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THE TECHNOLOGY LEARNING AREA: A CATALYST OF CREATIVITY IN FOUNDATION PHASE LEARNERS

Chapter 1
PROBLEM FORMULATION, AIMS AND RESEARCH DESIGN

1.1 Introduction

The introduction of Outcomes-Based Education (OBE) in Grade 1 in South African schools in 1998, signified the recognition and introduction of the technology learning area as one of the eight core learning areas identified by the Department of Education in recognition of the need to implement major changes in education in a move away from the apartment system of education to a new reflective and outcomes-based practice in schools from Grades R- 9 (Department of Education 1997:8; Pudi 2007:14-15; Stevens 2009:133). Since its introduction, the curriculum has been revised and refined several times. In 2009, the curriculum was again reviewed and the Minister of Basic Education announced the decision to amend the National Curriculum Statement. In 2012, the National Curriculum and Assessment Policy Statements (CAPS) for the National Curriculum, as part of a three year implementation phase-in period, were introduced in the Foundation Phase (Grades R -3) and Grade 10 (Department of Basic Education 2011e:4-5). The Minister of Education describes the CAPS curriculum as being more accessible and streamlined for teachers (Department of Basic Education 2011e:14). Certain terminologies have been discarded and/or changed and subjects have been reduced across the phases from Grades R-9 (Department of Basic Education 2011e:9).

In the Foundation Phase, four core subjects have been selected for facilitation, namely, home language, first additional language, mathematics and life skills. The life skills subject is divided into four content areas one of which is beginning knowledge. The content area of beginning knowledge draws on the subject disciplines of the social sciences (history and geography) and the natural sciences and technology. The other three content areas of life skills include personal and social well-being, creative arts and physical education (Department of Basic Education 2011b:8-9).

Technology, which is the product of human endeavour in response to needs, has existed throughout history. People have used a combination of knowledge, skills and available resources to find solutions to problems based on everyday needs and wants (Department of Education 2002:4). Today, people still have needs and wants and, due to the diverse and complex society in which we live, and the consequent accelerating developments in the technological world, a wide range of attitudes and values have had to be considered when developing technological solutions to problems. It is in this context that the Department of Education defines technology as “The use of knowledge, skills and resources to meet people’s needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration.” (Department of Basic Education 2011d:9).

Highlights of technology as a subject are its unique features and scope which include engaging learners in problem-solving activities rooted in real life contexts, encouraging divergent and creative thinking, combining thinking and doing that affords links between abstract thought and concrete understanding, as well as providing opportunities for different learning styles. In addition, learners are also exposed to entrepreneurial pursuits and the challenges of living in a technological society. The subject aims to develop learners’ technological literacy by giving them the opportunity to develop and apply specific skills to solve problems in their everyday world as they engage in the design process of investigating, designing, making, evaluating and communicating, whilst developing an increasing awareness of the interaction between technology, society and the environment (Department of Basic Education 2011d: 9-10). Technology as a subject encapsulates many of the critical outcomes which underpin the Education Constitution of South Africa. These critical outcomes aim to develop learners who, inter alia, are able to identify and solve problems and make decisions using critical and creative thinking, work effectively with others, critically evaluate information, use science and technology effectively and critically, be responsible and develop entrepreneurial skills (Department of Education 2002:1- 2). Its importance as an engine of change in a developing country like South Africa cannot be overemphasized (Pudi 2007:136).

1.2 Creativity and Technology

Cognitive theories of creativity which focus on the problem-solving process and encourage divergent thinking and meta-cognition mentioned by researchers in the field such as Cropley and Cropley (2010a:301- 317), Kozbelt, Beghetto and Runco (2010:20-47), Matlin (2009: 355 - 392) Runco and Albert (2010:3 -19), Russ and Fiorelli (2010: 233-249), Richards (2010:189-215), Weisberg (2006:464) and Wong and Siu (2012:436), would seem to support the nature of the design process which is described as a creative and iterative process by the Department of Basic Education (2011d:11 & 55) .

Roots of Constructivism which draw on theories of Piaget and Vygotsky, underpin the belief that children need to be given the opportunity to discover in order to construct knowledge in their own minds (Fisher 2005:12-13 &112; Jordan, Carlile & Stack 2008: 56-60; Pritchard 2009:117; Slavin 2006: 243). The researcher believes that the valuable features in teaching technology in the foundation phase where young learners, through active exploration of concrete objects during technological tasks, construct their own knowledge through the mediating and facilitating role of the teacher within a supportive and collaborative environment, and encourage the development of creative thinking skills. Knowledge gained through concrete exploration is transferred from the *hands to the head.*

Kaufman and Sternberg (2006:457-8) state that different cultures have different perspectives on what is means to be creative. Research on creativity predominates in American and Western psychological literature. In Africa, despite the recognition of creativity as a human and national development there is, at present, little published research on creative theories and practices. It is envisaged that this is likely to be developed as there is greater availability of formal education and increasing modernization of African communities in the next decade (Kaufman & Sternberg 2006:457-458). While there is both commonality and diversity on literature regarding creativity with respect to national traditions, scientific infrastructure and legislative support for creativity research, it is widely recognized that creativity is a universal phenomenon that is seen to be a contributing factor to the contributing growth of world civilization (Kaufman & Sternberg 2006:495-496). According to Mpofu, Myambo, Mogaji, Mashego and Khaleefu (cited in Kaufman &

Sternberg 2008: 484), African countries have a rich heritage of creative endeavours that reveal they are technologically advanced as any society of their time. The "Great Pyramids of Egypt" are well known in this regard.

