenda* is met (that is to have a good time) and also the visitor learns something new, or becomes more aware of, or interested in, something. This research emphasizes the important role that the *expectations* of the target group (the learners and teachers who visit the programme) and their *characteristics* and *background* play in a successful visit and that these factors should be kept in mind when a programme is designed.

Boddington and Coe (1996, cited in Hughes 2002, p. 2) identified a series of questions that should be explored within a public understanding of science evaluation. These include:

(a) *Audiences* – Which are the intended audiences? (example disabled, women)

(b) *Numbers* - How large an audience do you expect? (expected numbers for each category)

(c) *Experiences* - What will be their experiences at the event? (example fun and excitement, teamwork, problem-solving)

(d) *Education* - What will they learn about science at the event? (understanding of principles, specific facts, contribution of science to our well-being)

(e) *Attitudes* - Do you expect your audience's attitudes to science to be changed by the event? (stronger interest in scientific issues, stronger support for science)

(f) *Follow-up* - What do you expect your audiences to do after the event? (do projects at school, join a scientific society)

Distal outcomes – career choices

Salmi (2003) from The Finnish Science Centre, Finland, focused on four case studies relating to the motivation of school groups when visiting Heureka (the Finnish Science Centre), suggested that well organized programmes linking schools to the informal open learning environments of science centres are helpful in enhancing the *motivation of students towards science and technology.*

Subramaniam (2003, p. 368) stated that the results of another survey done by Salmi show that these informal learning institutions do wield an important influence on the *academic career choices* of students.

In conclusion it could be said that, although limited, the international research conducted on the evaluation of the effects of a mobile PUSET programme contributed towards the design of this study by providing some important guidelines regarding the evaluation of the effects of the TK programme.

Research Conducted on PUSET Programmes and the Evaluation thereof in South Africa

It was determined during the literature review that although PUSET is regarded as a high priority and a lot has been done to promote it in South Africa, very little research has been done to evaluate the actual effects of such programmes.

The search was initially done with the emphasis on the concepts of *understanding* and *engineering* specifically because the TK programme intended to create and promote PUSET with the main emphasis on engineering since the programme was an initiative of the faculties of engineering of UP and TUT to recruit students to study engineering. This search yielded no information and therefore it was then decided to broaden the scope of the search looking for research done on the evaluation of the effects of S&T programmes on PUSET. This included research done with regard to the effects of S&T centres; science centres; science museums; and science shows.
Once again the results of the literature search suggested that very little research regarding the evaluation of the effects of PUSET programmes was conducted in South Africa.

Hughes (2002, p. 1) of the Foundation for Education, Science and Technology (FEST), suggested that there is a lack of knowledge of and capacity in evaluation processes, scope and objectives, articulating relevant questions, selecting evaluators, writing terms of reference, effective ways of planning and monitoring evaluation in general in South Africa with regard to PUSET especially. This may be the reason why there is very little research on evaluation done in South Africa.

Hughes (2002, pp. 1, 6) stated that evaluations done by the Science and Society Directorate of the Department of Science and Technology in South Africa have focused largely on *project success and public and stakeholder opinion* of the event/activity, with little emphasis on the level of *public understanding* of science as a result of the science event, and the effect of individual projects on public perceptions.

Another important issue is that although evaluations can be a useful tool, it should be used with discretion so that the benefits outweigh the costs. Hughes (2002) suggested that in order to increase the cost-benefit ratio, a lot more thought should be given to how the results of evaluations were used for improvement and disseminated for broader benefit. As mentioned in chapter 1 of this study, it is foreseen that this study could contribute towards the knowledge of evaluation of the effects; the design, successful planning and implementation of similar PUSET programmes elsewhere.

The fact that not much research on the evaluation of S&T programmes has been done in South Africa was confirmed by Howie (1999, p. 72) reporting that none of the science and technology centres visited during a survey on science and technology centres in South Africa, appeared to have been externally evaluated. Furthermore, the majority of the delegates at the science and technology centres stakeholder workshop expressed a desire to have their centres evaluated in terms of added value for their visitors and for purposes of funding.

It has been determined during personal visits to and discussions with the managers of the TK programme, the MTN Sciencentre in Cape Town, the Discovery Science Centre, UP-with Science, TRAC, and Teachers' Outreach Workshops at the University of Pretoria, that apart from keeping records of the number of learners and schools who visited the centres no other evaluation of their actual effects on Public Understanding of Science, Engineering and Technology has been done. All these managers expressed the need for evaluation of effects rather than just recording the numbers of visitors to the centres (P.C. du Plessis, personal communication, January 28, and February 2, 2003).

Although the search resulted in very few references there was some research that contributed towards the design of this study providing some guidelines with regard to the evaluation of the effects of S&T programmes on PUSET and learners and teachers visiting S&T programmes.

According to Mvalo (2001, p. 3) from Cape Technikon, South Africa, the assessment process to evaluate the impact that the Discovery Centre in Cape Town has on the learning process of learners visiting the centre, includes a short test to determine how much of what the learners had been presented with, had positively affected them; and a questionnaire for teachers to obtain the following information from them: years of teaching experience; years of study in natural sciences; and the highest grade taught. The feedback (recommendations and comments) received from the educators is incorporated in ongoing assessment of the effects of the project. Although evaluation was done in this programme it is not clear what the indicators of success are.

SUNSTEP (Stellenbosch University Schools Technology in Electronics Programme) used a tool called VirtualBook™ to introduce basic electronics to learners in grades 6 to 9. According to Myburgh (n.d., p. 1) Programme Manager, University of Stellenbosch, South Africa, this programme also aims to create an awareness of electronics as a career opportunity.

The similarities between this programme and the TK programme are that it also focuses on communities considered to be disadvantaged; aims to create an awareness of SET careers; and encourages learners to take mathematics and science as subjects at school. However, the outcomes of these objectives have not been evaluated in SUNSTEP.

The effects of the VirtualBook™ programme were evaluated by administering a pre- and post-test for learners to determine what they have learned. It was determined during observation and through questionnaires that the learners found the programme interesting and enjoyable (Myburgh, n.d., p. 6). This research focused more on knowledge than the effects of the programme on PUSET and the visitors.

Dodd (2002, p. 12) of Columbia University, New York, United States of America, concluded as follows on an evaluation done on “Physics on the Move” a mobile science programme focusing on South African schools by a team of the University of the Witwatersrand School of science and technology: the programme was effective; pitched at the right level; very interactive with high retention; and it is important to have young people on the team. He also listed a number of shortcomings: more time should be spent at a given school and with teachers; language issues (example the worksheets used by the learners); and hands-on labs should be simplified. The relevance of these findings to the TK programme lies in the fact that it provided some guidelines for the evaluation of the effects of the TK programme.

The following topics were identified during the literature review as important in evaluating the effects of S&T programmes:

Intended objectives and actual outcomes

Edwards (2002, pp. 5, 6, 8) from The Open University, said that getting people to attend an event is not simply enough. It is possible to fill a hall to capacity but if these people are already interested and knowledgeable, does this really help to increase the public awareness of science? According to him the evaluation of the effects of a programme should not rest upon keeping records of how many people visited the programme but on whether it had an effect on the visitors. He further argued that to know whether a programme has been successful you need to establish how well *the objectives are met.* It was also observed by him that very few evaluations have been done by comparing the *intended objectives* with the *actual outcomes*. Although the objectives are mentioned in some cases, of the twenty-two reports of initiatives of public awareness of science he studied, only three of the reports mentioned a considerable number of objectives and made statements of success that related to their listed objectives. As mentioned in chapter 1 of this study the first research question was: How do the intended outcomes of the TK programme compare with the actual outcomes? The intended outcomes of the TK programme were identified and compared with the actual outcomes to determine what the effect of the programme was on PUSET, the learners and teachers who visited the programme.

3.3 CONCLUSION

In conclusion it could be said that the literature review provided clarity with regard to the use of the term Public *Understanding* of Science, Engineering and Technology (PUSET). It was determined that the term is used interchangeably when researchers and programme designers refer to the promotion of *understanding* and/or *awareness* of the importance of PUSET. The difference between PUSET and PASET became clear when the effects of a particular programme are evaluated. It is important to distinguish between the two concepts to determine what the programme actually achieved. The initial focus of this study was on PUSET, but during the interviews with the programme management and the literature review it became clear that the focus should rather be on PASET because the programme focuses more on promoting public awareness than on public understanding of SET.

During the literature review it was determined that previous studies done on PUSET programmes internationally focused more on what the programmes offered and why these programmes were important than on the evaluation of the effects of such programmes. This was also the case with regard to research conducted in South Africa.

The search was initially focused on research done on the evaluation of PUSET programmes but it did not result in adequate information. The search was then broadened to evaluation of science and technology (S&T) programmes which also resulted in very few references. The search was then broadened again to research done with regard to the evaluation of science programmes only.

The search was broadened to research conducted on the evaluation of science and technology (S&T) programmes instead of science, engineering and technology (SET) programmes. This still resulted in very few references. The search was then broadened again to research done with regard to science programmes only. The lack of relevant research on the evaluation of the effects of S&T programmes was confirmed by Brossard et al. (2005, p. 1100) who reported in their article *Scientific knowledge and attitude change: The impact of a citizen science project* that though various evaluations of the effects of informal science projects on scientific knowledge and attitudes toward science have been published most literature is devoted to learning in the context of science museums.

Although very few of the researchers specifically focused on the evaluation of the effects of science programmes they identified certain factors that play an important role in a successful visit to a science programme. The following were highlighted:

(a) the use of and the nature of hands-on exhibits (Rennie and McClafferty, 1996),

(b) the ambiance of the centre (Rennie and McClafferty, 1996),

(c) the important role of teacher involvement (Bowker, 2000),

(d) the entertainment or edutainment factor (Bowker, 2000),

(d) the strategies used with the implementation of the programmes (Bowker, 2000),

(e) the inclusion of teachers in the evaluation of a programme (Stocklmayer, 2003), and

(f) the importance of linking the visit to the school curriculum (Bowker, 2002).

The findings of the research discussed above identified several outcomes or effects on visitors to science programmes and the important role these programmes play. The value of the literature study was that it indicated certain crucial factors that play a role in the design and planning of S&T programmes to ensure success. These factors included: the use of hands-on exhibits; the ambience of the centre; the important role of teacher (facilitator) involvement; the entertainment (fun) factor; and the strategies used with the implementation of the programmes. The review suggested that visitors gain knowledge during visits and that their attitudes towards science changed positively.

Although some valuable information was obtained from the literature review, the review still did not specifically provide specific guidelines to evaluate the effects of S&T programmes on PUSET it confirmed that the research questions formulated to evaluate the effects of the TK programme were relevant. The literature study emphasised the importance of formulating clear objectives and to evaluate how these objectives are met (Edwards, 2002). This information related to the first research question, how do the intended outcomes of the TK programme compare with the actual outcomes? The research conducted by Bowker (2002) as well as Rennie and McClafferty (1996) referred to the process followed in the implementation of a programme as well as the factors that plays an important role in the success of a centre and this information played an important role in answering the second and third research questions namely does the intended process of the TK programme compare with the implemented process and to what extent was it anticipated that the actual input would result in the actual process?

The contribution of this study is that it aimed to determine what effect the TK programme has on learners and teachers in schools particularly in a developing context that are considered to be disadvantaged who visit the program and to what extent this created an understanding of SET. The uniqueness of this research lies in the fact that engineering was included as a field of study since the main objective of the TK programme was to promote the career of engineering and encourage learners to enrol for engineering studies at university.

3.4 CONCEPTUAL FRAMEWORK

In this section the conceptual framework for this study which underpins the research will be discussed. A conceptual framework can be defined as a model that allows the researcher to explore the relationships among variables in a logical and prescribed fashion (Anderson, 1990).

To explore the relationships among the variables of the TK programme as formulated in the research questions, that is the intended and actual outcomes; the intended process and the implemented process; and to what extent it was anticipated that the *actual input would result in the actual process, a model was developed (Figure 3.1 below) which represents the relationships of the components of a mobile unit communicating S&T for the purpose of promoting these areas. It is a systemic model exploring the relationships between components categorised into input, process, outcomes and distal outcomes as variables of the TK programme.*

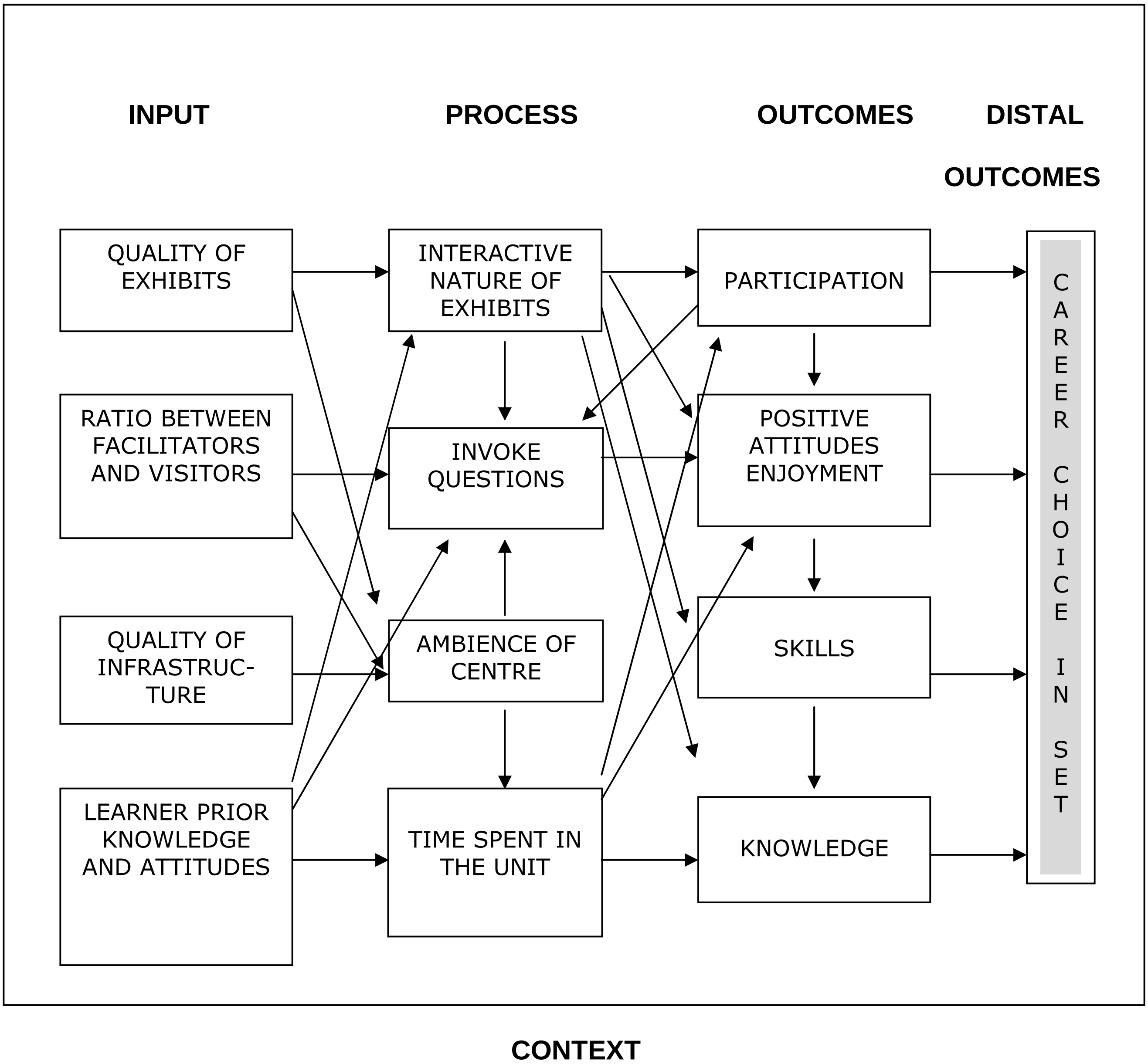

Figure 3.1. The conceptual framework developed for this study

Each of the components of the model is described below within the categories of input, process and output for the model.

CONTEXT

Boddington and Coe (1996, cited in Hughes 2002, p. 2) identified a series of questions that should be explored within a public understanding of science evaluation. One of the questions that should be asked is who the *audience* is. Perry (1993, cited in Rennie and McClafferty, 1996, p. 63) described a successful visit to a science museum as one in which *the visitor's agenda* is met (that is to have a good time). This emphasizes the important role that the *characteristics and background* of the target group (the learners and teachers who visit the programme) play in a successful visit.

INPUT

The *quality of exhibits* used in the programme needs to meet certain standards such as relevancy to what the visitors learn and teach at school, it must be in a good working order and be of an *interactive nature* - visitors must be able to play or interact with the exhibits and explore how it works (Rennie and McClafferty, 1996, p. 58).

Facilitators are employed to explain and demonstrate exhibits to the visitors - this invokes questions from visitors. The facilitators should also be helpful and approachable as this contributes towards the ambience (user-friendly nature) of the centre. With regard to facilitators Bowker (2002, p. 131) suggested that there should be a facilitator-child ration of 1:2 to enhance effective learning and teaching. In some countries facilitators are volunteers consisting of students and even retired former science teachers.

The *quality of the infrastructure* refers to accessibility; space (is there enough space in the unit for visitors to move around freely); does the layout of centre (the exhibits) allow interaction with the exhibits and does it contribute towards the smooth flow of traffic (visitors); and does the quality of the infrastructure contribute towards the ambience (atmosphere) of the centre (Rennie and McClafferty, 1996, p. 85).

Learner prior knowledge plays an important role in enabling visitors to link their existing knowledge to the new knowledge gained during a visit. It enables them to ask more questions and give them confidence to interact with exhibits they may recognise from existing knowledge (Bowker, 2002, pp. 131-132).

PROCESS

The *interactive nature of the exhibits* allows visitors to experiment and participate in the process through exploration of the exhibits. They gain new knowledge, develop skills and a positive attitude while they are enjoying themselves. The interactive nature of the exhibits contributes towards the ambience of the centre in the sense that the visitors can play, enjoy themselves and learn simultaneously (Rennie and McClafferty, 1996, p. 58).

A visit to a centre *invokes questions* from visitors that results in gaining of new knowledge, skills and a positive attitude (Rennie and McClafferty, 1996, p. 85).

The *ambience of the centre* (making it attractive; exciting to visit; user-friendly; and enjoyable) plays an important role in promoting curiosity, and positive attitudes (Rennie and McClafferty, 1996, p. 85).

The length of *time* spent in the centre during a visit contributes towards to effective teaching and learning (Bowker, 2002, pp. 131-133).

OUTCOMES

Visitors' *participation* (interaction with exhibits) leads to positive attitudes, enjoyment, skills development, new knowledge and eventually plays a role in the choice of a SET related career (Rix and Mcsorley, 1999, p. 590).

Positive attitudes of the visitors and *enjoyment* result in gaining new skills and knowledge that will also influence career choice (Rix and Mcsorley, 1999, p. 590).

The visitors develop certain *skills* in handling the exhibits which has an impact on their attitudes and enjoyment as they master the exhibit and may influence their future career choices (Rix and Mcsorley, 1999, p. 591).

More *knowledge* about how things work contributes towards a positive attitude and enjoyment and could eventually play a role in career choice (Rix and Mcsorley, 1999, p. 591).

According to Bowker (2002, p. 131) a successful visit depends on the *prior knowledge* and *attitudes* the learners bring with them. This will *evoke questions* leading to *new knowledge* and a better understanding how to use the interactive exhibits.

DISTAL OUTCOMES

Ultimately the visit may influence the visitors' future *career choice* - because of their participation they may get interested in SET- related careers.

It was determined during the review that there are certain crucial factors that play a vital role in the success of a programme and that there is a definite relationship between these factors. Some of these are discussed in the following paragraphs:

Exhibits of high quality contribute to active participation of visitors and enhance the ambience of the centre. The *interactive nature of exhibits* creates *positive attitudes* and enjoyment amongst visitors that lead to the *gaining of skills and knowledge.* It is extremely important that exhibits should be in an optimal working order as broken exhibits exacerbate visitors' irritation resulting in negative attitudes.

The important role played by *facilitators* should not be underestimated. Competent facilitators not only invoke questions from visitors but also contribute towards the *ambience* of the centre. It is important that there must be enough facilitators to give individual attention to visitors; the ideal is a ratio of 1:2 (Bowker, 2002, p. 131)

The ambience of the centre plays an important role in encouraging *participation,* creating *positive attitudes and enjoyment* amongst visitors. The ambience of the centre is dependent on the quality of the infrastructure of the programme.

Another important factor is the *prior knowledge* of the visitors visiting the programme. This plays a vital role in the way they interact with the exhibits, ask questions and gain knowledge. The length of *time* spent during the visit creates an opportunity to gain skills and knowledge through participation.

3.5 SUMMARY

This chapter focused on the results of the literature review and described and discussed the conceptual framework for this study. With regard to the literature study it could be said that the review resulted in some valuable information but did not provide substantial guidance on how to evaluate the effects of S&T programmes on PUSET or what the effects of similar programmes are on PUSET.

The most influential researchers that informed the development of the conceptual framework were Bowker (2002); Edwards (2002); Rennie and McClafferty (1996); Rix and Mcsorley (1999) and regarding the relationships between the different variables in a programme and Stake (1967) and Stuffelbeam (2000) regarding the development of an evaluation model.

The context of the TK programme differed from the programmes discussed in the literature review in marked ways:

(a) The studies described in the literature review took place in developed countries where some awareness of S&T can be expected. In contrast, the TK programme targeted learners and teachers in a Third World context.

(b) The TK programme focuses very strongly on the creation and promotion of an understanding of not only science and technology but engineering specifically.

(c) It has to provide career guidance, since most of the learners are not exposed to, for example, the career of engineering in their communities or schools.

(d) The main motivation behind the programme is to get more engineering students to enrol at the two institutions.

As no relevant theoretical/conceptual frameworks were uncovered in the literature search, a conceptual framework was developed for this study. This was informed by different authors in the literature review. This model represented an overview of the components of a programme communicating S&T for the purpose of promoting these areas. This was described by means of a systemic model exploring the relationships between input, process, outcomes and distal outcomes as to inform the key variables of the TK programme.

CHAPTER FOUR

RESEARCH DESIGN AND METHODS

4.1 INTRODUCTION

This chapter discusses the research design and the methodology that was applied in this study. The research questions are elaborated upon in section 4.2; in section 4.3 the research design is introduced; the research methods are discussed in section 4.4; the limitations of the study is dealt with in section 4.5; and a conclusion is made in section 4.6.

4.2 RESEARCH QUESTIONS

The *main objective* of this study was to evaluate the effects of the TK Technology Outreach Programme on teachers and learners in secondary schools considered to be disadvantaged and to determine to what extent this programme promoted PUSET (see conceptual framework chapter 3, p. 54).

Research question 1: How do the intended outcomes of the TK programme compare with the actual outcomes?

This question aimed to determine the effects of the TK programme on the promotion of PUSET on teachers and learners; to determine what the intended, actual and unexpected outcomes of the programme were and to compare the intended and actual outcomes. To answer this question the following specific questions were asked:

(a) What did the management intend to achieve with the programme?

(b) What were the intended outcomes and what actual outcomes were achieved?

(c) How did the actual outcomes compare with the intended outcomes?

(d) Were there any unintended outcomes?

Research question 2: How does the intended process of the programme compare with the implemented process?

This question aimed to determine what the intended and implemented processes were and how they compared. In other words what process had been envisaged by the management of TK formally and informally and what transpired when the mobile unit was sent out to schools and the community. To answer this question the following specific questions were asked:

(a) What was the intended process of the TK programme?

(b) What process was actually followed in the implementation of the programme?

(c) How did the intended process compare with the implemented process?

Research question 3: To what extent was it anticipated that the actual input would result in the actual process?

This question aimed to determine what the actual input and the actual processes were, and to what extent the actual input resulted in the actual process. To answer this question the following specific questions were asked:

(a) What was the actual input?

(b) Did the actual input result in the actual process?

4.3 RESEARCH DESIGN

This section presents the research approach adopted in this study to find answers to the three main research questions discussed in section 4.2. Thereafter for each research question a description is provided as to how the question was addressed in terms of the research approach adopted since the purpose of a research design is to provide the most valid and accurate answers possible to research questions (Wiersma, 1995). This study utilized evaluation research methods with the dominant method being a survey.

4.3.1 Theoretical Perspective

The theoretical perspective (philosophical stance) that lies behind the methodology used in the questions in this study is pragmatism. According to Creswell (2002, p. 12) there are many forms of pragmatism and for many of them, knowledge claims arise out of actions, situations, and consequences rather than antecedent conditions. He suggested that in pragmatism the problem is more important than the methods and researchers use all approaches to understand the problem. The problem addressed in this study is to determine the effects of a programme focusing on communicating science to the public using different approaches to collecting and analyzing data.

Creswell (2002, p. 12) stated further that pragmatism provides a basis for the following knowledge claims:

(a) Pragmatism is not committed to any one system of philosophy and reality.

(b) Individual researchers are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes.

(c) Pragmatists do not see the world as an absolute unity. Mixed method researchers look to many approaches to collecting and analyzing data rather than subscribing to only one way.

(d) Truth is what works at the time; it is not based in a strict dualism between the mind and a reality completely independent of the mind. In mixed methods research investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem.

(e) Pragmatist researchers look at the “what” and “how” to research based on its intended consequences – where they want to go with it. Mixed method researchers need to establish a purpose for their “mixing,” a rationale for the reasons why quantitative and qualitative data need to be mixed in the first place.

(f) Pragmatists agree that research always occurs in social, historical, political, and other contexts. Mixed methods studies may include a post-modern turn, a theoretical lens that is reflexive of social justice and political aims.

(g) Cherryholmes (1992, cited in Creswell, 2002) suggested that pragmatists believe that we need to stop asking questions about reality and the laws of nature and Rorty (1983, cited in Creswell, 2002) said that pragmatists would simply like to change the subject.

"Thus for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as to different forms of data collection and analysis in the mixed methods study" (Creswell, 2002, p. 12).

In conclusion it could be said that this study was conducted from a pragmatist stance since it focused on the problem of communicating SET to the public and looked at the "what" and "how" of the TK programme using quantitative and qualitative data to obtain the best understanding of the research problem.

4.3.2 The Evaluation Model of the Study

It is important to differentiate between *evaluation* and *evaluation research*. According to Worthen, Sanders and Fitzpatric (1987, p. 5) evaluation is the identification, clarification, and application of defensible criteria to determine an evaluation object's value (worth or merit), quality, utility, effectiveness, or significance in relation to those criteria. He continues by stating that evaluation uses inquiry and judgments methods, including:

(a) determining standards for judging quality and deciding whether those standards should be relative or absolute,

(b) collecting relevant information, and

(c) applying the standards to determine value, quality, utility, effectiveness, or significance.

According to Worthen et al. (1987, p. 5) evaluation research is a term used by many social scientists to denote any evaluation that employs a rigorous social science research methodology, as opposed to evaluations conducted with other methods. Weiss (1995, p. 4) refers to evaluation research as the utilization of methods of social science research to make the judging process more systematic and accurate rather than relying on the judgements of expert observers or periodic reports from staff.

Weiss (1995, p. 3) said that *evaluation* is an elastic word that stretches to cover judgments of many kinds. What all the uses of the word have in common is the notion of judging merit. The yardsticks used in evaluation can vary widely including amongst others effectiveness and efficiency, enjoyment and satisfaction.

The findings of this research are valuable in the sense that they provide certain criteria and guidelines in the design of the *evaluation* of the TK programme. It emphasized the importance of careful *design* of a programme to ensure that the process will result in the achievement of the intended objectives of a programme.

As mentioned in chapter 2 of this study the overall objective of the TK programme is to promote PUSET and that it became crucial to evaluate the effects of the programme in order to determine whether the overall objective has been achieved.

Stufflebeam (1973) is seen as influential in the field of evaluation as he developed an evaluation framework to serve managers and administrators facing educational decisions and views evaluation as the process of delineating, obtaining, and providing useful information for judging decision alternatives. This framework will realize the purpose of the evaluation of the programme namely to provide management with useful information to assist them to make an informed decision with regard to the termination or re-design of the programme (Worthen et al, 1997, p. 98).

To facilitate the understanding of the problem statement of this study two evaluation models were applied. To facilitate the evaluation and judging of the TK programme Stakes' model, a layout of statements of data to be collected by the evaluator of an educational program (Stake, 1967 cited in Stufflebeam, Madaus and Kellagan, 2000, p. 351) was used (see Figure 4.1 below) because it is more specific than the Context-Input-Process-Product (CIPP) model Figure 4.3 (Stufflebeam, Madaus and Kellaghan, 2000, p. 279).

According to Stake (1967, cited in Stufflebeam, Madaus and Kellaghan, 2000, p. 350) an evaluator usually needs more structure than a set of questions to help him decide what data to collect. He developed a matrix with thirteen information categories where the Rationale, Intents, Observations, Standards and Judgments were evaluated in terms of the antecedents, transactions and outcomes as shown in the diagram in Figure 4.1 (below).

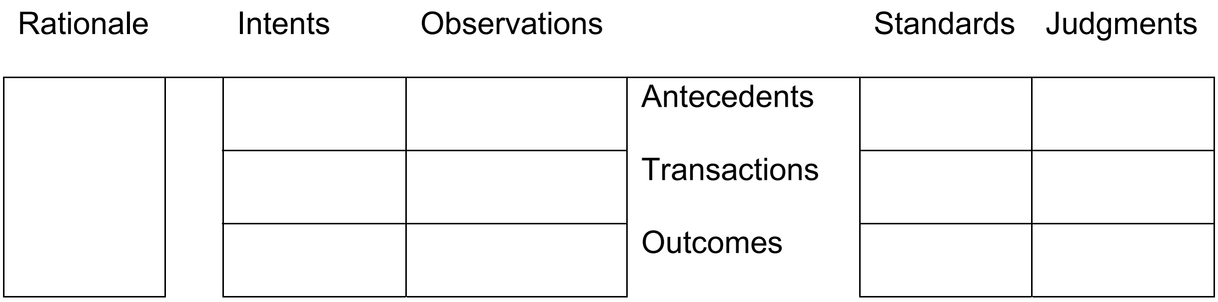

Figure 4.1. A layout of statements of data to be collected by the evaluator of an educational programme (Stake, 1967 cited in Stufflebeam, Madaus and Kellagan, 2000, p. 351)

For different evaluation purposes there will be different emphases on one side of the matrix or the other. In this study an adapted matrix was used that emphasized the side including intents and actual observations (see Table 4.1 below) for guidance to decide what data to gather. Using this matrix, the evaluator compared the information collected regarding the intentions of the TK programme (that is: intents) for the inputs, process and outcomes and for each of these compared it to what was found (that is: the actual) during the research.

	Intents	**Actual**
Inputs	Programme content Budget Human resources	Programme content Budget Human resources
Process	Implementation of the programme Hands-on exhibits	Implementation of the programme Hands-on exhibits
Outcomes	*Overall intended outcome:* The promotion of PUSET amongst learners and teachers *Specific outcomes:* • Expose learners and teachers to the basic concepts of SET • Create awareness amongst learners and teachers of the importance of S&T education • Create interest amongst learners in SET-related careers • Provide learners with information with regard to SET- related careers.	*Outcome:* The promotion of PUSET amongst learners and teachers *Specific outcomes:* • Expose learners and teachers to the basic concepts of SET • Create awareness amongst learners and teachers of the importance of S&T education • Create interest amongst learners in SET-related careers • Provide learners with information with regard to SET-related careers.

Table 4.1. *The adapted matrix for this study*

The CIPP Evaluation Model	
1. Context evaluation	To serve planning decisions. Determining what needs to be addressed by a programme helps in defining objectives for the programme.
2. Input evaluation	To serve structuring decisions. Determining what resources are available, what alternative strategies for the program should be considered, and what plan seems to have the best potential for meeting needs facilitates design of program procedures.
3. Process evaluation	To serve implementing decisions. How well is the plan being implemented? What barriers threaten its success? What revisions are needed? Once these questions are answered, procedures can be monitored, controlled and refined.
4. Product evaluation	To serve recycling decisions. What results were obtained? How well were needs reduced? What should be done with the programme after it has run its course? These questions are important in judging programme attainments.

Table 4.2. *The CIPP Evaluation Model (Worthen et al, 1997. p. 98)*

In the CIPP model mentioned above, *context* evaluations assess needs, problems, and opportunities as bases for defining goals and priorities and judging significance of outcomes. *Input* evaluations assess alternative approaches to meeting needs as a means of planning programmes and allocating resources. *Process* evaluations assess the implementation of plans to guide activities and later to help explain outcomes. *Product* evaluations identify intended and unintended outcomes both to help keep the process on track and determine effectiveness.

Adapted evaluation model

An adapted form of the CIPP evaluation model guided the implementation of this study focusing on the evaluation of the *context, input, process* and *product* of the TK programme (see Figure 4.2 below).

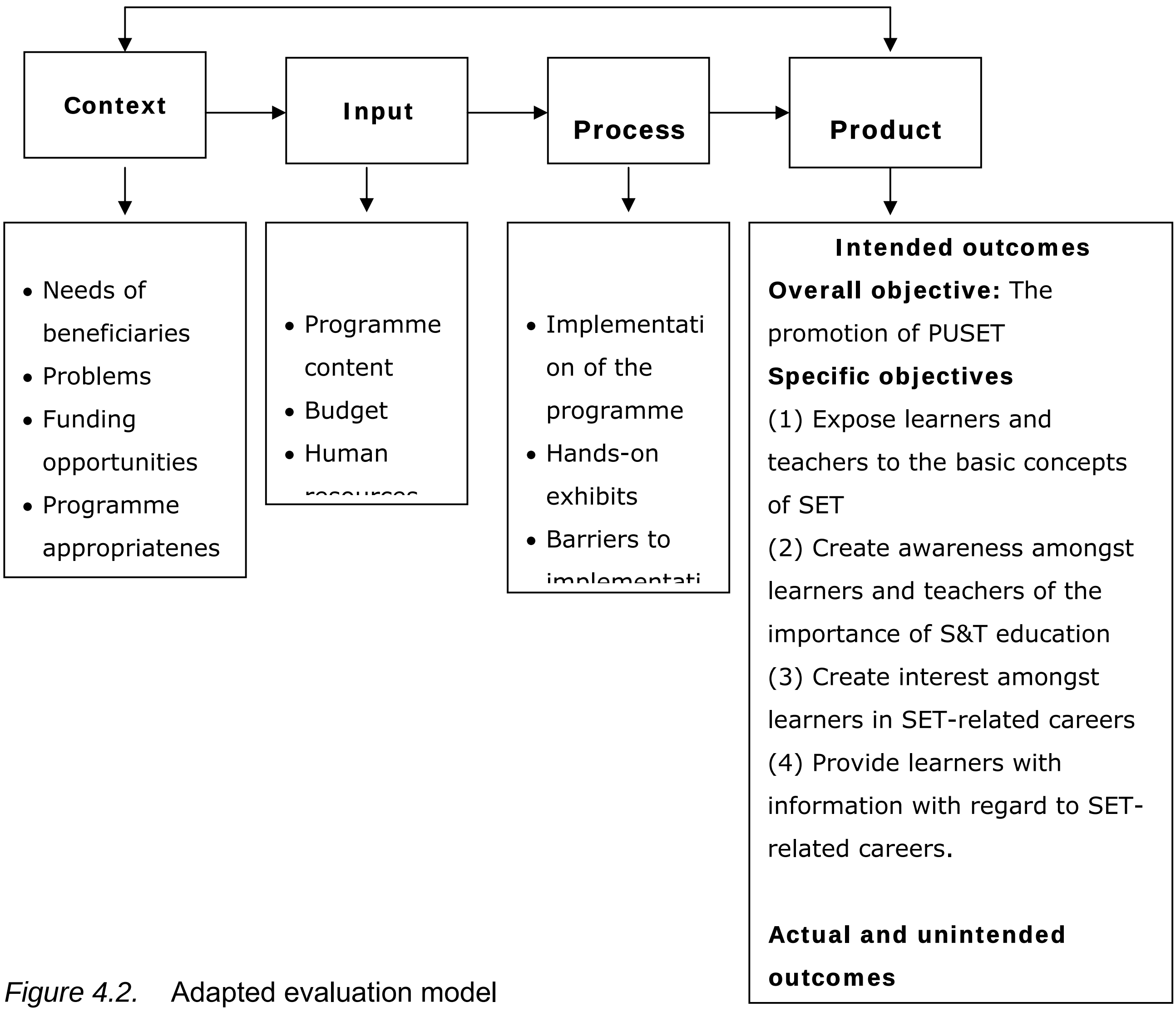

Figure 4.2. Adapted evaluation model

As with the original model, the major components comprised the context, input, process and product. These are elaborated on below.

Context

Context evaluation assesses needs, problems, assets, and opportunities within a defined environment. The *needs* include those things that are necessary or useful for fulfilling a defensible purpose. *Problems* are impediments to overcome in meeting and continuing to meet targeted needs. *Assets* include accessible expertise and services that could be used to help fulfil the targeted purpose. *Opportunities* include, especially funding programmes that might be tapped to support efforts to meet needs and solve associated problems (Stufflebeam et al, 2000. p. 287).

According to the original evaluation model, context evaluation assesses needs, problems, assets, and opportunities. In this study *context* did not include needs, problems and opportunities but only assets and the model was adapted to address the following aspects: (a) the context of the TK programme; and (b) the appropriateness of the programme.

Input

According to Stufflebeam et al. (2000, p. 291) an input evaluation assesses the proposed programme, project, or service strategy and the associated work plan as well as the budget for carrying out the effort.

In this study the evaluation of *input* focused on the programme or service strategy and the associated work plan and budget as in the model. The model was adapted to specifically evaluate the *content* of the programme, the programme activities and application of human resources (how many staff members are involved, their skills, qualifications, experience, and tasks).

Process

A process evaluation is an ongoing check on a plan's implementation plus documentation of the process, including changes in the plan as well as key omissions and/or poor execution of certain procedures (Stufflebeam et al, 2000. p. 294). Process evaluation will provide management with feedback about how efficiently staff is carrying out planned activities. It also helps staff to identify implementation problems and to make needed corrections.

In this research the evaluation of *process* was adapted to focus only on the implementation of the programme and not on the documentation of the process, including changes in the plan as well as key omissions and/or poor execution of certain procedures as in the original model.

Product

Stufflebeam et al. (2000, p. 297) stated that product evaluation is to measure, interpret, and judge achievements.

Evaluation of *product* in this study does not only refer to measuring, interpreting, and judging of achievements, but also the comparison between intended and actual achievements (outcomes). The model was adapted to include evaluating to what extent the programme was effective and how it contributed towards the achievement of the objectives of the programme

The use of questionnaires, semi-structured interviews, document analyses and observations to gather data to answer the following research questions were identified as the most suitable means to collect data in this study:

Research question 1: How do the intended outcomes compare with the actual outcomes?

To answer this question the programme documentation was analyzed and semi-structured interviews with the programme management (including the executive committee and operational manager) were conducted to evaluate the intended outcomes. The advantage of making use of semi-structured interviews was that it allowed for direct contact with the interviewees and the opportunity to use probing questions to obtain pertinent data on the TK programme.

To triangulate and verify the data, data was collected from four sources: programme management; programme documentation; learners; and teachers. The data obtained during the analyzing of the programme documentation, semi-structured interviews, observations and written questionnaires were used to evaluate and compare the intended outcomes of the programme, with the actual outcomes of the programme.

Research question 2: How does the intended process of the programme compare with the implemented process?

To address this question the programme documentation was analyzed; semi-structured interviews with programme management (including the executive committee and operational manager) were conducted to evaluate the intended process. The implemented or actual process was evaluated through the use of written questionnaires to teachers and learners; and observations during on-site visits to the programme.

To triangulate and verify the data, data was collected from five sources: programme management; programme documentation; learners; teachers; and observations. The data obtained during the studying of the programme documentation, semi-structured interviews, written questionnaires and observations were used to compare the intended implementation process of the programme with the implemented or actual process.

Research question 3: To what extent was it anticipated that the actual input would result in the actual process?

The programme documentation was analyzed and semi-structured interviews with programme management (including the executive committee and operational manager) and facilitators were conducted. The actual input and the actual process were evaluated through the analysis of the programme documentation; through the use of semi-structured interviews with facilitators; and observations of the process and visitors during on-site visits to the programme.

To triangulate and verify data, data was collected from four sources: programme management; facilitators; observations; and programme documentation. The data obtained during the analysis of the programme documentation, semi-structured interviews, and observations were used to compare the actual input of the programme with the actual process.