According to de Vries (2009:4) one of the motives for including technology education in the school curriculum is that it is seen as the subject "par excellence" that stimulates general abilities such as creativity, problem-solving and communication. This statement is supported by several readings on the subject which is seen to be an instrument for providing a foundation for creative thinking (Davies and Howe 2009:164; Hill 2009:81; Jeffrey and Woods 2009:37; Mahlke (1993) (cited in Pudi 2007: 73); McCormick 2009:363; Parkinson & Hope 2009: 260). Not only does the subject enhance the personal creativity of individual learners, but it also raises issues of responsibility to the environment, society and safety to the planet (Parkinson & Hope 2009: 260).

In the international education arena, a review of the development of technology education as a school subject in countries, including South Africa, shows that the subject is not a total newcomer to education, but one which has its roots in traditional craft and vocational-based programmes which, over the years, have broadened to include design and notions of technological literacy (Jones, Buntting & de Vries 2013:194). It has a historical link with science and is seen as a useful vehicle for contextualizing science within the curriculum due to the fact that it is easier to see how technology impacts on society and the environment and how technology, rather than science can be driven by the sociocultural context in which it is situated (Jones, Buntting & de Vries 2013:197. With traditional roots in vocationally-based and craft programmes the subject has broadened to include aspects of design and notions of technological literacy for all (Jones, Buntting & de Vries 2013:194). Its status as a school subject is, however, still perceived to be fragile, requiring the establishment of professional bodies, the necessary support for in-service and pre-service teacher training and professional learning and acceptance in the socio-political environment of schooling (Jones, Buntting & de Vries 2013:192). In the refined CAPS Foundation Phase curriculum technology comprises a very small part of the Life Skills subject. It shares a combined place with the Natural Sciences, and the Social Sciences under the content area of Beginning Knowledge, an aspect of Life Skills (Department of Basic Education 2011b:6 & 8).

1.3 Problem Statement

While some reference is made to the development of creative thinking skills in the South African school curriculum, little is known about how learners actually use their creative thinking skills to solve problems, or how these skills may be expected to develop in the Foundation Phase. The Technology Curriculum and Assessment Policy Statement (CAPS) makes specific reference to the creative and interactive use of the design process to develop solutions to identified problems or human needs (Department of Basic Education 2011d:67). Using the skills of investigation, design, make, evaluation and communication, the design process is used by engineers and the like when developing original ideas to meet needs or wants when solving problems (Department of Basic Education 2011d:55).

In the Foundation Phase CAPS curriculum, technology education is briefly mentioned as one of the specific aims of the Life Skills subject. This subject is described as a "cross-cutting subject" that should support the languages (home and first additional) and mathematics in the Foundation Phase. Described as aiming to guide and support learners for life-long learning and to equip learners for "meaningful and successful living in a rapidly changing and transforming society", five specific aims are specified for exposing and strengthening learners' knowledge, skills and values in certain areas. The notion of creativity is only linked to the four art forms that comprise the Creative Arts study area, namely dance, music, drama and visual art. Technology is not linked to creativity and is included separately in another specific aim that refers to developing an "awareness of social relationships, technological processes and elementary science (Department of Basic Education 2011a:8). An explanation of the Life Skills subject includes technology as forming part of beginning knowledge, one of four strands of learning which includes the subject disciplines of the social sciences and the natural sciences. Key concepts and skills of technology are listed in the explanation of beginning knowledge namely: "Technological process skills; investigate, design, make, evaluate, communicate" (Department of Basic Education 2011a:8). In the Foundation Phase Life Skills document there is no definition of technology, no explanation of the design process, and no mention of the key concepts and skills relating to technology as an aspect of beginning knowledge.

It is the aim of this research to investigate the value of technology as a subject in the South African Foundation Phase curriculum as a catalyst in developing young learners' creative thinking skills.

In an attempt to realize the aim of this research, the following key research questions are posed:

- What is the nature of creativity in technology?
- Can certain creative thinking patterns be observed as learners engage in the design process?
- Is so, what aspects or features of the design process can be identified as influencing and contributing to the development of young learners' creative thinking skills?
- Can creativity be assessed in technology?
- If so, what aspects of creativity can be assessed, what criteria will be used for assessment, and how will creativity be assessed?

1.4 Research Objectives

The Technology Curriculum and Assessment Policy Statement (CAPS), states that the subject develops learners' critical and creative thinking skills and stimulates learners to be innovative (Department of Basic Education 2011d: 9). Thus, the focus of this research will be to investigate the nature and value of technology as a school subject and its impact in developing foundation phase learners' creative thinking skills.

The primary objectives of this study will be to:

- Investigate the nature of the technology learning area in the Foundation Phase in the South African Curriculum, as a vehicle for developing and enhancing creative thinking skills.
- Explore the basic concepts of creativity.