Therefore in summary, the use of questionnaires, semi-structured interviews, observations and document analyses to gather data to answer the research questions were identified as the most suitable means to collect data in this study. The details of the research methods follow in 4.4.

4.4 RESEARCH METHODS

This section describes sampling and participation in the study in 4.4.1, the instruments that were developed in 4.4.2; and the data collection in 4.4.3. The procedures followed in the conducting of the research are presented in 4.4.4; and

4.4.5 discusses the data analysis. In 4.4.6 the validity, reliability and triangulation procedures are discussed, and 4.4.7 pays attention to the ethical concerns.

4.4.1 Sampling and Participants in the Study

The target populations for the study consisted of the following:

(a) the management of the TK programme,

(b) science and/or technology teachers,

(c) learners in grades 8 to 12 in secondary schools that were visited by the TK programme, and

(d) operational staff involved in the programme.

Each of these populations is discussed in terms of the sampling as follows:

(a) Sampling of executive committee members

The first population consisted of the executive committee members (management) of the TK programme representing the two universities (UP and TUT) and the operational staff of the programme (including the operational manager and a facilitator).

Seven of the 10 executive committee members were included in the study. The seven members were selected as follows: one member was selected from UP (this member is the only representative from the University on the TK board), two members from TUT (main campus), and one member from TUT (Soshanguve campus) to represent the universities in the study. These members were selected because they were involved in the initial design of the programme.

One member at senior management level from each of the two foundations (fund-raising divisions) of the two universities was selected because of the fact that the TK programme is dependent on funding obtained from donors by the foundations. The two members are directly involved with the raising of funds for the TK programme and they also represent the existing and potential new donors who provide funding for the programme. It was important during this study to determine what the prerequisites and expectations (expected outcomes) of donors funding the TK programme are because it has a direct effect on the continued existence of the programme. One of the prerequisites of funding is that the programme must be evaluated from time to time to verify that it makes a difference in the lives of the recipients (P. C. du Plessis, personal communication, February 14, 2003). Data was also collected from the operational manager of the programme who is a member of the board but also a facilitator in the programme.

The following criteria were used to select the sample of these members:

- Representatives from each University
- Members who were involved in the design of the initial programme
- Members who are responsible for strategic decision-making and planning
- Members who are responsible for fund-raising for the programme (because they have to sell the product to potential donors)

- Members who are involved in the operational management of the programme

The following individuals were interviewed:

- The chairperson of the TK board who is also the head of the department of civil engineering and biosystems at UP
- The vice-chairperson of the board who is also the executive director of strategic planning at TUT
- The executive director of the foundation of TUT responsible for fund-raising for the programme
- A senior fund-raiser from the UP
- Two senior lecturers from the faculties of engineering of TUT
- The operational manager of the TK programme

The main reasons for the selection of these members is the fact that they had been involved in the programme since the beginning and had first-hand knowledge of the programme and what was envisaged. They were also responsible for strategic planning, policy and decision-making.

Data was collected from the two facilitators who are responsible for demonstrations and explanations to teachers and learners during the visits of the TK programme to schools, career shows and open days.

(b) Sampling of schools

Data was collected from teachers and learners from four secondary schools visited by the unit over a period of one year. The average number of schools visited by the programme in a year is approximately 10 and therefore the five selected schools represented 50% of the schools visited during the period 2003-2004 (that is one year).

The following criteria were used to select the sample of these schools:

- The schools must have been visited by the TK programme during the period June 2003 to August 2004.
- The schools had to be close to Pretoria due to cost and time constraints since the questionnaires were administered personally.

The following five schools were selected initially:[1]

1. Vusi High School: visited by the programme in June 2003 (this school withdrew from the research at a very late stage).
2. Matlala College: visited by the programme in June 2003.
3. Jabulani High School: visited by the programme in February 2004.
4. Radebe High School: visited by the programme in June 2004.
5. Botshelo Technical High School: visited by the programme in August 2004.

(The first school withdrew but the last four schools participated in the research).

[1] The names of the schools were changed for confidentiality reasons

The schools are situated in and around Pretoria (Gauteng) in urban and semi-urban (township) areas. Three of the schools are situated in predominantly African townships and the fourth school (a private college) is situated in a suburb of Pretoria but is attended by learners from the adjacent African township. It was important for the research to administer the same questionnaires to different groups of learners to determine consistently what the long-term effects of the programme were. The first group was questioned during their visit to the programme, the second group was questioned six months after their visit to the programme and the third group a year after their visit to the TK programme.

(c) Sampling of teachers

The sampling of teachers and learners was done with the assistance of the principals of the four schools.

The sampling of teachers was done within practical constraints such as the availability of teachers, availability of classes and limited time allowed at the schools. Teachers who taught science and/or technology for grades 8-12 and who were available at the specific time of the visit were selected. Principals also assisted with the selection of the teachers. The seven teachers who participated in this study were also selected because of the fact that they visited the programme with the learners.

The following criteria were used to select the sample of teachers:

- The teachers must teach science and/or technology at school for grades 8-12
- Teachers must have visited the TK programme with the learners

The number of teachers per school is shown in Table 4.3 below.

Table 4.3 *Number of learners and teachers per school*

School	**Learners**	**Teachers**
Matlala College	79	2
Botshelo Technical High School	120	2
Jabulani High School	217	2
Radebe High School	159	1
Total	**575**	**7**

(d) Sampling of learners

The sampling of learners was done within the practical constraints of the school programme, availability of classes and limited time allowed at the schools. The number of learners per school is shown in Table 4.3 (above) and the number of learners per grade is shown in Table 4.4 (below).

Of the 575 learners who responded 228 were male and 281 were female. Due to missing data only 509 observations could be used to determine the percentage of males and females.

The only criteria used to select the sample of learners was that it should be learners from grade 8-12 who visited the TK programme at their school.

Table 4.4 *Number of learners per grade*

Grade	Number of learners
Grade 8	100
Grade 9	88
Grade 10	171
Grade 11	152
Grade 12	64
Total	**575**

According to Table 4.4 (above) the number of learners per grade varies. For instance Matlala College has a smaller number of learners per grade because of the fact that it is a private school and the current grade 8 learners (2004) did not visit the unit in 2003. Learners in grades 11 and 12 at Botshelo Technical High School did not visit the unit when the questionnaires were administered, because of the fact that they have seen it before. There was also reluctance amongst senior learners at this school to complete the questionnaire. At Jabulani High School there was more time to administer the questionnaires and there was full cooperation of everybody involved. The proportion of learners from each participating school is shown in Figure 4.3 (below) and the proportion of learners per grade is shown in Figure 4.4 (below).

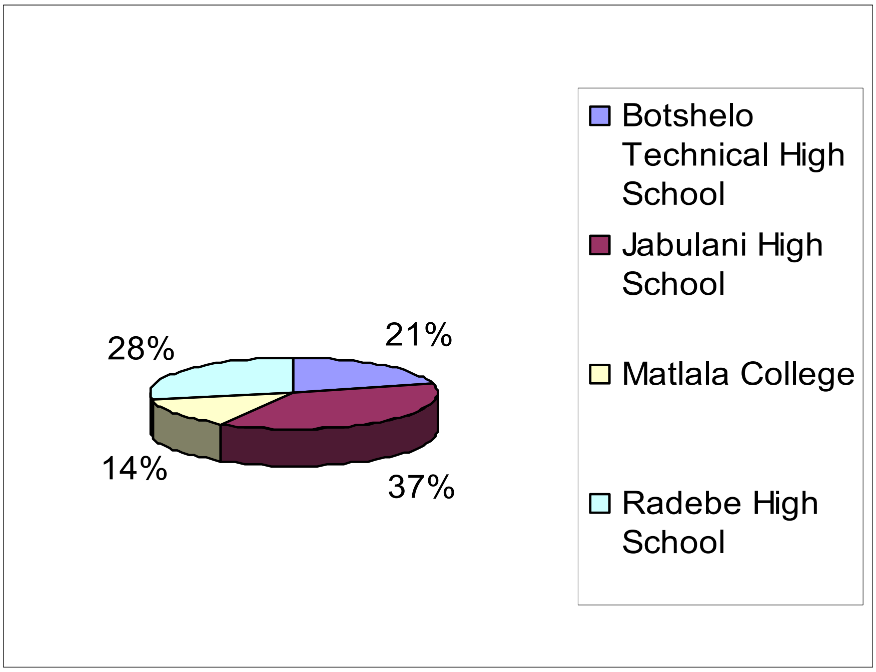

Figure 4.3. The proportion of learners from each participating school

The percentages reflected in Figure 4.3 (above) vary across schools because of the availability of classrooms, the number of learners in the school; learners not participating due to having seen the TK programme previously and the time constraints across all schools.

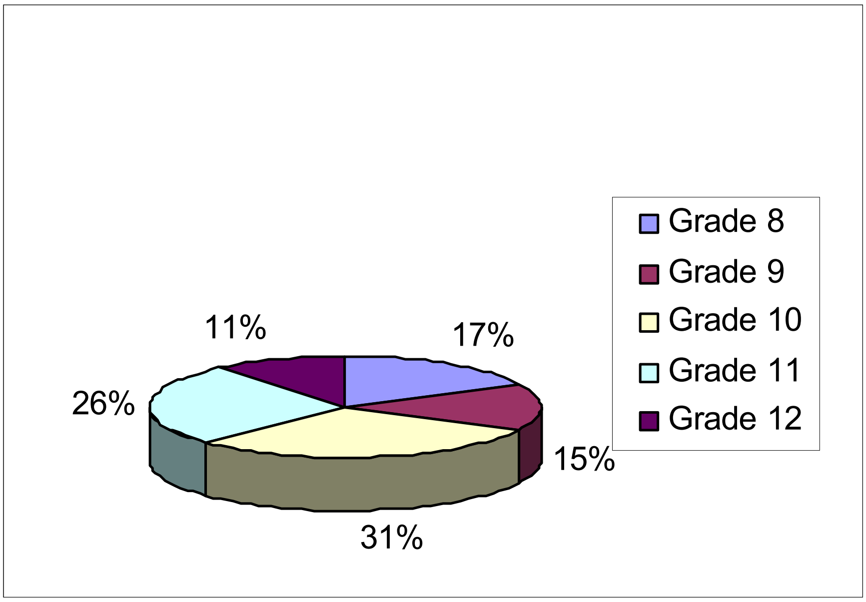

Figure 4.4. The proportion of learners per grade

The percentages reflected in Figure 4.4 (above) vary across grades because of the availability of classrooms at the time of the visit to the school; the number of learners in the school; and the time constraints.

The ages of the learners varied across the whole sample. The youngest learner was 12 years of age and the oldest was 23 years. The mean age of the learners was 16.4 (SD = 1.99). For the purpose of this study, the data on age were categorised for further analysis and ages 12-13 were grouped together; ages 14-17 were grouped together; and ages 18-23 were grouped together. Of the 575 learners, 412 took mathematics as a subject at school; 401 took science and 140 took technology as a subject at school. The low number of learners in technology is due to the fact that only grades 8 and 9 learners take technology as a compulsory learning area according to Curriculum 2005.

4.4.2 Instruments

In this study five sources of data were used and three different instruments were designed to collect data from three different groups of respondents. The data sources included (a) semi-structured interviews for management; (b) questionnaires for learners; (c) questionnaires for teachers; (d) programme documentation; and (e) observations.

Although three different instruments were used to collect data, similar questions were repeated in the different instruments so that the responses of teachers, learners and management could be compared.

(a) Semi-structured interviews with management

Interviews in this study were semi-structured and consisted of open-ended items which allowed for a greater degree of communication during which the interviewees could share their thoughts. In semi-structured interviews “The answers are open-ended, and there is more emphasis on the interviewee elaborating points of interest.” (Denscombe, 1998, p. 113). The interview questions were designed to obtain data from various perspectives that is from the perspective of management as well as from the perspective of operational staff (see Appendix A).

The interview questions were designed to obtain data from management (executive committee members and the operational manager) with regard to the following information: (a) background data of the TK programme; (b) the different role-players in the programme and their expectations; (c) needs analysis that has been done; (d) specific data with regard to the programme (including the overall objective, intended outcomes, input with regard to financial and human resources, infrastructure); (e) the programme content and activities (time schedules, staff involved, process); and (f) previous evaluations.

(b) Questionnaires

Two different questionnaires were administered: one for teachers and one for learners. The questionnaire was identified as the most suitable instrument for learners and teachers given the survey design of this study where a collection of facts and opinions had to be surveyed. The two questionnaires used in this study were designed to focus on opinions as the respondents' attitudes, views and preferences were investigated to determine the effects of the programme.

Questions were formulated in such a way that it was easy to understand. This was important due to the fact that English is the second or third language of the respondents. Both "open" and "closed" questions were used. Open questions were used to invite the respondents to give their opinions and views on their visit to the programme. The majority of the questions in the questionnaire were closed questions.

Questionnaire for teachers

A questionnaire was developed for teachers (see Appendix B). The questionnaire consisted of three sections: personal data; questions about their visit to the TK programme; and their specific opinion on the programme.

The questionnaire included nineteen items with most being closed items. It included questions regarding the following aspects: teachers' exposure to basic concepts of SET during their visit to the TK programme; the representation of the concepts of physical science and technology that they teach at school in the exhibits; awareness of the importance of S&T education at school level; their understanding of the demonstrations and explanations done by the facilitators; the competence and behaviour of the facilitators; and the quality of the exhibits.

Questionnaire for learners

A questionnaire was developed for learners (see Appendix C). The questionnaire consisted of four sections: personal data; questions about their visit to the TK programme; questions about different types of engineers; and their opinion on the programme.

The questionnaire consisted of twenty-six items with most being closed items. It included questions on specific data about the following aspects: the learners' exposure to basic concepts of SET during their visit to the TK programme; the representation of the concepts of physical science and technology they learn at school; the importance of S&T education at school level; their knowledge about SET-related careers; information about further studies; an awareness of the different S&T-related careers; understanding of the demonstrations and explanations; the competence and behaviour of facilitators; the quality of the exhibits; and their interest in S&T-related careers.

Piloting of instruments

The two questionnaires for learners and teachers and the semi-structured interviews with management were piloted to ensure that the wording, sequence of questions and the type of questions used in the instruments were related to the research questions and to the study as a whole. The administration procedures were also tested for example determining how long it would take to complete a questionnaire/interview for planning and scheduling purposes. The piloting was done during an on-site visit to the unit during an open day at TUT and during an interview with the manager of a similar programme.

Upon completion of the piloting process, the instruments were edited and finalized for the main study.

(c) Programme documentation

Programme documentation was a valuable source to obtain background information about the programme. The documents used in this study included: the TK programme's business plan; minutes of management meetings; progress reports to management and donors; and funding proposals to donors. Documentation for analysis was obtained from the management of the programme.

(d) Observations

According to Denscombe (1998, p. 139) observation draws on the direct evidence of the eye to witness events first hand and is based on the premise that, for certain purposes, it is best to observe what actually happens. This method was used because it is the best way to observe and evaluate what actually happens during the implementation of the TK programme. Denscombe (1998, pp. 141-150) distinguished between two types of observation namely systematic observation and participant observation. In this study participant observation done by the researcher was used because it is used by researchers to infiltrate situations to understand the culture and processes of groups being investigated.

Observations were done during a career show (visited by the general public, schools, students, learners, etc.); school visits; and open days (visited by the general public, schools, students, learners, etc.) to observe the behaviour of visitors and the implementation process of the programme.

(e) Field notes

Field notes were made during the observations to record behaviour of visitors and the process followed regarding the implementation of the TK programme.

(f) Evaluation of exhibits

The hands-on exhibits in the unit were evaluated to determine what SET concepts they represent and how these relate to the school curriculum for grades 8 to 12. Science and technology teachers as well as science and technology textbooks for grades 8-12 were consulted to determine what concepts were represented in the hands-on exhibits.

4.4.3 Data Collection

Initially the intention was to have included data from five schools, 10 science/technology teachers and 800 learners. But when the time arrived for the questionnaires to be administered one of the schools indicated at a very late stage that they could not participate in the research. Therefore, only four schools, seven teachers and 575 learners participated in the end. Questionnaires were handed out to learners to complete and taken in under the supervision of the researcher. Some of the questionnaires were mailed to teachers, one teacher did not respond.

Data was collected from seven of the 10 members of the executive committee of the programme as well as from programme documentation. This happened over a period of three months in 2003.

Data was collected from four secondary schools in and around Pretoria over a period of two months in 2004. The TK programme visited these schools as follows: Matlala College, a private school in Eastlynn (suburb of Pretoria next to Mamelodi township) in June 2003; Jabulani High School (Mamelodi township) February 2004; Radebe

High School (Mamelodi township) in June 2004 and Botshelo Technical High School (Atteridgeville township) in August 2004.

Data was collected from seven teachers at four secondary schools through the administering of questionnaires. Eight science/technology teachers (two per school) received questionnaires and only seven returned the questionnaires.

Questionnaires were administered to learners during August/September 2004. It is important to note that questionnaires were administered to learners at Botshelo Technical High School during the visit of the TK programme while questionnaires were administered at the other schools some time after their visit. This was done to determine whether there were any differences between the responses of the schools with regard to longer term effects.

4.4.4 Procedures

The following procedures were followed in conducting the research for this study: a review of the literature for information about programme evaluation, evaluation research, appropriate research methods and the evaluation of PUSET programmes nationally and internationally was conducted.

The literature review informed the design of the research and the methodology that were used. This included the following: deciding what data was needed and how the data will be collected; questionnaires for teachers and learners were developed; the content of the semi-structured interviews was finalized and the interview schedule was planned. The questionnaires for teachers and learners were then piloted during an on-site visit to the programme upon which adaptations were made to the questionnaires. The data from the pilot were then analysed and the modifications made. The final questionnaires were then administered at the selected schools. Semi-structured interviews were conducted with the management and the operational staff of the programme. The programme documentation was obtained from the management of the TK programme and studied. The programme was visited three times during open days at the universities and during a career show to observe the behaviour of visitors and the implementation process.

Raw data from questionnaires, semi-structured interviews, programme documentation and observations were then recorded, captured and processed, analyzed and interpreted.

4.4.5 Data Analysis

The first step in the analysis of the quantitative data from the teacher and learner questionnaires was to apply descriptive statistics including frequency counts, means, and standard deviations. According to Gay and Airasian (2003, p. 413) "descriptive statistics permit the researcher to meaningfully describe many pieces of data with a few indices." Since the survey method was used in this study the data analysis procedure consisted of calculating and interpreting descriptive statistics.

After the descriptive statistics inferential statistics were applied for example analysis of variance and the Scheffes test (a post hoc/multiple comparison test) in order to compare the mean scores of each pair of demographic groups.

Tables and figures were used to summarize the data so that it is presented in a manner that can be more easily interpreted.

The next step was to score and systematically organize data to facilitate data analysis. This process is described as per instrument used in the study in the following sections.

Questionnaire data

The following steps were taken to analyze the data from the closed questions on the questionnaire for learners:

(a) Since self-developed instruments were used in this study scoring was done by another person who independently scored some of the test results as a reliability check. This was done during the piloting of the questionnaires.

(b) Variables were coded and the results were then transferred to summary data sheets on computer using Microsoft Excel.

(c) The alphabetical response codes of the closed questions were converted into numeric response codes.

(d) Data was then imported into SAS (SAS 1999-2001 by SAS Institute Inc. Cary, North Carolina, United States of America). SAS is the preferred programme used by the statistics department of UP.

(e) Descriptive statistics; frequency counts and percentages were calculated for each option of each question.

(f) The scores for the negative questions were reversed so that a mean score could be calculated for each construct.

(g) The mean score for each learner for each construct/label was calculated. The total number of correct answers was done for the question about different types of engineers.

(h) An analysis of variance was done to compare the mean score for the following demographic groups: gender; school; and grade.

(i) Where there were significant differences between the means of the demographic groups it was followed up with the Scheffes test to compare the mean scores of each pair of demographic groups.

(j) The mean scores of each demographic group where then printed out and interpreted.

(k) The next step was to calculate the effect sizes to assist in an objective decision about practical significance. According to Cohen (1988) small effect size may be interpreted as $\eta^2 = 0,01$; medium equals $\eta^2 = 0,06$; and large as $\eta^2 = 0,14$. Medium and large effect sizes were considered of practical significance in this study.