- Analyze the nature of creativity during the technological design process of investigating, designing, making and evaluating in a technological context and identify key characteristics, skills and experiences that are influenced and developed during the technological process.
- Develop a Technology Creativity Assessment Model that will be used as a tool to assess young learners' creative input during technological tasks

The secondary objectives related to this study will be to:

- Investigate the influence of the social environment as a supporting mechanism for enhancing creative thought.
- Determine the influence of the outdoor classroom as a creative catalyst.
- Determine the teacher's role in planning technological tasks and activities.

1.5 Research Design

A qualitative naturalistic and ethnographic case study has formed the essence of this research using observations and interviews to collect data and generate theory *in situ* as the study has developed (Cohen, Manion & Morrison 2011:220; Creswell 2012:464-465; Denzin & Lincoln 2013:6-7; Flick 2009: 233; LeCompte & Preissle 2008: 32; Pellegrini 2004: 53-54; McMillan & Schumacher 2010: 342-344 & 350; Yin 2009:8-9).

The sampling population has comprised a quota sample of Grade 3 learners at an independent school, in KwaZulu-Natal. A systematic sampling procedure where every nth individual in the sampling population is chosen until the desired sample size is reached was used (Creswell 2012:143). A method of non-probability sampling was selected due to the researcher targeting a particular group of learners, in the full knowledge that it does not represent the wider learner population in schools in the KwaZulu-Natal Province. Significant strata of the population, namely gender and culture, have been used based on guidelines suggested in qualitative research literature (Bless, Higson-Smith & Kagee 2006:107; Cohen, Manion & Morrison 2011:153 & 155; Creswell 2014:465; Lankshear & Knobel, 2004:148-149; LeCompte & Preissle 2008:33; McMillan & Schumacher 2010:139-140; Terre Blanche, Durrheim & Painter 2007:139).

It is envisaged that the selection of a small number of individuals in this study will contribute to the researcher's understanding of the phenomenon of creativity in technology. Supported by the discussion on qualitative sampling by Gay, Mills and Airasian (2009:135), a unique research setting has been created with the primary goal of selecting participants who are deemed to add best to the understanding of the phenomenon under study. Sample quality, rather than sample quantity, has been the focus of the research study.

Ethical considerations such as anonymity and confidentiality have been ensured at all times. The selected sample of learners is well known to the researcher and they have been willing participants in the study.

It is acknowledged that validity is an important key to effective research. The research has, therefore, been addressed through honesty, depth, richness and scope of the collected data. Taking into consideration, the age of the learners in the sample, it is to be expected that their opinions, attitudes and perspectives will, to some degree, contribute to a degree of bias. Validity will therefore be a matter of degree, rather than an absolute state (Cohen, Manion & Morrison 2011:179; Gay, Mills & Airasian 2009:375; Lankshear & Knobel 2004:361; Maree, 2009: 80; McMillan & Schumacher 2010:109).

The premise of naturalistic study such as the one the researcher is proposing is characterized by uniqueness and idiosyncrasy, not only in the methods of research, but in the variable of creativity that will be researched during technological activities. Elements of naturalistic enquiry as stated by Cohen, Manion and Morrison (2011:219-223) and McMillan and Schumacher (2010:321-322), will be borne in mind: the concept of *stability of observations* made, i.e. whether the same observation would have been made in another setting; parallel *forms*, i.e. where the researcher would have made the same observations and interpretations of what had been seen, if she had paid attention to other phenomena during this time; *inter-rater reliability*, i.e. whether another technology teacher called upon to observe the learners, using the same phenomena, would have interpreted them in the same way.

1.6 Precedents in Study/Parallel Work in the Proposed Area of Study

Technology as a school subject has been part of the South African Outcomes-Based Education Curriculum since its introduction in 1998. Whilst some research has been conducted on this subject, research that explores the value of this learning area in the Foundation Phase of Education has yet to be explored and documented.

Based on readings on case study research as described by Creswell (2014:14) Cohen, Manion and Morrison (2011:289-294), Flick (2009:134), Nieuwenhuis (2009:75-760 and Yin (2009:3-10), the case study research method, as a study of a case in a particular context, has been selected in order to analyse learners engaged in the design process of technology in an attempt to develop a creativity assessment model for technology.

It is envisaged that this method of qualitative research design will help to build emergent theory from data collected, and highlight the role of technology education as a catalytic value in developing creative thinking in Foundation Phase Learners.

The proposed development of a creativity model for assessing the value of technology as a catalyst in developing Foundation Phase learners thinking skills is based on the researcher's study in the field of cognitive research on problem-solving and creativity and experience in teaching technology in the Foundation Phase. Key aspects of the design process such as investigating needs and problems, designing, making, evaluating and communicating, have been used as a basis for developing this model. Matlin's model of cognition (2009) which explores the mental processes of perception, memory, imagery, language, problem-solving, reasoning and decision-making where creativity is viewed as an aspect of problem-solving, will be used as the *kernel* for developing the model, due to its perceived correlation with the problem-based and creative nature of the design process.

Piaget's genetic epistemology which concentrates on the individual in learning, and Vygotsky's cultural-historical theory which concentrates on the social context in learning, both of which highlight the importance of both the individual solving real life problems through constructing his/her own knowledge, as well as in collaboration with others, have also formed the basis of developing the model. Both theories are seen to have a direct bearing on the teaching of technology in the Foundation Phase (Pass 2004: xiii).