The following steps were taken to analyze the data from the open-ended questions on the questionnaire for learners:

(a) Answers were analyzed and grouped together in related themes. The themes were then assigned numeric codes.

(b) Descriptive statistics; frequency counts and percentages were calculated for each theme for each open-ended question.

(c) Where the respondents had to mention three aspects of the visit to the TK programme that they enjoyed most, the three individual comments were consolidated. Frequency counts and percentages were calculated for each theme for each of the consolidated comments.

With regard to a question about the different types of engineers, the total number of correct answers was calculated.

Semi-structured interviews

Responses to questions asked during the interviews were recorded and analyzed through comparing the content of the responses of each interviewee with one another.

Document analysis

The analysis of documents can be divided into external and internal criticism. External criticism aims to discover whether a document is both genuine (that is not forged) and authentic (that is it is what it purports to be and truthfully reports on its subject) Barzun and Graff (197, p. 85).

In this study programme documentation was analyzed by using the internal criticism method in which the content of the documents was subjected to the following questions:

(a) What kind of document is it?

(b) What does it actually say? What terms are used?

(c) Who produced it?

(d) What was its purpose?

(e) When was it produced?

(f) Is it complete?

This information was then used to obtain background information about the TK programme.

Observations

Field notes were taken during observation of the behaviour of visitors (the general public) visiting the TK programme. Observations were made regarding the implementation process of the programme and analyzed by means of the following:

(a) How do the visitors behave during the visit?

(b) What emotions do they exhibit? (Example enjoyment, excitement, boredom, curiosity, frustration)

(c) What is the sequence of events during a visit?

Hands-on exhibits

The hands-on exhibits in the unit were listed and an education specialist was consulted to determine what SET concepts the exhibits represent and what concepts are taught in the S&T school curriculum for grades 8 to 12. The data was analyzed by comparing the list of concepts to the curriculum to determine to what extent there is a relation between the concepts represented by the hands-on exhibits and the concepts taught in the school curriculum.

4.4.6 Validity, Reliability and Triangulation

This section outlines the validity, reliability and triangulation procedures put in place to ensure that the data obtained from the questionnaires were valid and reliable.

Validity

Content validity requires that the instrument must show that it fairly and comprehensively covers the domain or items that it purports to cover (Cohen et al, 2000). To ensure validity the following measures were taken at different stages:

(a) Design stage

During the design stage of the research an appropriate time scale was chosen; adequate resources for the required research were allocated; an appropriate methodology was chosen for the answering of the research questions ensuring that the reliability levels were appropriate; appropriate instrumentation for gathering the type of data was selected; any ambiguity of instructions, terms and questions was avoided; instruments that will catch the complexity of issues were used; leading questions were avoided; it was ensured that the level of test was appropriate; instruments were not too long or too short through the piloting of the questionnaires;

too many or too few items of each construct were avoided; and an appropriate sample was used.

(b) Data analysis stage

During the data analysis stage respondent validation was used; subjective interpretation of data was avoided; and coding of qualitative data was done carefully.

(c) Data reporting stage

During the data reporting stage the using of data selectively and unrepresentatively (accentuating the positive and neglecting or ignoring the negative) was avoided; claims which are sustainable by the data was made; and it was ensured that the research questions were answered (Gay and Airasian, 2003).

Reliability

According to Cohen et al. (2000) reliability is a synonym for consistence and replicability over time, over instruments and over groups of respondents and is therefore concerned with precision and accuracy.

In order to determine an estimate of internal consistency of the instruments, the Cronbach Alpha was calculated. This measure indicates how all the items on a test relate to all the other items and to the total test score, thereby giving and indication of its internal consistency. The Cronbach Alpha score for all 18 questions in the learner questionnaire was 0.748 which is good. According to Garson (n.d.) the widely-accepted social science cut-off is that alpha should be .70 or higher for a set of items to be considered a scale, but some use .75 or .80 while others are as lenient as .60 which indicates that the Cronbach Alpha score for the questionnaire used in this study is acceptable.

Triangulation

Denzin (1994) distinguished between four basic types of triangulation; two of which have been applied in this study. These include data triangulation, and methodical triangulation*. Data triangulation* involves the use of a variety of data sources in a study and in this particular case these were present in the form of observations, interviews, document analysis and questionnaires. *Methodical triangulation* is the use of multiple methods to study a research problem as discussed in the previous sections of this chapter.

Cohen et al. (2001, p. 112) defined triangulation as the "use of two or more methods of data collection in the study of some aspect of human behaviour." According to Lin (1976, cited in Cohen et al, 2000) triangulation helps to ensure that data generated are not relics of one specific method of collection, by using different methods of data collection that substantially produce the same results.

Data triangulation involves the use of a variety of data sources in a study. In this study questionnaires, document analyses, semi-structured interviews and observations were used to collect data (to answer the research questions).

4.4.7 Ethical Concerns

The guidelines of UP with regard to ethical concerns were applied in the study.

The following principles were applied in this study:

(a) *Voluntary participation* in research, implying that the participants might withdraw from the research at any time.

(b) *Informed consent*, meaning that research participants must at all times be fully informed about the research process and purposes, and must given consent to their participation in the research.

(c) *Privacy,* meaning that the confidentiality and anonymity of human respondents must be protected at all times.

(d) *Trust,* which implies that human respondents will not be respondent to any acts of deception or betrayal in the research process or its published outcomes.

The above mentioned principles were applied in this study as follows: permission was obtained from the principals of schools to administer the questionnaires for learners and teachers in their schools and an undertaking was given that the school will remain anonymous by replacing the name of the school with a fictitious name.

It was also stated on the questionnaires that the motivation for the research is to obtain information that will help to improve the effectiveness and efficiency of the existing programme to the benefit of their school; that the research was operating according to the normal code of ethics and that participation was voluntary; and that the questionnaires were confidential and no one in their school would know what they had written.

4.5 LIMITATIONS OF THE STUDY

Long-term effects on the career choices of learners could not be evaluated because that would involve an investigation into the progress of learners involved in this programme at different tertiary institutions.

A limited number of schools were involved in the study. The reason being that the programme visited a limited number of schools during 2003 and 2004 due to a strategic decision by management to broaden the scope and include more science shows, career expos and open days at tertiary institutions in order to reach more learners.

With regard to the type of schools only urban, semi-urban, state/private schools were included in the study and no rural schools were involved.

A small number of teachers were involved in the research due to the fact that only science and/or technology teachers who visited the programme were questioned.

It is important to note that it was observed in their answers to open-ended questions on the questionnaires that specifically the lower grades (grades 8 and 9) may have experienced difficulties understanding English since it is their second language.

4.6 SUMMARY

This chapter outlined the research design and methodology that was used to undertake this study. Data on the implementation of the TK programme was collected by means of a survey where use was made of questionnaires and individual semi-structured interviews. In summary, this data collection strategy was suitable for the evaluation of the effects of the programme.

The next chapter (chapter 5) presents the findings of the study.

CHAPTER FIVE

FINDINGS OF THE STUDY

5.1 INTRODUCTION

The findings of the study are discussed in this chapter with reference to the research questions derived from the problem statement in chapter 1.

Section 5.2 addresses the first research question and investigates the relationship between the intended outcomes and actual outcomes of the programme. The results of the evaluation of the implementation of the programme with reference to the second research question are discussed in section 5.3. In section 5.4 the relationship between the inputs and the process of the programme related to the third research question is discussed. The chapter culminates with section 5.5 on conclusions.

5.2 THE RELATIONSHIP BETWEEN THE INTENDED OUTCOMES AND THE ACTUAL OUTCOMES OF THE PROGRAMME

This section focuses on the first research question: *How do the intended outcomes of the TK programme compare with the actual outcomes?*

To answer this question the intended outcomes and the actual outcomes of the TK programme were evaluated and compared.

The intended outcomes (objectives) of the TK programme were obtained from the TK programme's business plan (TK business plan. 2003) and during semi-structured interviews with operational staff and executive committee members.

As mentioned in chapter 2 the overall objective of the TK programme is to promote PUSET amongst learners and teachers in secondary schools that are considered to be disadvantaged and the specific objectives (intended outcomes) are to:

(a) expose teachers and learners to the basic concepts of SET,

(b) create and promote awareness amongst teachers and learners of the importance of S&T education at school level,

(c) create an interest amongst learners in SET-related careers, and

(d) provide learners with career information with regard to SET-related careers.

However, it was determined during interviews with the management team that the overall objective and the specific objectives (intended outcomes) of the programme were not clear to everybody involved in the programme and that these were perceived differently. Apart from that it was also determined that the members of the executive committee differed with regard to what they individually saw the main objective of the programme is (P. C. du Plessis, personal communication, February 14, 2003).

Seven executive committee members were interviewed to determine what they expected the intended outcomes of the TK programme should be. One of the members stated:

> *"We need impact not stats!" (Executive committee member, Tshwane University of Technology)*

This comment emphasizes the importance of evaluating the effect of a programme on visitors and not only looking at the numbers of people reached by a programme.

It was pointed out by this member that the programme should link up with the focus of the government namely the promotion of SET for economic growth; it must expose learners to basic concepts to prepare them for further studies and advertise engineering as a career.

Another member emphasized the importance of the innovative competitiveness of South Africa and pointed out that the programme should contribute towards the development of innovative thinking in South Africa (executive committee member, University of Pretoria. 2003).

One committee member expected that the TK programme should recruit quality students to study at the university and create an awareness of SET (executive committee member, Tshwane University of Technology. 2003).

According to the TK Business Plan (2003), the overall objective of the programme is to promote PUSET amongst learners and teachers. However there were divergent views amongst the executive committee members. Although some of the executive committee members interviewed agreed with this, others were convinced that the overall objective is to market the engineering faculties of the two institutions involved; to recruit engineering students; and to prepare learners for study at tertiary institutions based on their concern that students are not prepared for further studies and that very few enroll for engineering studies at the two universities (P. C. du Plessis, personal communication, February 14, 2003). In particular, the chairperson of the board was more concerned about the promotion of PUSET whilst the other members appeared to be more concerned about recruiting students to study engineering at the two institutions.

The following section explores the relationship between each of the intended outcomes and the actual outcomes of the programme.

5.2.1 Exposing teachers and learners to some basic concepts of SET.

To achieve this intended outcome the management of the TK programme planned to equip a trailer (see Figure 5.1 below) with hands-on science and technology exhibits representing some SET concepts (see Figure 5.2 below).

Figure 5.1. The outside of the trailer (TK unit)

Figure 5.2. Some of the hands-on exhibits on display in the TK unit

As the intended outcome of the TK programme was to expose the learners to some basic concepts in SET, it was expected that there would be some kind of design document that outlined what these basic concepts would be, their position in the school curricula and what exhibits would be most appropriate to demonstrate these. However, there was no information available indicating the relationship of the concepts represented by the exhibits to the school curricula, nor whether and how these concepts were taught and learned in school. According to the management of the TK programme the exhibits were initially chosen randomly and not specifically to represent the school curricula although some of the concepts are dealt with in the school curricula as seen in Table 5.1 below (P.C. du Plessis, personal communication, February 20, 2003). It is important to note that technology was not a learning area in secondary schools when the TK programme was designed.

To meet this need for information, a few specific questions were asked to determine to what extent the learners and teachers were exposed to the basic concepts of SET (listed in Table 5.1 below) during their visit to the TK programme. The following questions were asked:

(a) To what extent were teachers and learners exposed to some basic concepts of SET during their visit to the TK programme?

To address this question an evaluation was done of the hands-on exhibits in the unit to determine which SET concepts they represent. In column two of Table 5.1 (below) it is indicated which SET concepts were represented by the hands-on exhibits in the TK programme.

Table 5.1 *The SET concepts represented by the hands-on exhibits in the TK unit*

EXHIBIT	CONCEPT	SUBJECT	SCHOOL CURRICULUM
1 Hand battery	Electrical current flow	Science	grades 9, 11 and 12
2 Corner reflector	Reflection of images in mirrors	-	Not in curriculum
3 Plasma ball and tubes	Electromagnetic waves	Science	grades 11 and 12
4 Interactive pick-up cones	No specific concept	-	Not in curriculum
5 Flame engine	Combustion engine	Technology	Not in curriculum
6 Gearbox model	Mechanical engineering	Science and technology	grade 9
7 Differential gear model	Mechanical engineering	Science and technology	grade 9

Table 5.1 *(continued)*

EXHIBIT	CONCEPT	SUBJECT	SCHOOL CURRICULUM
8 Steering mechanism	Mechanical engineering	Technology	grade 8
9 Tunnel light	Reflection of light	Science	grades 9 and 10
10 Winding radio	Conversion of energy	Science	grades 9, 11 and 12
11 Zoetrope	Persistence of vision	Technology	Not in curriculum
12 Uphill roller	Gravity	Science	grades 11 and 12
13 Floating spindle	Magnetism	Science	Not in curriculum
14 Bernoulli blower	Air pressure	Technology	grade 8
15 Non-round wheels	Effect of different shapes on rolling action	Technology	Not in curriculum
16 Computers	Information technology	Technology	grade 9

Column one of the table is a list of the exhibits in the unit. Column two indicates the concept that the exhibit represents. The third column indicates in which subject the concept is taught at school level and the fourth column indicates in which grade(s) the concept is taught.

In conclusion it could be said that most of the exhibits represented S&T concepts that are taught at school level in grades 8-12 and learners and teachers were exposed to some basic concepts of S&T as depicted in Table 5.1 (above). However, the learners and teachers were not evaluated about the extent to which they recognized these SET concepts nor whether they understood these after the visit.

(b) To what extent did the concepts in the school curriculum correspond with the concepts represented by the hands-on exhibits in the TK programme?

The following textbooks (which are based on the S&T curricula of grades 8-12) were consulted to identify the S&T concepts learned and taught in natural science for grades 8 and 9; physical science for grades 10-12; and technology for grades 8 and 9:

Physical science for grades 11-12: Cräulo, V., Meyer, A., Muller, C., Spies, L. P., Van Harte, G. G., Van Zyl, E. J. (1999). *Physical Science. Grade 11 and 12. New Syllabus.*

Physical science for grade 10 (standard 8): Brink, B. du P., and Jones, R. C. (1993). *Physical Science Standard 8.*

Technology for grade 8. Clitheroe, F., Dilley, G. and Van der Westhuizen, G. (2000). *Dynamic Technology grade 8.*

Technology for grade 9: Barker, K. (2001). *Technology Today: an outcomes-based technology course: Grade 9, Senior Phase, Learners' Handbook.*

Natural science for grade 8: Davis, N., Lightfoot, J., Rijsdijk, C., Robinson, M., and Wood, A. (2001). *Successful Natural Science grade 9. Learners' book.*

Natural science for grade 9: Ayerst, P., Dalton, D., and Khumalo, G. (2000). *Shuters Natural Sciences grade 9. Learners' Handbook.*

It seemed that some of the concepts represented by the hand-on exhibits in the TK programme correspond with concepts dealt with in the curricula as indicated in Table 5.1 (above).

In conclusion it could be said that of the 16 exhibits, concepts reflected by six of the exhibits were not represented in the curricula, concepts in five exhibits were located in the science curricula, concepts in three of the exhibits were found in the technology curricula and two exhibits represented both science and technology concepts from the curricula. Most of the exhibits (63%) represented either science or technology concepts found in the curricula for grades 8-12. It could therefore be said that although it was not the intention of the designers of the TK programme to choose exhibits that will represent the concepts taught in school, it did in the majority of cases.

Data from the questionnaire completed by 575 learners and seven teachers were also analyzed.

Learners were asked to what extent the exhibits in the TK programme were consistent with what they were taught at school in order to ascertain the relevance of the exhibits to the curricula presented at school.

Eighty-three percent of the learners agreed that most of the exhibits in the TK programme represented the concepts they are taught in S&T at school. However, 44% of the learners also reported that it was not clear to them what the exhibits in the TK programme tried to illustrate about S&T.

This apparent contradiction could be attributed to the fact that learners could have linked the science and technology exhibits to science and technology subjects in the broader sense but when it comes to being specific about which concepts are represented by the hands-on exhibits they may not have been able to recognise these. Another possibility may be the fact that they recognized the broader concept but not the specific aspect of the concept being illustrated by the hands-on exhibit such as recognizing the concept of electricity in general, but not static electricity specifically.

It is important to note that the schools who were involved in the research are situated in communities considered to be disadvantaged and that the learners do not have access to the same S&T equipment and have very little exposure to science experiments and equipment displayed in the TK programme. This is largely due to the fact that the schools do not have the resources (funding, facilities or equipment) needed to perform experiments or to illustrate the concepts in the curricula particularly. In many cases the exhibits would have been new to the learners and they might therefore not have been able to recognise which concepts the hands-on exhibits actually represented.

The following comments were made by learners (in response to whether the exhibits represented S&T concepts learned at school) with regard to what they experienced during their visit to the TK programme:

> *"I experienced things I never know (sic) like a radio with no cells or electricity." (Grade 10 learner, age 17, Radebe High School)*

> *"The experience was very good because I learned many things that I didn't know about today's technology." (Grade 10 learner, age 16, Radebe High School)*

> *"It is something different from what we actually learn in the science class and it's interesting." (Grade 11 learner, age 15, Matlala College)*

> *"I have experienced cool things that I have never seen before." (Grade 10 learner, age 16, Matlala College)*

These comments suggest that learners have learned something new and that some had gained some new knowledge. They also indicated that they have never seen the equipment (exhibits) before and that these were different from what they learn at school. Perhaps this could be because of the fact that they attend schools considered to be disadvantaged or because it is not part of the curricula implemented in their classrooms. It is therefore possible that they could not recognise specific concepts represented by the exhibits to link it with what they are taught at school.

The responses of the learners from different schools, grades and gender were compared looking at the mean scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) regarding the relevance of the exhibits to the science and technology curricula. It was. There was no significant difference between males and females Table 5.2 (below) and schools Table 5.3 (below).

Table 5.2 *Relevance of the exhibits to the S&T curricula by gender*

Gender	N	Mean	Std. Deviation
1 (male)	288	2.29	0.63
2 (female)	280	2.20	0.57
Total	568	2.24	0.60

Table 5.3 *Relevance of the exhibits to the S&T curricula by school*

School	N	Mean	Std. Deviation
Botshelo Technical High School	199	2.22	0.62
Jabulani High School	217	2.29	0.54
Matlala College	79	2.37	0.68
Radebe High School	159	2.16	0.63
Total	**574**	**2.25**	**0.61**

Significant differences with regard to the relevance of the exhibits to the S&T curricula were found between grades (Table 5.4 below). Whilst differences were tested between each of all five grades, the only differences were found between learners in grade 8 (2.45) versus those in grade 9 (2.41) and also when learners in grade 11 (2.13) were compared to those in grade 12 (1.99). The effect size was medium (η^2 = .059).

Table 5.4 *The relevance of exhibits to the school curricula by grade*

Grade	N	Mean	Std. Deviation
8	100	2.45	0.59
9	88	2.41	0.55
10	170	2.25	0.58
11	152	2.13	0.64
12	64	1.99	0.51
Total	**574**	**2.25**	**0.61**

These scores (Table 5.4 above) could have been influenced by the fact that not all the learners in grades 10-12 who visited the unit took science as a subject (Table 5.5 below) although all the learners in grades 8 and 9 did. Learners who do not take science as a subject may not have been able to recognise the concepts represented in the school curricula but responded despite this.

Table 5.5 *The number of learners in grades 10-12 that take science as a subject (overleaf)*

Table 5.5 *The number of learners in grades 10-12 that take science as a subject*

Grade	**Total number of learners who visited the unit**	**Science as subject**		**Total number of learners who take science as a subject**	**Percentage that take science**	
		Male	Female		Male	Female
10	171	74	62	136 (80%)	54%	46%
11	152	57	76	133 (88%)	43%	57%
12	64	20	23	43 (67%)	47%	53%

According to Table 5.5 (above) most of the grade 10 and 11 learners (80% and 88% respectively) visiting the unit were found to take science as a subject whilst two-thirds of the visiting grade 12 learners took science as a subject.

Another factor that could have influenced the responses is the fact that learners were questioned in the middle of the school year and they might not have known what the curriculum included for the rest of the year.

It was determined during the curriculum analysis (Table 5.1 above) that 50% of the hands-on exhibits represented concepts that are taught in the grade 8 and 9 curricula at school. This might explain their responses. Thirty-one percent of the exhibits represented concepts in the curricula of grades 10 and 11 and only 25% of the exhibits represented concepts taught in the grade 12 curriculum (electrical current flow; electromagnetic waves; and conversion of energy). This could have contributed to the response of the grade 12 learners to this question. With regard to the latter, only 67% of the grade 12 learners who visited the programme took science as a subject.

The teachers concurred with the learners as 80% of them agreed that some of the exhibits represented what they taught at school. The other 20% said that the exhibits should be more representative of the curriculum. It would help them in their teaching since the schools did not have the resources to equip themselves with such experiments.

The following comment was made by a teacher in the questionnaire with regard to the relevance of the exhibits to the school curricula:

> *"It shows some of the things that we do in the classroom practically." (Grade 9 Teacher, Botshelo Technical High School)*

This statement suggests (at least according to this teacher) that not all the exhibits represent the content of the school curricula in S&T. It also suggests that there is some practical work taking place at schools considered to be disadvantaged.

In conclusion it could be said that the hands-on exhibits in the TK programme appeared to represent some of the basic SET concepts although it was not initially specified or planned by the designers of the programme which concepts they would like to specifically expose the visitors to. Teachers and learners indicated that the S&T concepts they learn/teach at school were represented in the hands-on exhibits but teachers felt in general that exhibits could be more representative of the school curricula. With regard to the concepts in the school curricula corresponding with the concepts represented by the hands-on exhibits in the TK programme it could be said that although the designers of the programme did not specifically had in mind that the exhibits should correspond with the schools curricula they did in some cases. It was determined during the curricula analysis (Table 5.1 above) that 50% of the hands-on exhibits represented concepts that are taught in the grade 8 and 9 S&T curricula at school that may explain their responses. Thirty-one percent of the exhibits represented concepts in the science curricula of grades 10 and 11 and only 25% of the exhibits represented concepts taught in the grade 12 science curriculum. It is important to note that the school curricula cannot include everything about S&T. Therefore programmes such as the TK programme could play a major role in exposing learners to the bigger picture of S&T beyond the curriculum.

5.2.2 Creating awareness amongst teachers and learners of the importance of S&T education at school level.

The following specific questions were asked to determine whether teachers and learners were more aware of the importance of S&T education at school after their visit to the TK programme:

(a) To what extent did the TK programme emphasize the importance of S&T education at school level?

Learners and teachers were asked whether the TK programme emphasized the importance of S&T education at school level.

Of the total number of learners (n=575) 85% responded that the exhibits and demonstrations in the TK programme promoted the importance of S&T education at school.

Six out of the seven teachers who visited the TK programme agreed that the exhibits and demonstrations in the TK programme promoted the importance of S&T education at school.

(b) To what extent did the visit to the TK programme make teachers and learners more aware of the importance of S&T education at school level?

Learners and teachers were asked whether they were more aware of the importance of S&T education at school after their visit to the TK programme than before.

Of the total number of learners (n=575) 91% of the learners felt that they were more aware of the importance of S&T education at school after their visit to the TK programme.

The responses of the learners from different schools, grades and gender were compared looking at the mean scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) regarding the importance of S&T education at school. There was no significant difference between males and females Table 5.6 (below) and schools Table 5.7 (below).

Table 5.6 *The importance of S&T education at school by gender*

Gender	N	Mean	Std. Deviation
1 (male)	288	1.60	0.64
2 (female)	281	1.53	0.65
Total	**569**	**1.57**	**0.64**

Table 5.7 *The importance of S&T education at school by school*

School	N	Mean	Std. Deviation
Botshelo Technical High School	120	1.63	0.63
Jabulani High School	217	1.60	0.66
Matlala College	79	1.76	0.82
Radebe High School	159	1.40	0.48
Total	**575**	**1.57**	**0.65**

Significant differences with regard to the importance of S&T education were found between grades (Table 5.8 below). Whilst differences were tested between each of all five grades, the only differences were found between learners in grade 8 (1.80) versus those in grade 9 (1.75) and also when learners in grade 11 (1.39) were compared to those in grade 12 (1.39). The effect size was medium ($\eta^2 = .062$).

Table 5.8 *The importance of S&T education at school by grade*

Grade	**N**	**Mean**	**Std. Deviation**
8	100	1.80	0.69
9	88	1.75	0.70
10	171	1.58	0.67
11	152	1.39	048
12	64	1.39	0.57
Total	**575**	**1.57**	**0.65**

There seems to be an association between responses regarding the importance of S&T and the grade level (Table 5.8). There is a downward pattern in the mean score from the learners in the lower grades to the learners in the higher grades. Grade 8 and 9 learners seemed to be more aware of the importance of S&T education at school level after their visit to the TK programme. Whilst grade 11 and 12 learners seemed to be the least aware of the importance of S&T education at school level.

These results could be attributed to the fact that grades 8 and 9 learners visited a programme with hands-on exhibits for the first time in their school career and this may have made a big impression on them. This emerged during observations during visits to the unit where it was observed that the younger learners (grades 8 and 9) were much more interested and excited about the visit than the older learners.

Learners were asked what they experienced during their visit to the TK programme and to motivate why they would encourage their friends to visit the programme. They commented as follows:

> *"I experienced that science is the key for jobs (sic)..." (Grade 11 learner, age 17, Radebe High School*

> *"Because it is very interesting and could motivate one to choose engineering as a career." (Grade 12 learner, age 17, Botshelo Technical High School)*

> *"I would advise my friend to visit, so that she could learn (sic) more information about becoming an engineer." (Grade 12 learner, age 18, Jabulani High School)*

> *"Science is the way to go if you want a bright future." (Grade 9 learner, age 15, Matlala College)*

It seems that learners were more aware of the importance of science education upon their visit to the TK programme and they linked it to the possibility to follow a career in engineering and to future jobs.

With regard to the importance of S&T education at school level learners reported as follows:

> *"It makes me understand the importance of science and technology." (Grade 11 learner, age 19, Jabulani High School)*

> *"The Tsebo Koloing bus helped me to notice that science is a very huge step of (sic) education." (Grade 11 learner, age 17, Radebe High School)*

> *"My experience was to understand (sic) physical science and technology of (sic) their importance." (Grade 10 learner, age 16, Jabulani High School)*

> *"Because they will understand the importance of science and technology." (Grade10 learner, age 15, Radebe High School)*

> *"I have learn (sic) how important physical science and technology in my school (sic)." (Grade 11 learner, age 19, Radebe High School)*

> *"My experience to (sic) the Tsebo Koloing bus was good because we learned how science is (sic) important in our everyday lives." (Grade 10 learner, age 15, Botshelo Technical High School)*

> *"Yes because it will encourage them to do (sic) science and technology." (Grade 8 learner, age 14, Botshelo Technical High School)*

"I experience that physical science is very important in future (sic)." (Grade 10 learner, age 16, Radebe High School)

It could be said that learners were more aware of the importance of S&T education upon their visit to the TK programme and that the visit had raised the profile of S&T within the mind of the learners and also enhanced the image of S&T in career terms.

Some of the learners linked the importance of science and technology to daily living. They commented as follows:

"We learned that physical science and technology are important and can be used in our daily life (sic)." (Grade 10 learner, age 15, Radebe High School)

This statement suggests that the learner understands that science and technology is not just something around us but that these could actually be utilized by people in their daily lives. This comment is consistent with the education movement of science and society where there is a constructivist approach to science and technology and teaching children about the relevance of science in their daily lives.

"Because I would like my friend to know that science and technology is important in our lives." (Grade 9 learner, age 14, Matlala College)

"I experience (sic) science is an important factor in our everyday life (sic)." (Grade 12 learner, age 17, Botshelo Technical High School)

According to the above statements some of the learners saw the relationship between what they saw in the programme and daily life.

Six out of the seven teachers who responded felt that their visit to the TK programme made them more aware of the importance of S&T education at school. Only one teacher slightly disagreed.

In conclusion it could be said that when comparing this intended outcome (to create an awareness of the importance of S&T education at school) and the actual outcome, the participants felt that the TK programme emphasized the importance of S&T education at school level and that the programme created an awareness of the importance of S&T education amongst teachers and specifically amongst the younger learners. The above mentioned statements indicate that learners were able to relate science and technology to their daily lives and that they became aware of the importance of these subjects regarding the future.

5.2.3 Creating interest amongst learners in SET-related careers.

The following specific question was asked to determine whether learners are more interested in SET-related careers after their visit to the TK programme:

(a) To what extent was the interest of the learners in SET-related careers stimulated during their visit to the TK programme?

Learners were asked whether their interest in SET-related careers was stimulated during their visit to the TK programme. Ninety percent of the learners indicated that they were more interested in SET-related careers after their visit to the TK programme.

The responses of the learners were analyzed by school, grade and gender looking at the mean scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) regarding their interest in SET-related careers. There was no significant difference between males and females Table 5.9 (below), and schools Table 5.10 (below).

Table 5.9 *Learners' interest in SET-related careers by gender* (overleaf)

Table 5.9 *Learners' interest in SET-related careers by gender*

Gender	N	Mean	Std. Deviation
1 (male)	287	1.53	0.69
2 (female)	281	1.53	0.66
Total	**568**	**1.53**	**0.68**

Table 5.10 *Learners' interest in SET-related careers by school*

School	N	Mean	Std. Deviation
Botshelo Technical High School	120	1.55	0.65
Jabulani High School	217	1.61	0.76
Matlala College	79	1.66	0.67
Radebe High School	158	1.35	0.54
Total	**574**	**1.53**	**0.68**

Significant differences with regard to the learners' interest in SET-related careers were found between grades (Table 5.11 below). Whilst differences were tested between each of all five grades, the only differences were found between learners in grade 8 (1.71) versus those in grade 11 (1.34) and also when learners in grade 9 (1.65) were compared to those in grade 11 (1.34). The effect size was medium (η^2 = .038).

Table 5.11 *Learners' interest in SET-related careers by grade*

Grade	N	Mean	Std. Deviation
8	100	1.71	0.80
9	88	1.65	0.69
10	170	1.54	0.70
11	152	1.34	0.50
12	64	1.55	0.69
Total	**574**	**1.53**	**0.68**

This difference may be attributed to the fact that it was observed during an on-site visit than the younger learners were much more excited and curious during their visit to the programme than the senior learners. This could be explained by the fact that all grade 8 and 9 learners took science whereas, only two-thirds of the older learners took science in grade 12.

Learners were asked in the questionnaires what they experienced during their visit to the TK programme and to motivate whether they would encourage their friends to visit the programme. They commented as follows with regard to engineering as possible career:

> *"It was very interesting because I felt (sic) to be an electrical engineer when I grow up." (Grade 10 learner, age 17, Radebe High School)*

"Because it is very good for choosing a career (sic) and you gain a lot of knowledge, etc." (Grade 8 learner, age 14, Botshelo Technical High School)

"My experience (sic) is how to be an engineer." (Grade 10 learner, age 17, Botshelo Technical High School)

"I am interested in science more (sic) and enjoy it now." (Grade 11 learner, age 17, Matlala College)

"The bus got me more interested in science." (Grade 11 learner, 19, Matlala College)

"Because we get to gain more knowledge about science and also understand about our future careers." (Grade10 learner, age 15, Matlala College)

"I learned more about how science, technology and engineering work hand in hand and how to pursue your dream." (Grade 11 learner, 16, Radebe High School)

"It is a very good place to visit about (sic) different engineers." (Grade 12 learner, age 19, Jabulani High School)

According to the above statements it seems as if learners' interest in SET-related careers was stimulated during their visit to the programme with specific reference to engineering as a possible career. There seems to be an interest in engineering careers although engineering as such was not emphasized in the hand-on exhibits.

It was mentioned by one of the executive committee members that the overall objective of the TK programme is to promote the faculties of engineering at the two universities and encourage learners to apply for science and engineering studies at the university (P. C. du Plessis, personal communication, February 14, 2003). It seems as if this overall objective was achieved in part by the programme.

The possibility that the visit to the TK programme might have had an influence on the visitors' future career choice was not specifically investigated. However, statistics were obtained from UP to determine whether learners from the four schools where the research was done, enrolled for either engineering or science studies. The following statistics (Table 5.12 below) were obtained from the UP:

Table 5.12 *The number of students who enrolled for science and engineering studies at the University of Pretoria (1995; 2000; and 2005) (overleaf)*

Table 5.12 *The number of students who enrolled for science and engineering studies at the University of Pretoria (1995; 2000; and 2005)*

Faculty	**Total number of students for 1995**	**Total number of students for 2000**	**Total number of students for 2005**
Engineering, building environment and IT	4583	6091	7947
Natural and agricultural sciences	2698	3201	5356
Total	**7281**	**9292**	**13303**

There was an increase of seven percent from 1995 to 2000 and an increase of 13% from 2000 to 2005 in the total number of students who enrolled for studies at the faculty of engineering, building environment and IT; and the faculty of natural and agricultural sciences. The number of students who enrolled for natural and agricultural sciences doubled from 1995 to 2005 (see Table 5.12).

Table 5.13 *The number of students from participating schools who enrolled for science and engineering studies at the University of Pretoria between 2001 and 2005*

Faculty	**School**	**2001- 2005**
Engineering, building environment and IT	Matlala College	2
	Jubelani High School	1
	Radebe High School	

Table 5.13 (continue)

Faculty	School	2001- 2005
Natural and agricultural sciences	Jubulani High School	2
	Radebe High School	1

Three learners from participating schools enrolled for studies at the faculty of engineering, building environment and IT and three at the faculty of natural and agricultural sciences between 2001 and 2005. It is suggested that the visit to the TK programme could have influenced a total of six learners to enrol for studies at UP since 2001. The extent to which this can be contributed to the programme is unknown.

In conclusion it could be said that when comparing the intended outcome (to create an interest in SET-related careers) and the actual outcome of the programme this outcome appeared to be achieved to some extent by the programme.

5.2.4 Providing learners with information about SET-related careers

The following specific questions were asked to determine whether learners have obtained information with regard to SET-related careers during their visit to the TK programme:

(a) To what extent did the learners obtain information about admission requirements and application procedures to study in SET-related careers after their visit to the TK programme?

Learners were asked whether they know what the *admission requirements* for further study are, *where to apply* for further study and whether they have a better understanding of which *subjects to take* to study further.

Of the total number of learners (n=575) 79% replied that they knew what the admission requirements for further studies at tertiary education institutions were after their visit to the TK programme and 21% of the learners replied that they didn't know what the *entry requirements* for further studies were. Seventy-two percent of the learners replied that they knew *where and how to apply* for further studies and 28% replied that they didn't know where and how to apply for further studies.

Seventy-eight percent of the learners indicated that they knew *which subjects to take* at school to study engineering and 12% indicated that they didn't know which subjects to take at school to study engineering.

In order to review similarities and differences of the learners the responses of the learners from different schools, grades and gender were compared looking at the mean of the scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) regarding the information about SET-related careers. There was no significant difference between males and females Table 5.14 (below), and grades Table 5.15 (below).

Table 5.14 *Information received by learners about SET-related careers by gender*

Gender	N	Mean	Std. Deviation
1 (male)	287	1.85	0.68
2 (female)	279	1.90	0.73
Total	**566**	**1.88**	**0.71**

Table 5.15 *Information received by learners about SET-related careers by grade*

Grade	N	Mean	Std. Deviation
8	100	1.96	0.82
9	87	1.93	0.68
10	170	1.89	0.65
11	151	1.87	0.73
12	64	1.66	0.62
Total	**572**	**1.88**	**0.71**

Significant differences with regard to the information received by learners about SET-related careers were found between schools (Table 5.16 below). Whilst differences were tested between each of all four schools when compared Matlala College (2.37) differed from Botshelo Technical High School (1.74), Jabulani High School (1.78), and Radebe High School (1.88). The effect size was medium to large effect (η^2 = .080).

Table 5.16 *Information received by learners about SET-related careers by school*

School	N	Mean	Std. Deviation
Botshelo Technical High School	120	1.74	0.66
Jabulani High School	217	1.78	0.67
Matlala College	77	2.37	0.81
Radebe High School	156	1.88	0.61
Total	**572**	**1.88**	**0.71**

According to the mean scores in Table 5.16 (above) the learners from Matlala College appeared to have more information about SET-related careers (2.37). Learners from Botshelo Technical High School appeared to have less information about SET-related careers (1.74). This difference could be attributed to the fact that Matlala College is a private school and that learners might be better informed regarding career guidance.

Learners were asked in open-ended questions what they experienced during their visit to the TK programme and to motivate why they would encourage their friends to visit the programme. The following responses relate to the question whether learners obtained more information regarding SET-related careers:

> *"The importance of engineering in life, and the subjects that you must have when you want to do (sic) engineering." (Grade 12 learner, 18, Jabulani High School)*

"I would advice (sic) my friend to visit, so that she could learn more information about becoming an engineer." (Grade 12 learner, 18, Jabulani High School)

"My experience of (sic) the visit to the Tsebo Koloing bus – I experience (sic) how to apply for further studies in engineering and technology." (Grade 12 learner, 18, Jabulani High School)

"I have learned which subjects to take to qualify and which career to follow." (Grade 11 learner, 18, Radebe High School)

"How to apply for careers of engineering, technology and physical science as well as the differences (sic)." (grade 11 learner, 17, Radebe High School).

"There is a lot to learn about careers and how to get to a tertiary level and work for your future." (Grade 11 learner, 16, Matlala High School)

"It was very nice we learn (sic) things which help us to choose the right career." (Grade 8 learner, 13, Botshelo Technical High School)

"I experience is (sic) I learn (sic) how to become an engineer." (Grade 9 learner, 13, Botshelo Technical High School)

"I was very happy but I didn't find the career that I want to do (chemical engineer)." (Grade 10 learner, 17, Radebe High School)

Learners felt that it was worthwhile to visit the programme and that they would encourage their friends to visit it too because they could gain a lot from it especially with regard to career related information.

(b) To what extent did the learners gain knowledge about SET-related careers during their visit to the TK programme?

To determine what knowledge learners gained by visiting the TK programme learners where asked whether they have a clear understanding of SET-related careers after their visit to the programme. Eighty-seven percent said that they have a clear understanding of SET careers while 13% reported that they did not have a clear understanding of SET-related careers after their visit.

(c) What was the learners' existing knowledge about different types of engineers?

To answer this question the learners were asked to mark the correct ones in the following list of "engineers":

a. Civil engineer
b. Mechanical engineer
c. Psychiatric engineer
d. Electronic engineer
e. Orthopaedic engineer
f. Surgical engineer
g. Chemical engineer
h. Electrical engineer
i. Industrial engineer
j. Aviation engineer

The results are indicated in Figure 5.3 (below).

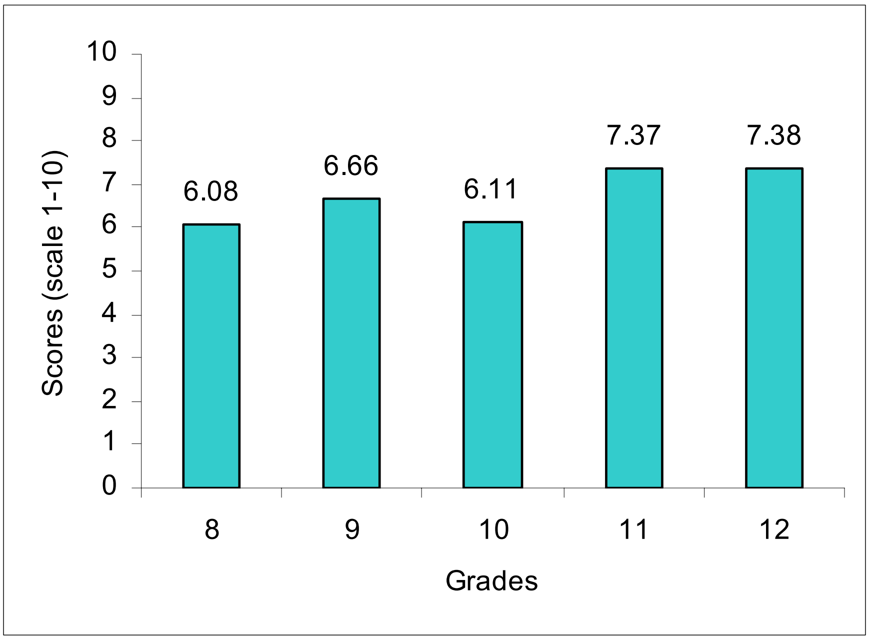

Figure 5.3. The average score out of 10 for the different grades

Figure 5.3 (above) shows that grade 8 learners (as expected) identified the fewest types of engineers (6.08), followed by grade 10 (6.11) and grade 9 (6.66). Grade 12 scored the highest (7.38) followed by grade 11 (7.37). The higher scores of grades 11 and 12 could be attributed to the fact that they have been exposed to career guidance during visits to career shows, open days, and talks delivered at their schools by the two universities' recruitment departments.