1.7 Elucidation of Concepts

1.7.1 The Foundation Phase

The Foundation Phase is the first phase of education in the South African General Education and Training Band (Grades R, 1, 2 and 3). The focus of education in this phase is the development of learners' primary knowledge and values, thereby laying the foundation for further learning (Department of Education 2003b:19).

1.7.2 The Learner

In terms of the South African Schools Act (Republic of South Africa 1996), the term learner will refer to any person receiving education or obliged to receive education.

1.7.3 The Foundation Phase Learner

According to the National Education Policy Act (Republic of South Africa 1996), the age of learners in the Foundation Phase could range between five and ten years of age.

In this study learners in the Foundation Phase will specifically refer to learners in Grade 3, the selected sample for this research project.

1.7.4 Technology as a School Subject

In the context of technology as a school subject in the South Education curriculum, it is defined as the use of knowledge, skills and resources to meet people's needs (Department of Basic Education 2011d:9).

Technology as a school subject aims to contribute to learners' technological literacy by giving them opportunities to apply specific skills to solve technological problems. It also develops learners' understanding and use of concepts and knowledge used in technology, as well as an appreciation of the interaction between society, technology and the environment. (Department of Basic Education 2011d:9).

1.7.5 The Design Process

The design (technological) process forms the backbone of Technology as a subject. It includes investigating, designing, making, evaluating and communicating (IDMEC) (Department of Basic Education 2011d:5).

In the context of this study, the term *design process* will be conceptualized as a systematic, iterative and cyclic process which includes feedback links within all aspects of the technological process. It will encapsulate the problem-solving and designing activities of learners as they engage in technological activities from the inception of an idea through the developmental process of designing, making, evaluating.

1.7.6 Creativity

In the context of this study, creativity will be conceptualized as the ability to produce work that is novel, i.e. original and unexpected, as well as work that is appropriate, i.e. useful, adaptive and takes into consideration task constraints (Sternberg 1999:3).

1.8 Chapter Divisions

This study is further divided into the following components:

1.8.1 Chapter Two: The Nature of Creativity

Chapter Two explores the basic concepts of creativity as researched by experts in the field. Matlin's cognitive model of problem-solving and creativity is discussed and the corresponding link to her model and the design process in technology is briefly alluded to.

1.8.2 Chapter Three: The Nature of Technology

Chapter Three explores the nature of technology in the South African school curriculum, as it relates to the Department of Basic Education's documentation on the subject, as well as the international perspective on the developing philosophy of technology education in the curricula. The facilitation of the subject across the different phases and the more recent emphasis focusing on the conceptual knowledge of the subject, as opposed to emphasis on the procedural knowledge of the design process, is also explored and discussed. The link between creativity and the technological design process will also be explored, supported by creativity research discussed in Chapter Two and school-based technological research. .

1.8.3 Chapter Four: The Research Design and Methodology

The focus of Chapter Four is the research design and methodology used in this study. The initial part of the chapter explores the theoretical basis for selecting qualitative research and is followed by a description of case study research. A model, which has been developed in order to assess the nature of technology as a catalyst of creativity in Foundation Phase learners, is proposed. The model encapsulates Matlin's model of problem-solving and creativity and includes characteristics of creativity based on significant research readings in the field. The design process of technology is central to the model. All the data collected during the different stages of the design process has been analyzed within the context of identified categories, and related qualifiers, according to a coding system developed for the purpose of identifying patterns and relationships within the model.

1.8.4 Chapter Five: Presentation and Analysis of Data

Chapter Five presents an analysis of data within the framework of the proposed creativity assessment model for technology introduced in Chapter Four. Based on Matlin's theory of problem-solving and creativity, as well as selected theories of early creativity researchers such as Guilford, Rhodes and Wallas and the CAPS Policy Document for technology (Senior Phase) developed by the Department of Basic Education, a coding system that highlights the main components of the design process and variables of creativity considered important to this study, has been used to analyse data collected in the study.

1.8.5 Chapter Six: Summary, Findings and Recommendations

Chapter Six provides an overview of the investigation and includes a summary of findings and recommendations. The final chapter reflects on the value of technology education as a catalyst for developing young learners' creative thinking skills in the Foundation Phase, and its potential within the context of curriculum change and development, in developing learners' knowledge and skills for preparing for the world of work, and life in general, in the 21st century.

1.9 Conclusion

It is within the context of this background information and introduction to the research topic, that research to determine the value of the technology education, as a catalyst in developing and enhancing creative thinking skills in Grade 3 learners, in the Foundation Phase, is proposed.

Chapter 2

UNDERSTANDING CREATIVITY

2.1 INTRODUCTION

Creativity is a multifaceted phenomenon that requires a multitude of approaches in order to be understood. A variety of factors such as individual, situational, social and cultural all work together to determine a creative outcome. Today there is a greater emphasis placed on creativity by society than ever before. Seen as a unique human quality that differentiates human beings from the animal kingdom, the role and value of creativity is a powerful force in social transformation and economic growth in a rapidly changing and competitive society. The striving towards, and achieving of, new goals, through creative innovation is accordingly a must in order for organizations to ensure survival and avoid the risk of failure in the 21st century (Andriopoulos & Dawson 2009:24; Gundry 2007:1; Kaufman & Baer 2006:164; Kaufman & Sternberg 2010: xiii & 49; Matlin 2009:385; Weisberg 2006:70; Ward & Kolymyts 2010:93; Zeng, Proctor & Slavendy 2011:24).