In conclusion it could be said that when comparing the intended outcome (*to provide learners with information with regard to SET-related careers)* and the actual outcome this outcome was achieved by the programme. Learners received information about SET-related careers and they were aware of the admission requirements for further study and where and how to apply.

The following questions were asked to *teachers* who visited the programme to determine the specific effects of the TK programme on their learners and their own teaching:

(d) How has the visit to the TK programme affected your learners in their S&T learning?

Two of the teachers reported that learners are more encouraged and interested in S&T at school after their visit to the TK programme. One of the teachers however, felt that the learners were not serious about what they could gain from the visit and reported as follows:

> *"Many went there to play and did not connect this to their learning." (Teacher, Jabulani High School)*

This tendency was also observed during on-site visits. It could be contributed to the fact that the visit to the TK programme was compulsory and not all learners were interested in S&T.

It seemed as if the other four teachers did not interpret this question correctly because their answers were nonsensical.

(e) Did your visit to the TK programme have any effect on your understanding of SET?

Three of the respondents indicated that their visit had a positive effect on their understanding of SET.

> *"Gained more knowledge/understand science much better, cope with classroom situation." (Teacher, Jabulani High School)*

One of the teachers reported that the time spent in the unit was too short.

It could be said that the visit to the TK programme had a positive effect on the teachers regarding their understanding of SET.

5.2.5 Conclusion

When comparing the intended outcomes of the TK programme with the actual outcomes, it could be said that the programme appeared to be successful in that it succeeded in exposing teachers and learners to some basic concepts of SET. Although the designers of the programme did not necessarily chose each hands-on exhibit to represent what learners and teachers learned and taught in the school curricula, it in some cases did. The programme seemed to create and promote awareness amongst teachers and learners of the importance of S&T education at school level. Learners reported being more interested in SET-related careers and were provided with career information with regard to SET-related careers although the planned career lecture for grades 11 and 12 was not presented at the schools involved in the research. Teachers also indicated that the visit to the TK programme had a positive effect on the learners and on themselves regarding the learning and teaching of S&T at school.

5.3 THE RESULTS OF THE EVALUATION OF THE IMPLEMENTATION OF THE PROGRAMME

This section deals with the second research question: *How does the intended process of the programme compare with the implemented process?*

To answer this question the implemented process and the intended process were compared and evaluated. Information with regard to the intended process and the implemented process was obtained from the programme's TK business plan (2003), interviews with operational staff and executive committee members as well as observations during on-site visits.

According to information obtained from the documentation of the programme and interviews with operational staff, the intended process included the following:

(a) arranging of visits at secondary schools, career shows, open days at universities and science expos,

(b) demonstrations and explanations of hands-on exhibits to visitors,

(c) answering of questions from visitors, and

(d) the presentation of a career guidance lecture about SET-related careers to grades 11 and 12 at the schools.

The operational manager of the TK programme explained during an interview that the process followed consisted of the following:

(a) The unit normally stays for five days at one school. According to the manager of the programme it takes about 30 minutes for 25 learners to go through the unit.

(b) Learners in grades 8-12 visit the unit.

(c) In most cases the unit is visited by S&T teachers who visit the unit on their own. (They do not accompany the learners during visits at schools only during science or career shows.)

(d) Teachers do not attend career guidance lectures presented to grades 11 and 12.

(e) Teachers are requested to prepare the learners for the visit explaining to them what the TK programme is all about and what is expected of them during and after the visit.

According to the TK Programme Annual Progress Report (2003) the implementation process was sometimes hampered by practical issues such as time constraints, safe parking of the unit at schools in the townships, vandalism and theft of equipment (exhibits) and instruction cards by learners.

The operational manager indicated that the career guidance lecture was not presented at the four schools involved in this study due to practical problems such as time constraints.

It was observed during an on-site visit at one of the schools that the teachers did not go into the unit with the learners. They merely accompanied them from the classroom to the unit. During this specific visit it was observed that the teachers and facilitators were having casual conversations outside the unit while the learners were in the unit. This resulted in the learners exploring the exhibits on their own having no one to demonstrate or explain the concepts to them which could have an effect on their learning.

The unit was overcrowded most of the time and learners did not have the opportunity to explore each exhibit. Learners tended to get stuck in the computer section (playing games on the computers) and did not want to move on to the rest of the unit. This actually caused conflict amongst some of the learners. There was a problem with the flow of traffic. The unit has two doors and visitors moved in and out both doors causing further obstruction. It was noticed that the doors are not marked with *entrance* and *exit* signs. It was noticed that learners entering into the unit, went randomly to exhibits, in stead of starting at one point and moving through to the exit. This caused serious obstruction to the movement of visitors. This situation affected the availability of facilitators because they could not move around to pay attention to individual learners who needed assistance.

With regard to the instruction cards at each exhibit it was observed that some of the instruction cards were missing, the instructions were not always easy to understand and to follow and the font used for the headings on the cards was difficult to read.

In conclusion it could be said that the intended process resulted in the implemented process although certain factors for example the limited time allowed during visits; the over crowdedness of the unit; and the fact that the career guidance lecture was not presented at the schools could have had a negative effect on the achievement of the intended process.

The following specific questions were asked to determine what the actual process was during the implementation of the programme:

(a) Did the learners understand the concepts demonstrated and explained to them by the facilitators?

Of the total number of learners who responded (n=575) 85% said that the concepts demonstrated and explained to them by facilitators were understandable while nearly a quarter of the learners indicated that the demonstrations and explanations did not make sense to them.

One of the seven teachers did not agree that the facilitators were competent in explaining and demonstrating the different concepts represented by the hands-on exhibits although the rest of the teachers felt that the facilitators were competent.

It could be concluded that the majority of the learners and the teachers agreed that they understood the concepts explained and demonstrated by the facilitators.

(b) What rating would describe their visit to the TK programme best?

Learners were asked *to rate* their *overall experience* during their visit to the TK programme on a scale of 1-5 (“very good”, “good”, “average”, “bad” and “very bad”).

The score points “very good” and “good” were combined as “good” and score points “bad” and “very bad” were combined as “bad”. Ninety-three percent of the learners said that their visit to the TK programme was good; six percent indicated that it was average and 0.6% felt that it was a bad experience.

Most of the learners rated their experience as good. Only a very small percentage of the learners indicated that it was not a good experience. This may relate to the fact that learners did not have enough time to look at all the exhibits; that the unit was too full; and that some of the learners (visitors) did not behave well. This was confirmed during on-site visits by the researcher.

During observations it was noticed that learners enjoyed the challenge to master the games (puzzles, etc. outside the unit), they even challenged one another. It was also observed that the grade 8 and 9 learners were more excited about their visit. They were curious and tended to ask more questions about the exhibits.

The responses of the different schools, grades and gender were compared looking at the mean of the scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) regarding the competence of the facilitators. There was no significant difference between males and females Table 5.17 (below) and schools Table 5.18 (below).

Table 5.17 *The competence of facilitators by learners by gender*

Gender	**N**	**Mean**	**Std. Deviation**
1 (male)	287	1.62	0.58
2 (female)	279	1.60	0.54
Total	**566**	**1.61**	**0.56**

Table 5.18 *The competence of facilitators as rated by learners by school*

School	**N**	**Mean**	Std. Deviation
Botshelo Technical High School	120	1.58	0.54
Jabulani High School	217	1.63	0.63
Matlala College	77	1.81	0.56
Radebe High School	158	1.53	0.47
Total	**572**	**1.61**	**0.57**

Significant differences with regard to the competence of facilitators were found between grades (Table 5.19 below). Whilst differences were tested between each of all five grades, the only differences were found between learners in grade 9 (1.75) versus those in grade 11 (1.46) and also when learners in grade 8 (1.76) were compared to those in grade 11 (1.46). The effect size was small to medium (η^2 = .042).

Table 5.19 *The competence of facilitators as rated by learners by grade*

Grade	N	Mean	Std. Deviation
8	100	1.76	0.66
9	87	1.75	0.56
10	170	1.62	0.59
11	151	1.46	0.45
12	64	1.55	0.51
Total	**572**	**1.61**	**0.57**

It is suggested that the lower grades scored higher because of the fact that they asked more questions and therefore had more personal contact (interaction) with the facilitators, while the higher grades did not have the same interaction because they may be more familiar with the exhibits and concepts and could explore the exhibits more independently.

The following open-ended questions were asked to determine learners' *opinions* of the programme:

(a) What was your experience during your visit to the TK programme?

Table 5.20 *Consolidated comments about the experience of learners during their visit by grade (%)*

Learners' Comments	% of learners
Learned something about S&T specifically	40
Enjoyed it/educational	26
Aware of engineering as a career	8
Learned something about careers	5
Learned something (in general)	20
Understand SET	1
What we learn at school	0.6

According to the statistics in Table 5.20 (above) forty percent (less than half) of the learners indicated that they learned something about S&T specifically during their visit and 20% indicated that the learned something in general. Twenty-seven percent replied that it was enjoyable and educational for them to visit the TK programme. Only eight percent indicated that they were more aware of engineering as a career. It is important to note that only one percent reported that they understood SET better. This underscores the earlier observation that this programme promotes *awareness* of SET more than the *understanding* of it.

(b) Describe three things that you enjoyed about your visit to the TK programme

Take note: The percentages in Table 5.21 (below) refer to the number of comments made not learners. (Total number of comments made: 1247).

Table 5.21 *Consolidated comments about what learners enjoyed during their visit by grade (%)*

	Grades					
Comments made	**8**	**9**	**10**	**11**	**12**	**Total**
The science exhibits	6.42	3.69	10.02	11.07	4.65	35.85
Technology exhibits	3.53	2.41	7.94	5.45	1.92	21.25
The facilitation	0.32	0.32	1.44	2.25	0.40	4.73
Hands-on experience	0.32	0.32	1.04	0.80	0.48	2.97
Condition of the unit	0.00	0.08	0.00	0.08	0.00	0.16
Instruction cards	3.93	3.77	6.82	5.93	3.45	23.90
Music	0.00	0.00	0.24	0.00	0.00	0.24
Everything	0.08	0.00	0.00	0.08	0.08	0.24
S&T and mathematics	0.24	0.24	0.80	0.64	0.16	2.09
Technology interesting	0.40	0.32	0.72	0.80	0.40	2.65
Enjoyed/educational	0.40	0.00	1.04	0.56	0.16	2.17

Table 5.21 *(continued)*

Comments made	8	9	10	11	12	Total
Learned something	0.08	0.00	0.08	0.40	0.00	0.56
Importance of science education	0.08	0.08	0.56	0.08	0.08	0.88
Learned about engineering	0.00	0.16	0.40	0.48	0.16	1.20
Career information	0.08	0.00	0.00	0.72	0.32	1.12
Total	**15.88**	**11.39**	**31.11**	**29.35**	**12.27**	**100**

According to the statistics in Table 5.14 (above) thirty-six percent of the comments made by learners referred to science exhibits and 22% to technology exhibits. It is interesting to note that 24% of the comments were about the instruction cards. This could be contributed to the fact that learners were reliant on the cards for information because facilitators could not assist everybody due to the large numbers of learners visiting the unit simultaneously.

(c) Describe three things that you did not enjoy about your visit to the TK programme

It is important to note that 1247 comments were made by learners about what they enjoyed regarding their visit in comparison with 566 comments about what they did not enjoy during their visit to the programme. This suggests that learners were more positive about their visit and that they found it enjoyable.

Take note: The percentages in Table 5.22 (below) refer to the number of comments made not learners. (Total number of comments made: 566).

Table 5.22 *Consolidated comments about what learners did not enjoy during their visit by grade (%)*

	Grades					
Comments made	**8**	**9**	**10**	**11**	**12**	**Total**
Not enough time	6.18	4.59	9.19	12.37	4.77	37
Lack of space	5.65	3.18	10.42	13.96	4.77	38
The process followed	0.35	0.00	0.00	0.00	0.18	0.5
Other learners' behaviour	0.53	0.18	0.53	1.24	0.88	3
Facilitation	0.35	0.71	1.77	3.18	0.71	7
Broken exhibits	1.41	0.53	1.24	1.77	0.00	5
Outdated exhibits	0.00	0.18	0.88	0.71	0.18	2
Science exhibits	0.53	0.00	0.88	1.24	0.00	3

Table 5.22 *Consolidated comments about what learners did not enjoy during their visit by grade (%) (continued)*

	Grades					
Comments made	**8**	**9**	**10**	**11**	**12**	**Total**
Technology and engineering exhibits	0.53	0.18	0.35	0.53	0.00	2
Did not enjoy it	0.53	0.53	1.06	1.06	0.00	3
Total	**16.08**	**10.07**	**26.33**	**36.04**	**11.48**	**100**

Thirty-seven percent of the comments in Table 5.15, related to the fact that the time allocated to spend in the unit was inadequate and another 38% of the comments referred to the fact that the unit (bus) was overcrowded. Added together 75% of the comments referred to time and space. This problem was also observed during on-site visits. There was a bottleneck with regard to the flow of visitors. Too many learners were in the unit at the same time. It was noted during observation that it was not possible for a learner to attend to each exhibit because of the time limit. They tended to skip some of the exhibits.

Seven percent of the comments indicated that the learners were not happy with the way in which the facilitators acted. This could be because of the fact that there were too many learners and not enough facilitators to pay personal attention to them.

(d) Would you tell your friends that they should visit the TK programme?

Five hundred and five (88%) of the 575 learners who responded, replied that they would recommend a visit to the TK programme to their friends while only two learners said that they would not recommend their friends to visit the programme.

Learners were asked *why* they would recommend a visit to the programme to their friends.

Table 5.23 *Consolidated comments about why learners would recommend a visit to the programme by grade (%)*

Learners' Comments	**% of learners**
They will learn something about S&T	25
Because S&T is important	25
It is enjoyable / educational	37
It represents curriculum	10
They will learn about engineering	3

Twenty-five percent of the learners indicated that they would recommend a visit to the TK programme to their friends because they learned something about S&T (see Table 5.23). Another 25% indicated that they would recommend their friends to visit the programme because S&T is important. Thirty-seven percent reported that they *enjoyed* the visit and found it *educational* therefore they would recommend it to their friends. This comment actually refers to the concept of "edutainment" (a combination of education and entertainment). Only three percent of the learners indicated that their friends will learn something about engineering during a visit to the TK programme. This could be attributed to the fact that the exhibits did not explicitly represent engineering concepts. As mentioned earlier engineering could be defined as the application of science and technology.

Learners were asked why they would *not recommend* it to their friends to visit the TK programme.

Only two learners responded to this question. They respectively said that their friends already visited the programme (they might have been in the same school/class) and that the unit was too full (overcrowded) and smelled very bad which made it uncomfortable.

Teachers were asked what their opinion of the TK programme was. The following specific questions were asked:

(e) Explain how your visit to the TK programme influenced your teaching.

Of the seven teachers who responded, six indicated that their visit to the TK programme had a good (positive) influence on their teaching because they gained more knowledge and understanding of S&T concepts that equipped them to be more effective in their teaching. Only one teacher evaluated the visit as average.

(f) How has the visit to the programme affected your learners in their S&T learning?

Teachers responded as follows to this question:

> *"Learners participate in class because they have seen some of the models and demonstrations." (Teacher, Jabulani High School)*
>
> *"They have gained more interest in science and technology." (Teacher, Boshelo Technical High School)*
>
> *"Encourages the learner to do (sic) science and technology." (Teacher Jabulani High School)*
>
> *"There is a good understanding of concepts and it was very practical." (Teacher Matlala College)*
>
> *"Many went there to play and did not connect this to their learning." (Teacher Jabulani High School)*

It could be said that most of the teachers indicated that the visit had a positive effect on their learners and that the learners were more interested and positive about S&T at school.

The last comment however correlates with some of the learners' comments that some of the learners did not behave themselves well in the unit.

(g) Would you recommend other S&T teachers to visit the programme? Motivate your answer.

All seven of the teachers said that they would recommend it to their colleagues to visit the TK programme for the following reasons:

> *"So that they can see some of the things their learners can do as projects and encourage them." (Teacher, Jabulani High School)*

> *"Those activities were mind provoking (sic), interesting and impressing (sic)." (Teacher, Boshelo Technical High School)*

> *"It is a valuable teaching aid which is very practical." (Teacher, Matlala College)*

> *"Hands on (sic) experiments are good. Equipment is too expensive for schools to purchase." (Teacher, Matlala College)*

> *"To be empowered to develop skills." (Teacher, Jabulani High School)*

In conclusion it could be said that all the teachers indicated that they would recommend it to their colleagues to visit the TK programme because they could benefit from it.

(d) Did your visit to the programme have any effect on your understanding of SET? Motivate your answer.

Teachers responded as follows to this question:

> *"The exhibitions helps (sic) understand how designing a project can be easy. Stimulates your thinking." (Teacher, Jabulani High School)*

> *"I got the understanding (sic) of technology and what it is all about." (Teacher, Boshelo Technical High School)*

> *"Because of all equipment displayed in the unit I was able to understand how technology works." (Teacher, Matlala College)*

> *"Spend too little time (middle of exam)." (Teacher, Matlala College)*

> *"It shows some of the things we do in the classroom practically." (Teacher, Botshelo Technical High School)*

> *"Gained more knowledge / understand science much better cope with classroom situation (sic)." (Teacher, Jabulani High School)*

The majority of the teachers indicated that the visit to the TK programme had a positive effect on their own understanding of SET. Only one teacher disagreed.

In conclusion it could be said that the implemented process compares well with the intended process although certain aspects could be improved upon for example the length of time the learners spent in the unit and the limited space in the unit. The facilitators were competent with regard to the demonstrations and explanations of concepts although many learners did not consult the facilitators because of their availability. It seemed as if the overall experience of the learners and teachers during their visit to the TK programme was positive.

5.4 THE RELATIONSHIP BETWEEN THE INPUTS AND THE PROCESS OF THE PROGRAMME

This section addresses the third research question: *To what extent was it anticipated that the actual input would result in the actual process?*

To answer this question the actual input and the actual process were evaluated and compared. Information with regard to the input into the programme was obtained from the TK programme's business plan and during interviews with operational staff and executive committee members.

Financial resources

Although it was not the intention of this study to analyze the financial aspects of the programme it is important just to mention that funding came mainly from donors and as mentioned in chapter 1 the evaluation of the effect of such programmes became a prerequisite for funding. It became important for the management of the TK programme to decide whether this expense is worth the effects of the programme. This was determined during interviews with the management of the programme who indicated that they are concerned about the high running costs of the programme specifically with reference to transport and maintenance costs (P. C. du Plessis, personal communication, February 20, 2003).

According to the business plans of the programme (TK business plan. 2001, 2002, 2003) the amount budgeted for the implementation of the programme increased from R350 000.00 p.a. to R550 000.00 p.a. (an increase of R200 000.00) over a period of five years.

Human resources

Initially there was only one facilitator. At the time of this evaluation two facilitators were employed. One of them was the operational manager of the programme. They were both qualified science teachers. Only one of the facilitators had teaching experience.

Learners and teachers were asked to rate the *behaviour* of the facilitators. Ninety-one percent of the learners reported that the facilitators were helpful and six of the seven teachers agreed that the facilitators were approachable and helpful. Although the facilitators could not be blamed, it was observed that the facilitators could not cope with the large numbers of learners who visited the unit simultaneously.

Infrastructure

The infrastructure of the TK programme consisted of a big trailer (pulled by a mechanical horse) equipped with S&T hands-on exhibits and games (puzzles). The operational staff had an equipped office from where they operated from.

Learners and teachers were asked to comment about the *quality* of the *exhibits* and the *unit* as a whole. The majority of learners replied that the exhibits were in good working order. However, 28% of the learners said that some of the exhibits were broken. Eighty-six percent of the learners found the written instructions (instruction cards) at the exhibits understandable.

The responses of the different schools, grades and genders were compared looking at the mean of the scores on a Likert scale (the scale details are as follows: A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot recoded as follows: A = 4, B = 3, C = 2, and D = 1) about the quality of the exhibits and the unit. There was no significant difference between males and females Table 5.24 (below) and schools Table 5.25 (below).

Table 5.24 *The quality of exhibits and the TK unit by gender*

Gender	N	Mean	Std. Deviation
1 (male)	287	1.74	0.58
2 (female)	279	1.63	0.54
Total	**566**	**1.69**	**0.56**

Table 5.25 *The quality of exhibits and the TK unit by school*

School	N	Mean	Std. Deviation
Botshelo Technical High School	120	1.69	0.57
Jabulani High School	217	1.66	0.56
Matlala College	77	1.71	0.63
Radebe High School	158	1.72	0.55
Total	**572**	**1.69**	**0.57**

Significant differences with regard to the quality of the exhibits and the TK unit were found between grades (Table 5.26 below). Whilst differences were tested between each of all five grades, the only differences were found between learners in grade 10 (1.81) versus those in grade 11 (1.55) and also when learners in grade 8 (1.72) were compared to those in grade 9 (1.74) and those in grade 12 (1.60). The effect size was small to medium ($\eta^2 = .033$).

Table 5.26 *The quality of the exhibits and the TK unit by grade*

Grade	N	Mean	Std. Deviation
8	100	1.72	.065
9	87	1.74	.056
10	170	1.81	.060
11	151	1.55	.044
12	64	1.60	.053
Total	**572**	**1.69**	**.057**

Grade 10 (1.81) was most impressed with the quality of the programme for no obvious reason followed by grades 8 and 9 (1.72 and 1.74) whilst grade 11 and 12 (1.55 and 1.6) were least impressed (Table 5.26).

All the teachers agreed that the overall quality of the TK programme and the exhibits were good.

In conclusion it could be said that the actual input into the programme resulted in the actual process but that there is a concern with regard to the high maintenance costs and the availability of funding. The majority of learners thought that the overall quality of the TK programme and specifically the quality of the exhibits were of a high standard.

5.5 CONCLUSION

In conclusion it could be said that there is a relation between the intended outcomes and the actual outcomes of the programme. With regard to the first intended outcome *to expose learners and teachers to the basic concepts of SET* it could be said that the hands-on exhibits in the TK programme appeared to represent some of the basic SET concepts. The programme appeared to be successful in that it succeeded in exposing teachers and learners to some basic concepts of SET such as electricity, energy, magnetism, mechanical engineering, gravity, etc. Teachers and learners indicated that the S&T concepts they learned/taught at school were represented in the hands-on exhibits but teachers felt in general that exhibits could be more representative of the school curricula.

When comparing the second intended outcome *to create an awareness of the importance of S&T education at school* with the actual outcome the programme seemed to create and promote awareness amongst teachers and learners of the importance of S&T education.

With regard to the third intended outcome *to provide learners with information with regard to SET-related careers* it appeared that learners received some information about engineering careers and they knew what the admission requirements for further study were and where to study. Learners reported being more interested in SET-related careers.

With regard to the results of the evaluation of the implementation of the programme it could be said that the actual process (implementation) of the TK programme compares well with the planned process although certain aspects could be improved upon such as the flow of traffic through the unit, the length of time spent in the unit, the over crowdedness of the unit, etc. The facilitators were competent with regard to the demonstrations and explanations of concepts. It seems as if the overall experience of the learners and teachers during their visit to the TK programme was positive.

There is a relation between the inputs and the process of the programme because the actual input into the programme resulted in the actual process but there is a concern with regard to the high maintenance costs and the availability of funding.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The main conclusions and overall recommendations of this study are presented and discussed in this chapter. Section 6.2 provides a summary of the key findings of the study in relation with the research questions; some methodological reflections on the findings are dealt with in section 6.3; in section 6.4 the findings are discussed in relationship with the conceptual framework; main conclusions and overall recommendations are made in section 6.5; and section 6.6 summarizes the chapter.

6.2 SUMMARY OF KEY FINDINGS

This section provides a summary of the key findings of the study in relation with the research questions.

The overall objective of this study was to evaluate the effects of the TK programme on the Public Understanding of Science, Engineering and Technology (PUSET) in secondary schools that are considered to be disadvantaged.

The following three research questions were derived from the problem statement discussed in chapter 1 of this study:

(a) How do the intended outcomes of the TK programme compare with the actual outcomes?

(d) How does the intended process of the TK programme compare with the implemented process?

(e) To what extent was it anticipated that the actual input would result in the actual process?

The first research question namely *how the intended outcomes of the TK programme compare with the actual outcomes,* aimed to determine what the intended, actual, and unexpected outcomes of the programme were; and to compare the intended outcomes with the actual outcomes.

It was determined during interviews with the management team of the TK programme that the overall objective and the specific objectives of the programme were not clear to everybody involved in the programme. According to the TK business plan (2003) the overall objective of the programme was to promote PUSET amongst learners and teachers. However, there were divergent views amongst the executive committee members. Although some of the executive committee members interviewed during the research agreed with this overall objective, others were convinced that the overall objective was to market the engineering faculties of the two institutions involved; to recruit engineering students; and to prepare learners for study at tertiary institutions based on their concern that students were not prepared for further studies and that very few enrol for engineering studies at the two universities (P.C. du Plessis, personal communication, 16 May, 2003).

The intended outcomes of the TK programme were to:

(a) expose teachers and learners to the basic concepts of SET,

(b) create and promote awareness amongst teachers and learners of the importance of S&T education at school level,

(c) create an interest amongst learners in SET-related careers, and

(d) provide learners with career information with regard to SET-related careers.

The following is a summary of the key findings of the study in relation with the intended outcomes and actual outcomes.

The first intended outcome of the TK programme was to expose teachers and learners to the basic concepts of SET (see 5.2.1 in chapter 5).

Although it was not initially specified or planned by the designers of the TK programme which SET concepts they would like to expose the visitors to it appeared that the hands-on exhibits in the unit actually represented some of the basic concepts in SET.

With regard to the concepts taught and learned in the school curriculum corresponding with the concepts represented by the hands-on exhibits in the TK programme it could be said that the hands-on exhibits did in some cases represent concepts in the curriculum although the designers of the programme did not specifically have in mind that the exhibits should correspond with the school curricula. It is important to note and perhaps it is self-evident that the school curricula cannot accommodate everything about S&T and therefore programmes such as the TK programme could play a major role in exposing learners to the bigger picture of S&T beyond the curriculum.

The second intended outcome was to create and promote awareness amongst teachers and learners of the importance of S&T education at school level (see 5.2.2 in chapter 5).

The learners and teachers appeared to be more aware of the importance of S&T education at school after their visit to the TK programme and therefore it could be said that the importance of S&T education at school level was emphasized by the TK programme. It also created an awareness of the importance of S&T education amongst teachers and learners.

The third intended outcome was to create an interest amongst learners in SET-related careers (see 5.2.3 in chapter 5).

Most of the learners who visited the TK programme indicated that they were more interested in SET-related careers after their visit to the TK programme and it seems as if interest in SET-related careers was stimulated by the programme. This could also be attributed to the fact that these learners may have had a lack of stimulation due to the fact that they attended schools considered to be disadvantaged and that the visit to the programme opened new career possibilities to them that they were not aware of.

The fourth intended outcome was to provide learners with career information with regard to SET-related careers (see 5.2.4 in chapter 5).

Most of the learners reported that they obtained career information with regard to SET-related careers although the planned career lecture for Grades 11 and 12 was not presented at the schools involved in the research.

In summary, when comparing the intended outcomes of the TK programme with the actual outcomes, the programme appeared to be successful in: (a) exposing teachers and learners to some of the basic concepts of SET and representing some of the concepts in the curriculum in the hands-on exhibits; (b) creating and promoting some awareness amongst teachers and learners of the importance of S&T education at school level; (c) stimulating the interest of most of the learners in SET-related careers; and (d) providing visitors with some information about SET-related careers.

Unintended outcomes

Some of the learners were also able to relate science and technology to their daily lives and they became aware of the importance of these subjects regarding the future. Teachers indicated that the visit to the TK programme had a positive effect on the learners and on them regarding the learning and teaching of S&T at school.

It was also revealed during the research that learners had a lot of fun during their visit to the TK programme. It was observed during visits to the mobile unit in the field that most of the learners really enjoyed their visit to the programme and seemed to have a lot of fun while learning about SET. This emphasized the important role played by edutainment (education through entertainment) in SET programmes although it was not the intention of the TK programme to focus on edutainment as such. The important role that the concept of edutainment play in successful programmes was also highlighted by Rix and Mcsorley (1999) in an investigation into the role that school-based interactive science centres may play in the education of primary-aged children. Their survey highlighted the success of the mini-museum in terms of the children's enjoyment of their visits.

It was noticed from the responses of the learners that they had obtained some information about SET-related careers. This was not expected because of the fact that the intended career lecture was not presented at these schools.

It appears that the TK programme actually created and promoted an *awareness* of SET rather than *understanding* because only one percent of the learners reported that they understood SET better upon their visit to the programme.

The second research question namely *how the intended process of the programme compared with the implemented process,* aimed to determine what the intended and actual processes were and how they compared (see 5.2 in chapter 5).

The TK programme consisted of a mobile unit (truck) equipped with hands-on science, engineering and technology exhibits. The unit was parked at a school during which teachers and learners visited the unit. The facilitators provided information, performed demonstrations and answered questions on an individual basis during visits. The unit also visited open days at the two universities, career shows and science expos where the general public, including prospective students, teachers and learners, visited it (see 2.6 in chapter 2).

In summary it could be said that the implemented process compared well with the intended process although certain aspects could be improved upon for instance the length of time the learners spend in the unit; the limited space in the unit; the logistics (flow of traffic through the unit); and the consistent presentation of the career lecture. The facilitators appeared to be competent because the majority of the learners and the teachers agreed that they understood the concepts explained and demonstrated by the facilitators, although many learners did not consult the facilitators possibly because of the fact that there were only two facilitators (ratio 2:25). It could be that most of the learners were not interested to ask questions that will help them to understand the concepts or that they were not confident enough to pose questions.

It seemed as if the overall experience of the learners who visited the TK programme was positive (see 5.3.2. in chapter 5). Most of the learners rated their experience as good although a small percentage of the learners indicated that it was not a good experience. Possible reasons for the latter were reported as being the fact that learners did not have enough time to look at all the exhibits; that the unit was too full; and that some of the learners (visitors) did not behave well. This was confirmed during on-site visits by the researcher.

During observations it was noticed that learners enjoyed the challenge to master the games (puzzles, etc. outside the unit), they even challenged one another. This once again emphasized the importance of the concept of edutainment mentioned earlier in this chapter. It seemed as if younger learners (Grade 8 and 9) were more receptive than the older learners. It was observed that they were more excited about their visit and that they were curious and tended to ask more questions about the exhibits and they were generally less inhibited than the older learners.

The third research question namely to what extent it was anticipated that the actual input would result in the actual process, *aimed to determine what the actual input and the actual process were, and to what extent the actual input resulted in the actual process.*

The actual input (see 5.4 in chapter 5) of the TK programme included the following:

(a) Financial resources

Although it was not the intention of this study to analyze the financial input of the programme it was determined that the annual running cost of the programme amounts to ±R500 000.00. Since the funding for the programme came mainly from donors it became crucial for the management of the TK programme to evaluate the effects of the programme and decide whether it was worth the financial input.

(b) Human resources

It was determined that two facilitators were responsible for the implementation of the programme of which one was the operational manager of the programme.

The majority of the learners and teachers reported that the facilitators were approachable and helpful. Although the facilitators could not be blamed, it was observed that they could not cope with the large numbers of learners who visited the unit simultaneously.

(c) Infrastructure

The infrastructure of the programme consisted of a big trailer equipped with SET hands-on exhibits and games and an equipped office from where they operated. Learners and teachers agreed that the quality of the programme was of a high standard although it was observed that some of the exhibits were out of order from time to time.

In summary, when comparing the actual input and the actual process, it appeared that it could have been anticipated that the actual input into the TK programme would result in the actual process although there is a concern about high running costs and the sustainability of the programme in the long term due to the lack of consistent funding.

6.3 SOME METHODOLOGICAL REFLECTIONS ON THE FINDINGS

This section reflects on the evaluation model and research methods used in this study.

To facilitate the evaluation and judging of the TK programme Stakes' model, a layout of statements of data to be collected by the evaluator of an educational program (Stake, 1967 cited in Stufflebeam, Madaus and Kellagan, 2000, p. 351) was used as well as the CIPP evaluation model (Stufflebeam, Madaus and Kellaghan, 2000, p. 279) was applied to guide this study. It seemed to be the most suitable model to be used although it had to be adapted for the study because the model focuses on the evaluation of the *context, input, process* and *product* of a programme (see 4.3.2 in chapter 4).

The survey method had been used in this study and to collect data the following instruments were used: Semi-structured interviews with the management of the programme produced valuable data; Questionnaires for learners provided data but on reflection it would have been valuable to conduct semi-structured interviews as well or focus groups with learners. The reason for this is that the reliability of the data collected via the questionnaires may have been influenced by the fact that the questionnaires were in English which is the second and even third language of the learners. It is possible in some cases that learners may have misunderstood the questions and that their answers to open-ended questions in which their opinions were asked could have been misinterpreted as they found it difficult to express themselves in English. A possible solution to this problem could be to translate the questionnaires into their mother tongue but this option is not practical and cost effective due to the many different ethnic languages spoken in one school. The questionnaire for teachers was also written in English. The fact that teachers are more fluent in English made the data more reliable although it would have been useful to conduct semi-structured interviews with the teachers as well. Document analyses and on site observations produced valuable data although the content of the programme documentation were not consistent especially with regard to the different versions of the business plan. One of the schools pulled out of the research at a very late stage and due to time constraints it could not be replaced by another school. However, the four schools who participated provided sufficient data to work with.

6.4 THE FINDINGS IN RELATION TO THE CONCEPTUAL FRAMEWORK

In this section the findings of the study in relation with the conceptual frame work will be discussed (see Figure 3.1, p. 53).

During the evaluation of the programme it was found that there was a definite relationship between the *input, process, outcomes* and *distal outcomes* of a programme. Input includes: the quality of the exhibits, the ratio between facilitators and learners; the quality of the infrastructure, learners' prior knowledge and attitudes. The process includes: the interactive nature of the exhibits, invoke questions, the ambience of centre and the time spend in the unit. The outcomes include: participation, positive attitudes, enjoyment, the gaining of new skills and knowledge. The distal outcomes include career choice in SET.

Exhibits used in a programme should adhere to certain *quality standards* such as relevancy, being in good working order and being of an interactive nature. These standards contribute towards a successful visit according to (Rennie and McClafferty, 1996, p. 58). Except for a few exhibits that were *broken* at the time of the on-site visit, the *overall quality of the exhibits* in the TK programme was good and it adhered to the above mentioned quality standards. The *interactive nature of the exhibits* encouraged the learners to *participate* in the programme and learn more about SET which could lead to the *choosing of a career in SET*.

The *ratio between facilitators and visitors* plays an important role in the success of a programme. According to Bowker (2002, p. 131) facilitators are employed to explain and demonstrate exhibits and *invoke questions* from visitors. A facilitator-visitor ratio of 1:2 may be ideal and enhances effective learning and teaching but may be unrealistic to implement due to funding constraints and the availability of qualified facilitators. The TK programme employed only two facilitators and although they were competent to perform the tasks, it was not possible for them to pay individual (quality) attention to visitors due to the large numbers of learners visiting the unit simultaneously. It was observed however, that the exhibits *invoked questions* from learners because they asked questions regarding the exhibits (about how it works and what it represents) which led to the development of *positive attitudes and enjoyment* during their visit and might have played a role in choosing a SET-related career in future.

The *quality of the infrastructure* refers to accessibility, space and layout. It contributes towards the *ambience of a centre* (Rennie and McClafferty, 1996, p. 58). It was observed during the on-site visits that the flow of traffic through the unit was hampered by the limited space in the unit. The overcrowded nature of the unit seemed to have a negative effect on the *ambience* of the unit and led to the frustration of visitors. It should however be kept in mind that the TK programme is a mobile unit and that space is limited. However, the layout of the unit was attractive and of a high standard in spite of the limited space and it contributed towards the ambience of the unit in the sense that it looked interesting and stimulated the learners' curiosity about *SET-related careers.*

According to Bowker (2002, p. 131) a successful visit depends on the *prior knowledge and attitudes* the learners bring with them. The prior knowledge of the learners had a direct effect on the *length of time* learners spent at an exhibit. It was observed that if the concept was already known to them they moved on to the next exhibit unless the concept was represented or explained in a new way. It was observed that some learners *asked questions* to the facilitators to explain concepts and demonstrate how the exhibit worked which led to obtaining of knew *knowledge* and an interest in *SET-related careers*.

The *interactive nature of the exhibits* in a S&T centre allows visitors to experiment and *participate* and during the process gain new *knowledge,* develop *skills* and a *positive attitude* while they are enjoying themselves. All the exhibits in the TK unit were of an *interactive nature* and this led to active *participation* of the learners in the programme and appeared to result in learners obtaining new *knowledge* and developing *skills*. The interactive nature of exhibits also *invoked questions* from learners because they wanted to know how the exhibit worked. This led to the gaining of new knowledge and the development of skills. This observation confirmed the comment made by Rennie and McClafferty (1996, p. 85) that a visit to a centre *invokes questions* resulting in gaining of new *knowledge* and a *positive attitude* amongst visitors.

Rennie and McClafferty (1996, p. 85) stated that the *ambience* of a centre plays an important role in creating *curiosity,* a *positive attitude* and making it *attractive* and *enjoyable.* The atmosphere in a centre creates the desire in the visitors to *spend more time and ask questions* because they become *curious* about what they see. This contributes to the development of *positive attitudes* towards SET which may eventually lead to choosing a SET-related *career* in future. The layout of the TK mobile unit contributed towards the ambience of the unit.

According to Bowker (2002, p. 131) the length of *time* spent in a centre and the flow of traffic (visitors) lead to effective teaching and learning. It is therefore important to ensure that visitors have enough time and space to explore. It was observed during on site visits to the TK programme that the limited time learners could spend during their visit and the *overcrowded nature* of the unit seemed to be barriers to successful and effective implementation of the programme.

Rix and Mcsorley (1999, p. 590) observed that visitors' *participation* in a programme also leads to the development of *positive attitudes, enjoyment*, *skills* development and obtaining of new *knowledge.* Once visitors gain more *knowledge* about how things work and develop a *positive attitude* it could eventually play a role in *career choice* (Rix and Mcsorley, 1999, p. 590). The overall objective of the TK programme was to promote PUSET amongst learners and teachers in order to motivate them to *choose a career* in the field of SET.

Boddington and Coe (1996, cited in Hughes 2002, p. 2) identified a series of questions that should be explored within a public understanding of science evaluation. Two of the questions identified in their research were as follows: (a) Attitudes - Do you expect your audience's attitudes to science to be changed by the event? (Stronger interest in scientific issues, stronger support for science) and (b) Follow-up - What do you expect your audiences to do after the event? According to the responses of the teachers who participated in this study it seemed that the attitudes of the learners changed after their visit to the TK programme and that they were more interested in S&T at school. It was determined during the study that although it was important for the two universities to encourage learners to enrol for engineering studies with them they did not follow up whether this objective was achieved by the programme.

A visit to a centre may also influence the learners' future career choice. Because of their *participation* in the programme they may get interested in *SET-related careers.* It was determined that eight learners from the schools who participated in the research enrolled for studies at the University of Pretoria for studies in the SET field. The TK programme could have influenced their choice but this research was unable to confirm this.

6.5 MAIN CONCLUSIONS AND OVERALL RECOMMENDATIONS

In this section the main conclusions and overall recommendations are discussed.

Practical implications

(a) The point of departure for a successful outreach programme is a clearly identified need, an overall objective (or mission statement) and measurable intended outcomes.

The overall objective and the intended outcomes of the programme should be clear and well understood by all role-players not only to measure achievement and progress but also to evaluate the effects of the programme on the recipients. The formulation of an overall objective and specific outcomes will only be possible if the needs and expectations of the different role-players such as the business sector, government, schools, society and funders are assessed, defined and understood. These needs and expectations should be kept in mind when a programme is designed, planned and implemented. The management of the TK programme did not conduct a needs assessment therefore, the specific needs of all the role-players involved in the TK programme were not clearly defined which reflected in the uncertainty of what the overall objective and specific outcomes of the programme were.