What is creativity and how can it be defined? According to Kaufman & Sternberg (2010: xiii), creativity can refer to a person, a process, a place or a product. It can be found in geniuses and in young children. It has been studied by psychologists, economists and all types of scholars from Aristotle to Einstein. After more than six decades of intensive research, there is still debate on how creativity can be measured, improved and utilized. The intangible nature of creativity makes it difficult to define and has resulted in a number of definitions. Many theorists and researchers do, however, agree on, and include, components of novelty or originality in their definitions (Andriopoulos & Dawson 2009:24; Kaufman & Baer 2006:164; Kaufman & Sternberg 2006:2; Kaufman & Sternberg 2010:xiii; Matlin 2009:385; Runco 2007: ix; Weisberg 2006:70). A concise definition that encapsulates the essence of creativity for the purpose of this research is cited by Sternberg (1999: xiii) in the first handbook of creativity to be published. He defines creativity as "... the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive concerning task constraints)". Most definitions of creativity comprise three elements, first that the creative idea must represent something new, innovative or different. Secondly, that the creative ideas must be of good quality and thirdly, that the creative response must be appropriate to the task at hand. A creative response is thus seen to be novel, good and relevant (Kaufman & Sternberg 2010: xiii).

In the past two decades, the notion of creativity in education has gained increasing universal significance spanning numerous cultures around the world. Much work has been undertaken by policymakers, practitioners and researchers from their own particular perspectives that range from conceptual understanding to classroom practicalities (Beghetto 2010:449; Craft, Cremin & Burnard 2008: xix). Partly, as a response to rapid social, technological, economic and environmental change, research conducted in the United Kingdom has highlighted the concept of creativity as being within the reach of all human beings across a wide spectrum (Craft & Jeffrey 2008:577). Creativity has become embedded in the Foundation Stage Curriculum and the National Curriculum for schools in England (Craft 2009:5). Countries that have endorsed the creativity initiative realize the importance of developing their students' creative potential as both a good investment in their own future and that of their country (Craft & Jeffrey 2008:577).

In South Africa, the Department of Basic Education endorses the importance of developing learners' creative potential. One of the main aims of the Curriculum and Assessment Policy Statement (CAPS) states that it aims to produce learners who are able to "identify and solve problems and make decisions using critical and creative thinking" (Department of Basic Education 2011d:9).

Whilst many approaches to the studying of creativity have been devised by theorists in an attempt to understand its diversity, complexity in interdisciplinary nature, this chapter will highlight and broadly review the relevant developments in creativity research as they may be deemed appropriate in the education of young children. A more in-depth review of the cognitive theory of creativity with particular reference to Maltin's cognitive theory of problem-solving and creativity, will also be used as a springboard for researching creativity in technology education in chapter three.

2.2 A BRIEF HISTORICAL REVIEW OF CREATIVITY RESEARCH

According to Weisberg (2006:90), an interest in the origin of new ideas dates back many thousands of years, when it had been believed that truly novel ideas producing creative leaps forward must have come from extraordinary sources. Creative ideas seen to be gifts from the Gods originated with the Greeks and attracted scholars such as Plato and Aristotle. In more recent times, beliefs about the sources for creative ideas has moved away from the supernatural to the internal processes of thought, i.e. divergent thinking, unconscious thinking, psychopathological thinking and intuitive leaps of insight. It is interesting to note that the Freudian conception of the unconscious has also been applied to creativity (Herbert 2010:11 & 31; Weisberg 2006: 92).

In the late nineteenth century, a different conception of the role of the unconscious thinking in creativity was proposed by Poincaré (1854-1912), a world-renowned mathematician and scientist who centred on the phenomena of *illumination* and *incubation* in unconscious thinking. According to his theory, illumination is described as a sudden appearance in consciousness of a creative idea or solution when one has not consciously dwelled on the matter. Incubation is described as unconscious thinking about the problem while consciously thinking about something else (Weisberg 2006: 93-94). Elaborating on Poincaré's theory, is Wallas's (1926) well-known 4 stage model of creativity that includes the processes of *preparation, incubation, illumination and verification* (Weisberg 2006:94 & 397-398). These stages are still referred to in many modern theories of creativity today and will be used in this research to develop a creativity assessment model for technology.