(b) The implemented process should be evaluated on a continuous basis, resulting in the re-designing and re-planning of the programme and the adjustment of the implementation process.

Some practical problems emerged during the implementation process of the TK programme. It is recommended that the following issues should be attended to. In order to ensure that there is enough space for visitors to move around freely, numbers entering the unit should be limited to a manageable and comfortable number. Over-crowdedness could hamper the process. Logistics should be planned properly to promote the flow of traffic through the centre. For example an entrance and exit route should be designed to prevent visitors causing obstructions. Facilitators should guide visitors and prevent them from getting stuck at a specific exhibit. Another important factor is the time (duration) of the visit. There should be ample time for visitors to interact with each exhibit. In the case of a mobile unit visiting schools and institutions access and parking space should be taken into account. The scheduling of visits should be done carefully taking travelling time and preparation of the unit into account.

(c) The success of the implemented process depends heavily on the input for example quality of the infrastructure, availability of human resources and sufficient funding.

The quality of the infrastructure contributes towards the ambience of the centre which plays an important role in creating curiosity, a positive attitude and making it attractive and enjoyable for the visitors (Rennie and McClafferty, 1996, p. 85). It is important that everything in the centre or unit is in a good working condition and of a high quality. It is also crucial for a mobile unit to have the support of an office where the administration of the programme could be taken care of. Facilitators should be qualified science and technology teachers with teaching experience. According to Bowker (2002, p. 131) the ratio of facilitators to visitors should preferably be 1:2 to enable visitors to ask questions and receive individual attention. This however may not be feasible because of the implication on costs and the availability of qualified facilitators.

(d) The implementation of mobile outreach programmes could play a valuable role in reaching learners and teachers in schools considered to be disadvantaged and who do not have access to S&T centres that are usually situated in towns and cities.

It is however, important to decide in advance whether the content of the programme should focus on the enhancement of the existing S&T school curricula or on enrichment because schools in these areas may not have the means to demonstrate the content of the curriculum and such a programme could play a valuable role in complementing the curricula in this regard. The hands-on exhibits displayed in the TK programme were chosen randomly by the programme designers. Although it was not their intention to ensure that the exhibits are representative of the school curriculum some of the exhibits did represent the school curricula. It is important to decide whether a programme must adhere to (represent) or complement the school curriculum. If it is decided that it should represent concepts taught in the school curricula it is recommended that the relevant curricula be studied and that the content of the programme, for example the hands-on exhibits be chosen to represent the curricula. It is however recommended to follow the complement-the-curricula-route rather than representing the curricula because the overall objective of the programme was to create and promote PUSET and not necessarily to represent the existing curricula. It might also be boring for the learners to see and experience what they have already learned at school. The motivation behind the content should rather be to expose *the visitors* to new information, new experiences and to stimulate their interest in SET-related careers in an exciting and fresh way. This implies sticking to the basic concepts of SET but presenting it in a different way that they can identify with. It is also recommended that fun elements (edutainment) be built into the programme to create enjoyment and excitement. Activities should appeal to all their senses to make it an unforgettable experience. One of the key aspects about the Eden project is that it gives children the 'real' experience of being in a tropical rainforest with all the humidity, sounds and a visual feast of exotic plants (Bowker, 2002, p. 131).

(e) The success of programmes depends on the identification of a specific target group.

The TK programme targeted grade 8-12 learners and S&T teachers in secondary schools situated in communities considered to be disadvantaged but did not conduct a needs analysis to determine the demographic, geographic and psychographic characteristics regarding the target group. Apart from the above a proper study should also be conducted with regard to the target group to identify the following: What are *their* specific needs and not the needs of the scientific world, community or country for more scientists. Boddington and Coe (1996, cited in Hughes 2002, p. 2) identified a series of questions that should be explored within a public understanding of science evaluation. One of the questions that should be asked is who the audience (beneficiaries) is. What excites them? What do they enjoy? What is important for them to know? What skills do they need to develop? According to Perry (1993, cited in Rennie and McClafferty, 1996, p. 63) a successful visit to a science programme is one in which the visitor's agenda is met (that is to have a good time) and also if the visitor learns something new, or becomes more aware of, or interested in, something. It is important to make an informed decision about the age of the target group especially if one of the objectives of the programme is to create an interest in SET-related careers to enable learners to make the right subject choices while they are in the lower grades. The visit to the programme should explain and complement what they already experience in everyday life regarding science and technology concepts. Stocklmayer (2003, p. 232) reported that teachers who visited the Shell Questacon Science Circus in Australia indicated that the image of science was ‘fun, interesting, not just about text books but practical and hands-on’ and ‘it communicated that science is part of everyday life and relevant’.

Policy Implications

When engaging into S&T programmes cognizance should be taken of existing policies for example the government and the institution where the programme is positioned. It is also important to ensure that a policy regarding PUSET initiatives is developed and implemented for such programmes before it is developed and implemented at university (faculty) level. Policies of different role-players (example schools, universities, state departments, private initiatives) should be obtained and studied before the programme is developed to ensure that it is taken into consideration.

Financial implications

As mentioned in chapter 1 there is a need for S&T centres to become financially self-sufficient. Taylor (2003) stated that there is a pronounced need for S&T centres to have a diversified portfolio of financial support to cover the administrative, operational and maintenance costs of these institutions. The impact of the programme on funds should be evaluated in advance and research should be done to determine the availability of funding in the long term. There may also be hidden costs that should be taken into account when programmes are developed to prevent financial crises. For example the maintenance of exhibits and the infrastructure could result in major expenses. Increasingly funders are insisting on evaluation of the impact and the monitoring of programmes - ensure that these activities are planned in advance and included in funding proposals.

Research implications

It was observed during on-site visits and confirmed by the literature (Rennie and McClafferty, 1996, p. 85) that the interactive nature of the exhibits in a centre allows visitors to experiment and participate and during the process gain *new knowledge* and *develop skills*. Although it seemed as if the learners who visited the TK programme gained new knowledge and skills during their visit, it was not scientifically determined what specific new knowledge and skills they obtained and whether they had a better understanding of SET after their visit. This leaves room for more research on the evaluation of knowledge and skills prior to a visit and after a visit to determine whether the visit had an effect on the knowledge and skills of the visitors.

More research should be conducted internationally and in South Africa on the effects of S&T mobile units on PUSET in order to contribute towards: (a) improvement of the effectiveness and efficiency of existing programmes; (b) the design and development of new programmes; and (c) the expansion of existing knowledge and skills within organisations, etc. to enable them to conduct internal evaluation of programmes. This will ensure that the intended outcomes of such programmes result in the actual outcomes and proof that the programme has a measurable impact on PUSET.

6.6 SUMMARY

The importance of this study lies in the fact that it provides insight into and understanding of the role and the effects of a mobile science centre on PUSET within a developing world context. It also shed some light on how to evaluate the effects of S&T programmes on learners and teachers who visited a S&T programme and to what extent the programme created and promoted PUSET.

The main contribution of this study to the body of knowledge for science centres, in particular mobile science centres, was the insight into and understanding of a number of factors (categorised as inputs, process, outcomes) that ultimately had an direct/indirect effect on the promotion of PUSET via a mobile S&T centre as well as the development of a unique conceptual framework applying two evaluation models: a layout of statements of data to be collected by the evaluator of an educational program Stake (1967, cited in Stufflebeam, Madaus and Kellagan, 2000, p. 351) and the CIPP Evaluation Model (Worthen et al, 1997. p. 98) that could guide the evaluation of the effects of S&T programmes (see chapter 4). This framework illustrates the relationships and outcomes of such programmes which have previously not been done. This study emphasized the importance of intensive research and proper planning of outreach programmes with regard to needs assessment; identification of target groups; programme design, programme development and content; as well as programme implementation and evaluation.

Although some valuable information was obtained from this research, there is much scope for further research on how to evaluate the effects of S&T programmes on PUSET.

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APPENDICES

APPENDIX A

SEMI-STRUCTURED INTERVIEWS

SEMI-STRUCTURED INTERVIEW TO OBTAIN BACKGROUND INFORMATION

OF THE TK PROGRAMME

PROGRAMME: ______________________________

NAME OF INTERVIEWEE: ____________________ POSITION: ____________________

CONTACT DETAILS: TEL: ________________________ FAX: ______________________

CELL: ________________________

E-MAIL ADDRESS: ____________________________

DATE OF INTERVIEW: _________________________

A. INTRODUCTION AND FORMALITIES

- Give some background information of interviewer and assignment
- Obtain permission to record the discussion
- Reassurance of confidentiality
- Who else should be interviewed? Where and when?

____

____

- What are your expectations regarding this evaluation? What would you like to achieve? Any specific needs you would like to be addressed?

____

____

____

B. GENERAL INFORMATION

- What is your position and role in the programme?

___

___

- Who else is involved in the programme? Different role-players?

___

___

- When did the programme start?

___

___

- How did it come about?

___

___

- Was a needs analysis done before the establishment of the programme? Results?

___

___

- What are the expectations of your funders and the University?

___

___

C. SPECIFIC INFORMATION REGARDING THE PROGRAMME

Documentation

- Do you have a business or programme plan? Funding proposals? If not, what is the vision, mission, objectives and expected outcomes of the programme?

___

___

- Any other documentation, e.g. minutes, progress reports, brochures, pamphlets.

___

___

Operation

- Where do you operate?

___

___

- What does the programme include? How does it operate? Activities? Methods? When? Frequency?

___

___

- Who is involved?

___

___

Impact of the programme

- Was the programme evaluated before? Do you have any reports?

___

___

- What impact did it have so far? How did you establish it?

___

___

- Do you think the impact can be improved?

___

___

- Do you experience any problems that may have a negative effect on the impact?

___

___

- What is your future vision for the programme? What new ideas do you have?

___

___

D. FINISHING THE INTERVIEW

Any comments/questions/suggestions?

___

___

Process to be followed: on-site visits, interviews, questionnaires, and a final feed back report.

___

___

APPENDIX B

QUESTIONNAIRE FOR TEACHERS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

QUESTIONNAIRE FOR TEACHERS

Teacher ID ……………………..

TSEBO KOLOING TECHNOLOGY OUTREACH PROGRAMME
QUESTIONNAIRE FOR TEACHERS

ABOUT THIS QUESTIONNAIRE

This questionnaire is part of a research project conducted by the University of Pretoria and the Tshwane University of Technology to determine the impact of the Tsebo Koloing Programme. This programme consists of a bus equipped with hands-on exhibits of science, engineering and technology and it visits schools, science shows, and open days. The purpose of this bus is to promote Public Understanding of Physical science, Engineering and Technology of learners and teachers in secondary schools.

The motivation for this research is to obtain information that will assist to improve the effectiveness and efficiency of the existing programme to the benefit of your school.

Please note that this research is operating according to the normal code of ethics and that participation is voluntary. This questionnaire is confidential and no one in your school will know what you have written. This is not a test. There are no right or wrong answers, so you should not worry about it. Please just answer as honestly as you can.

GENERAL INSTRUCTIONS

In this questionnaire you will find questions about yourself. Some questions ask for facts while other questions ask for your opinion.

Read each question carefully and respond as accurately and carefully as possible. You may ask for help if you do not understand something, or if you are not sure how to answer.

Some of the questions will be followed by a few possible choices indicated with a letter next to or below it. For these questions, circle the letter as shown below in the example.

1.	I like ice cream.	Agree a lot	Agree a little	Disagree a little	Disagree a lot
		[A]	B	C	D

"A" has been circled because you strongly agree with the statement.

QUESTIONNAIRE

SECTION ONE - ABOUT YOURSELF

1. First name: ....
2. Surname: ....
3. Gender: Male □ Female □ Age: ………..
4. School: …………………………………………………..
5. Which of the following subjects do you teach and to which grades:

   Physical science □ Grade(s): ....

   Technology □ Grade(s): …………..

   Mathematics □ Grade(s): …………..
6. What qualification do you have in the following subjects:

   Physical science: …………………………… No qualification □

   Mathematics: …………………………… No qualification □

   Technology: …………………………… No qualification □
8. Today's date: Day ..…/….. Month ...../..... Year …../…..
9. When did you visit Tsebo Koloing? …………………………

SECTION TWO - YOUR VISIT TO THE TSEBO KOLOING UNIT

How much do you agree with these statements about the Tsebo Koloing Unit? After each statement please circle one of the following letters which have the meaning as indicated:

A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Office use
a. Most of the exhibits in the unit represent what I teach in physical science and/or technology.	A	B	C	D	1

b. It was not clear to me which physical science, engineering, and technology concepts were represented by the exhibits.	A	B	C	D	1
c. Most of the exhibits in the unit did not represent what I teach in physical science and/or technology.	A	B	C	D	1
d. The exhibits and demonstrations emphasised the importance of physical science and technology education at my school.	A	B	C	D	2
e. I am now more aware of the importance of physical science and technology education at my school because of Tsebo Koloing.	A	B	C	D	2
f. The quality of the hands-on-exhibits in the unit was good overall.	A	B	C	D	2
g. I have a clear understanding of the different careers related to physical science and technology because of the visit to the unit.	A	B	C	D	3
h. The time I have spent in the Unit was long enough.	A	B	C	D	5
i. The unit did not emphasise the importance of physical science and technology education at my school.	A	B	C	D	5
j. The instructions on the exhibits were easy to understand and to follow.	A	B	C	D	5
k. The demonstrations of the different physical science, engineering and technology concepts were clear and understandable.	A	B	C	D	6
l. The demonstrations of the different physical science, engineering and technology concepts did not make any sense to me.	A	B	C	D	6
m. The facilitators were approachable and helpful.	A	B	C	D	9
n. The facilitators explained the different concepts very well.	A	B	C	D	9
o. The quality of the exhibits and the unit is high.	A	B	C	D	10

SECTION THREE - YOUR OPINION

a. Explain how your visit to the Tsebo Koloing Unit influenced your teaching

Very good □ Good □ Average □ Bad □ Very bad □

b. How has the visit to the Unit affected your learners in their physical science and technology learning?

____

____

c. Would you recommend other science and technology teachers to visit the Unit? Yes □ No □

If your answer is yes, explain why.

i)____

____

If your answer is no, explain why.

ii)____

____

d. Did your visit to the Unit have any impact on your understanding of science, engineering, and technology? Yes □ No □

If your answer is yes, explain why.

i)____

____

If your answer is no, explain why.

ii)____

____

THANK YOU FOR YOUR PARTICIPATION!

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UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

APPENDIX C

QUESTIONNAIRE FOR LEARNERS

UNIVERSITEIT VAN PRETORIA
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QUESTIONNAIRE FOR LEARNERS

Learner ID ……………………..…..

TSEBO KOLOING TECHNOLOGY OUTREACH PROGRAMME

QUESTIONNAIRE FOR LEARNERS

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Read each question carefully and respond as accurately and carefully as possible. You may ask for help if you do not understand something, or if you are not sure how to answer.

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1.	I like ice cream.	Agree a lot	Agree a little	Disagree a little	Disagree a lot
		[A]	B	C	D

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"A" has been circled because you strongly agree with the statement.

QUESTIONNAIRE

SECTION ONE - ABOUT YOURSELF

1. First name: ....
2. Surname: ....
3. Gender: Male □ Female □
4. Your age: …….
5. School: …………………………………………………..
6. Grade: ………….
7. Which of the following subjects do you take:

   Physical science □ Technology □ Mathematics □
8. Today's date: Day …../..... Month ...../….. Year …../…..
9. When did you visit Tsebo Koloing? …………………….

SECTION TWO - YOUR VISIT TO THE TSEBO KOLOING BUS

How much do you agree with these statements about the Tsebo Koloing Bus? After each statement please circle one of the following letters which have the meaning as indicated:

A = agree a lot, B = agree a little, C = disagree a little, D = disagree a lot.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Office use
a. Most of the exhibits in the bus are similar to what I learn in physical science and technology at school.	A	B	C	D	1
b. It was not clear to me what the exhibits in the bus tried to explain about physical science, engineering and technology.	A	B	C	D	1
c. Most of the information and the exhibits in the bus are very different to what I learn in physical science and technology at my school.	A	B	C	D	1

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Office use
d. The exhibits and demonstrations emphasized the importance of physical science and technology education at my school.	A	B	C	D	2
e. I am now more aware of the importance of physical science and technology education at my school.	A	B	C	D	2
f. The bus did not emphasize the importance of physical science and technology education at my school.	A	B	C	D	2
g. I am more interested in the different careers related to physical science and technology after my visit to the bus.	A	B	C	D	3
h. I have a clear understanding of the different careers related to physical science and technology because of the visit to the bus.	A	B	C	D	3
i. I am not more interested in physical science and technology careers after my visit to the bus.	A	B	C	D	3
j. I know how to apply for further studies in engineering and technology.	A	B	C	D	4
k. I know what marks I must have to apply for studies at the different higher education institutions.	A	B	C	D	4
l. The career lecture helped me to know which subjects I must take at school to qualify for admission to study engineering.	A	B	C	D	4
m. The time I have spent in the Bus was long enough.	A	B	C	D	5
n. The hands-on-exhibits in the bus was in good working order.	A	B	C	D	5
o. The instructions on the exhibits were easy to understand and to follow.	A	B	C	D	5
p. The demonstrations and explanations done by the facilitator were clear and understandable and helped me to understand physical science, engineering and technology better.	A	B	C	D	6

	Agree a lot	Agree a little	Disagree a little	Disagree a lot	Office use
q. The demonstrations and explanations done by the facilitator of physical science, engineering and technology did not make any sense to me.	A	B	C	D	6
r. The facilitators were friendly and helpful.	A	B	C	D	9
s. The facilitators made physical science, engineering, and technology easy to understand.	A	B	C	D	9
t. Some of the exhibits in the bus were broken.	A	B	C	D	10

SECTION THREE

1. Which of the following best describes your experience (visit) to the Tsebo Koloing Bus?

   Very good □ Good □ Average □ Bad □ Very bad □

2. The following is a list of different types of Engineers. However, not all are correct.

   Mark only the correct ones by putting an **X** in the box next to the item.

   a. Civil engineer □
   b. Mechanical engineer □
   c. Psychiatric engineer □
   d. Electronic engineer □
   e. Orthopaedic engineer □
   f. Surgical engineer □
   g. Chemical engineer □
   h. Electrical engineer □
   i. Industrial engineer □
   j. Aviation engineer □

SECTION FOUR - YOUR OPINION

a. What was your experience of your visit to the Tsebo Koloing bus?

____

____

b. Describe the three things that you enjoyed about your visit to the Tsebo Koloing Bus.

1.____

2.____

3.____

c. Describe the three things that you did not enjoy about your visit to the Tsebo Koloing Bus.

1.____

2.____

3.____

d. Would you tell your friends that they should visit the Bus? Yes □ No □

i) If your answer is yes, explain why.

____

____

ii) If your answer is no, explain why.

____

____

THANK YOU FOR YOUR PARTICIPATION!

APPENDIX D

LETTER TO SCHOOL PRINCIPALS

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

URGENT FAX MESSAGE

ATTENTION: THE PRINCIPAL

SCHOOL: RADEBE HIGH SCHOOL

FROM: LINA DU PLESSIS

DATE: 2 AUGUST 2004

SUBJECT: PERMISSION TO CONDUCT RESEARCH

Dear Sir/Madam

The UNIVERSITY OF PRETORIA and TSHWANE UNIVERSITY OF TECHNOLOGY is currently conducting research to determine the impact of the Tsebo Koloing Technology Outreach Programme on the Public Understanding of Physical science, Engineering and Technology on learners and teachers in secondary schools. The motivation for this research is to obtain information that will help them to improve the effectiveness and efficiency of the existing programme to the benefit of your school.

We've selected your school to be part of this research since the unit visited your school during 2003 and we therefore kindly request your permission to conduct the following research at your school:

1. Learners who visited the bus at your school and the Science and Technology teachers will be requested to complete questionnaires (it will take 20 minutes maximum).
2. The researcher will conduct interviews with the Science and Technology teachers and a number of learners while the rest complete the questionnaires.
3. We need the following number of learners:
   Grade 9 - 50
   Grade 10 - 50
   Grade 11 - 50
   Grade 12 - 40

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We would like to visit you school on **Tuesday 3 August 2004** if possible.

We thank you in advance for you cooperation.   It is highly appreciated.

Best regards

……………………………….

PC du Plessis: Researcher

Tel: 012 348 4962 / Cell 083 272 7163

APPENDIX D

CLEARANCE CERTIFICATE