According to Runco and Albert (2010:3), the field of creativity as it exists today emerged mainly as a result of the pioneering efforts of American Psychologists, J.P. Guilford (1950) and E. Paul Torrance (1962). Both theorists concentrated on the notion of *divergent thinking*, which is described as breaking away from past, i.e. *diverging* from the old to produce novel ideas and multiple ideas (Weisberg 2006:95-96), as a basis for defining creativity. These theorists devised psychometric tests that aimed to assess this type of thinking using the traditional indices of fluency, originality, flexibility and elaboration (Runco 2010:414; Sternberg 2006:87). Torrance's contribution to creativity research is still widely recognized today. Based on the original Torrance Tests of Creative Thinking (TTCT) which produced scores in the original areas of *fluency* (how many different responses have been produced, *flexibility* (how many categories of responses were produced), *originality* (how novel and unique the responses were) and *elaboration* (how detailed and developed they were) (Kaufman & Sternberg 2007: 56-57), the TTCT tests, although more streamlined (Plucker & Makel 2010:53), are still used to assess creative talent today (Sternberg 2006:87). Although much criticism has been levelled at the reliability and practical value of the traditional divergent testing instrument, the practical implications of the research results highlight the value of divergent thinking and underscore the important role that adults such as parents and teachers should play in encouraging, modelling, valuing the divergent thinking of their children and providing opportunities for its practice (Runco, Millar, Selcuk & Cramond 2010:361-368).

2.3 THEORIES OF CREATIVITY

Since the pioneering efforts on divergent through production, the study of creativity has generated many new approaches (Kozbelt, Beghetto & Runco 2010:20). There is much to be learned about creativity both by looking back on what has been researched before, and by looking forward with new research and theories that are being developed (Runco & Albert 2010:3).

A comparative review of major contemporary theories of creativity reveals a multitude of theoretical perspectives with different assumptions and methods that operate at different levels of analysis (Kozbelt, Beghetto & Runco 2010:20-21). Due to the nature of this study it is not possible to discuss all the different theories. Only selected theories deemed relevant to this study will be discussed.

2.3.1 Classifying and Comparing Theories: Type and Orientations

In an attempt to review the diverse and complex theories of creativity in order to characterize their commonalties whilst recognizing their important differences, Kozbelt, Beghetto & Runco (2010:20-47) identify ten major categories of theories, some of which are known in creativity literature and some of which are not. It is acknowledged that there is as much within-category variation in the type of theories as there is difference between the different categories. An example of within-category variation pertains to the orientation of the theory, i.e. more scientific versus more metaphorical. Scientifically oriented theories have the underlying goal of mapping empirical reality of creative phenomena of aspiring to meet traditional scientific standards in the search for objective truths that have universal applicability, whilst in contrast, the more metaphorical oriented theories offer an alternative and more speculative stance. They focus on provoking new understanding, possibilities and hypothetical modes of *what if* thinking that relate more to everyday life (Kozbelt, Beghetto & Runco 2010:21-22). While it is beyond the scope of this research to explore all theories fully, a brief review of those theories that are seen to encapsulate the main distinguishing features of creativity in terms of their relevance to education and the teaching of technology in the Foundation Phase will be discussed.

2.3.1.1 Guilford's Theory (1950)

According to Weisberg (2006:464) the core of the creative thought process is arrived at once the person begins to think about the problem or challenge at hand and consciously works towards the goal of solving it. In this context, he makes reference to Guilford (1950) who focused on the generation of ideas, i.e. the more ideas generated, the greater the chance of producing a creative and useful outcome. According to this traditional theory, the following indices typify the creative thinker and thinking processes as follows:

a) Fluency

A fluent thinker is described as having the capacity to produce multiple ideas in a certain period of time that are relevant to a particular situation (Weisberg 2006: 464).

b) Flexibility

A creative thinker will exercise flexibility and will break away from habitual ways of thinking, seek new ways of thinking and come up with novel ideas (Weisberg 2006: 464).

c) Originality

A creative thinker will produce original ideas not previously perceived by many other people. In Guildford's view, a person who produces a number of original ideas is likely to produce creative solutions to problems.

d) Elaboration

Guilford took these measures of fluency, flexibility and originality and combined them into *divergent thinking*, a mode of thinking which, in his view, plays a critical role in the creative process where the person produces ideas that *diverge* from the more usual.

According to Guilford (1950), divergent thinking is a type of thinking which plays a critical role in the creative process where a person is seen as being able to *diverge,* or move away, from the usual type of thinking. He perceived divergent thinking as a general trait of people relevant across a broad range of activities that might be approached creatively. In contrast, convergent thinking is seen to occur when a person uses available information to converge on a single answer in order to solve a problem. Where divergent thinking produces many possible ideas, convergent thinking narrows down the ideas to produce a potentially useful solution (Weisberg 2006:464-465).

Later, Guilford's original proposal relating to the notion of divergent thinking was to include the notion of *elaboration,* i.e. "the extension of ideas within a specific category of responses ... to fill [ideas] out with details" (Guilford 1967:138 cited in Kaufman, Plucker & Baer 2008:18).

2.3.1.2 An Alliterative Framework of Creativity: *The 4P's (6P's) of Creativity*

The traditional four-perspective model of creativity developed by Rhodes (1961) is regularly cited and is helpful in studying the complex nature of creativity. According to this model, creativity is viewed as a dynamic phenomenon that comprises four interactive components focusing on the creative *person,* the creative *process*, the creative *product* and the creative *press* (place) (Fishkin & Johnson 1998: 40; Kaufman, Plucker & Baer 2008: 19; Kozbelt, Beghetto & Runco 2010:24-25).

The traditional *4 P's of creativity* framework has been extended to include two additional aspects, namely *persuasion* (Simonton 1990) and *potential* (Runco 2003) cited in Kozbelt, Beghetto and Runco (2010:25). The *6P's of creativity* alliterative framework is seen as another way of comparing the scope of the different theoretical perspectives of creativity (Kozbelt, Beghetto & Runco 2010:25), and will be incorporated in developing a creativity assessment model for technology education. A brief description of the *6 P's of creativity is as follows:*

a) The Creative Process – Wallas' 4 Stage Model

Theories focusing on the creative process aim to understand the mental processes that occur when a person engages in creative thought (Beghetto & Runco 2010:24)

Wallas' four stage process (1926) was one of the earliest descriptions of the creative process which may be described as the real experience of being creative, i.e. the way in which creativity actually happens. (Gundry, 2007:4; Kaufman, Plucker & Baer 2008:5). The four creative thought stages as originally identified by Wallas are briefly described below:

i) Preparation

This stage is focuses on the initial conscious effort of gathering information about and exploring the problem from all angles. Information and knowledge about the problem is collected and viewed from multiple perspectives. If an impasse is reached, the person will break from working on the problem while the unconscious keeps working.

ii) Incubation

This is the stage of unconscious thinking about and working on the problem. It involves conscious pausing from the problem which is set aside and *put on the back burner* (Gundry 2007:4; Kozbelt, Beghetto & Runco 2010:24; Matlin 2009:382; Sternberg & Sternberg 2012:508; Weisberg 2006:398). Robinson-Riegler and Robinson-Riegler (2008:469) describe incubation as a productive inactivity.

iii) Illumination

According to Runco 2007:20), the illumination stage of Wallas' model is best known because it leads to the "a-ha" experience. It is also described as the stage where *the light bulb comes on*, and ideas which begin to flow may be experienced as a flash of insight, i.e. a "*eureka"* moment (Gundry 2007:4). Runco (2007:20-21) states that insight is unlike divergent thinking, as it leads to one solution, rather than various areas of thought. It is sudden; hence the light bulb is its common symbol. Robinson-Riegler and Robinson-Riegler (2008:469 -471) refer to the person arriving at a "critical insight" after the incubation period where there is a sudden realization of the solution via a key idea.

iv) Verification

The idea that arose during the illumination stage now requires verification and testing to determine its feasibility (Gundry 2007:4; Weisberg 2006:398) According to Runco (2007:19), verification is vitally important for creativity in terms of both its originality and effectiveness. He states that a more recent application of this stage model includes "recursion", i.e. the notion that the person may revisit early stages and cycle through the creative process rather than working in a linear fashion. This stage focuses on the testing of the idea and reducing it to its precise form.

b) The Creative *Product*

MacKinnon (1978) described the study of products as the "bedrock" of creativity research, and Guilford argued that creativity must lead to something useful (Cropley & Cropley 2010a:303). What is considered to be the most objective approach to creativity is the focus on the creative product (works of art, inventions, etc.). Products are more readily observable than the other *P's of creativity* (Cropley & Cropley 2010a:304). They can be observed and counted and permit considerable quantitative objectivity and reliability due to their availability for judgment and assessment (Kozbelt, Beghetto & Runco 2010:24).

c) The Creative *Person*

The creative person or personality has been a longstanding focus of creativity research. Early research compared traits that were indicative and contra-indicative of people's creative potential (Barron 1995 & Helson 1972 cited in Kozbelt, Beghetto & Runco 2010:25). Several traits are described as cutting across the creative person domain, e.g. openness to experience, intrinsic motivation, autonomy, and risk-taker. In addition, certain traits seem to be more prevalent in certain domains. Expressions of personality often depend on the setting in which an individual exists and creativity tends to flourish where there are opportunities for exploration and individual work, and when originality is supported and valued (Kozbelt, Beghetto & Runco 2010:25).

Straddling both the creative person and the creative press, Amabile's research on motivation and creativity (1996) reveals that extrinsic motivation such as rewarding behaviour can have a negative effective on creative behaviour (Feist 2010:122). Universally acknowledged for her empirical research in the social psychology of creativity, she highlights the importance of social and environmental influences on creativity and the role of intrinsic motivation (Amabile 1996:3 & 15).

d) The Creative *Press* (Place)

Expression of the personality usually often depends on the setting or climate in which a person is situated. The term place or "press" (referring to pressures) is useful for determining the interaction between the person and the environment. Creativity is seen to flourish in an environment that encourages active exploration, independence and an appreciation of, and support for, original work (Kozbelt, Beghetto & Runco 2010:25).

According to Kozbelt, Beghetto and Runco (2010:38-39), the *systems* theories of creativity take a broad, qualitative and contextual view of creativity. Creativity is seen to arise as a result of interacting components of a complex system. Whilst this theory addresses each of the 4 P's, Csikszentmihalyi's model cited by Kozbelt, Beghetto and Runco (2010:38-39) within the context of *press,* is worth mentioning here. He has taken a slightly different systems approach by broadly focussing on the phenomenon of creativity, and emphasizing the ever-present role of *place* (or environment) among the P's. What is interesting is that his theory elaborates the nature of the creative person by detailing how individuals, other than the creator, contribute to the emergence of creativity. He argued that creative judgments stem from the domain of knowledge that exists in a discipline; the individual who acquires the domain knowledge; the field that comprises members of the discipline; and experts who judge the novelties produced within the discipline. The advantage of the systems view, according to Csikszentmihalyi, is that since it acknowledges the importance of extra personal sociocultural factors in creativity, it can be used to generate specific hypotheses about how the domain field and individual, particularly personal backgrounds, culture and society, impact on creativity (Kozbelt, Beghetto & Runco 2010:38-39).

e) Creative *Persuasion*

Simonton (1990) cited in Kozbelt, Beghetto and Runco (2010:25), in a link with the alliterative framework described above, offers an additional perspective on the *4 P's of creativity.* He describes creativity as persuasion where creative people are seen to be able to change the way others think due to their persuasiveness, i.e. to be persuasive one needs to be creative. This notion of creativity as persuasion shares an assumptions with creativity theories that include a social perspective (Kozbelt *et al*. 2010:25).

f) Creative *Potential*

A more recent development to extend the alliterative framework in terms of process, products, personality, places and persuasion, is suggested by Runco (2008) cited in Kozbelt, Beghetto and Runco (2010:25). He proposes the notion of creative *potential* within the organization *of* a hierarchy of creativity, commencing with theories of creative *performances* versus creative *potentials*. He advocates that theories of creative *performance* can be divided into *product* and *persuasion* theories, and other aspects of creativity that focus on behaviour. Theories of creative *potential* can be divided into creative personalities and places, and can include any other aspects of creativity that recognize creative potential and subjective processes. This hierarchical framework is then seen to capture the original 4 P's of creativity. However, it also incorporates recent research on everyday creativity including the creativity of children and others who have the potential, but require educational intervention and support to realize their creative talents (Kozbelt, Beghetto & Runco 2010:25).

2.3.1.3 Categories of Magnitude – *Smaller c* versus *Larger C*

According to Kozbelt, Beghetto and Runco (2010:23), when comparing theories of creativity, it has been useful to differentiate between the traditional levels of creative magnitude such as *smaller c* (more subjective) versus *Larger C* (more objective) creativity. The most common distinction used when comparing theoretical conceptions of creativity has been the *Big C,* (eminent and unambiguous examples of creative expression, not readily attainable by everyone), and *little-c* (everyday, non-eminent and accessible to almost everyone) dichotomy. Kozbelt, Beghetto and

Runco (2010:23-24) argue for an additional two categories in the traditional levels of creative magnitude and suggest a *mini-c* and *Pro-C* for a more clear-cut classification. By adding the *mini-c* category, the objective and subjective forms of little-c creativity will be more clearly differentiated. By adding the *Pro-C* category the grey area between little-c and Big-C creativity will be addressed since it makes room for professional-level creators who have not yet attained (or may never attain) eminent status. Beghetto and Kaufman (2010: 191-203) also make mention of these two additional categories. .

2.3.1.4 A Cognitive Theory of Creativity

Cognitive theories of creativity emphasize the creative person and the creative process. These theories can be varied in nature, e.g. they can either focus on universal thought processes such as attention and memory; individual thought processes such as divergent thinking; conscious thought processes such as tactics, preconscious or unintentional processes. Alternatively, they may posit that creativity is a type of problem-solving, or argue that it is a process of problem-finding which is relatively independent of problem-solving (Kozbelt, Beghetto and Runco 2010:31).

According to Matlin (2009:2-3), cognition is a mental process that describes a range of mental activities that include acquiring, storing, transforming and using knowledge. A related term, cognitive psychology has a twofold meaning. Sometimes it may be used as a synonym for cognition, where it refers a variety of mental activities as mentioned above, or, alternatively, it may refer to a particular theoretical approach to psychology. More specifically, the cognitive approach is a theoretical orientation that focuses on the mental processes in humans and their acquisition of knowledge (Matlin 2009:8). Different types of mental processes are identified, such as the basic mental processes of perception, memory and language, and the higher-order processes of problem-solving, deductive reasoning and decision-making. These higher-order mental processes depend on the basic mental processes (Matlin 2009: 22-23). Of particular interest for this research, due to its link with the design process in technology education is the notion of creativity which is seen as an aspect of problem-solving, one of the higher-order mental processes, identified by Matlin.

Cognitive theories of creativity often focus specifically on the problem-solving process. Acknowledging that there are many kinds of problems, Runco (2007:10) explains that there are two kinds in particular which elicit contrasting ways of thinking; namely open-ended problems that allow for a number of varied responses, and closed problems that require a single response. Differing viewpoints as to whether creativity is a kind of problem-solving or whether problem-solving is a kind of creativity depends on how problems are defined. Guilford (1965) believed in the case of a genuine problem, there is some novel behaviour on the part of the problem-solver and, thus, there is some degree of creativity. According to Guilford, all problem-solving is creative (Runco 2007:15-16).

According to Matlin (2009:357), every problem contains three components; namely the initial state, the goal state and the obstacles. The initial state describes the beginning of the problem situation; the goal state is the end state that is reached when the problem is solved; and the obstacles describe the restrictions and difficulties that are encountered when a person proceeds from the initial state to the goal state.

2.3.1.5 Developmental Approaches to Creativity

Russ and Fiorelli (2010:233) pose the following questions: “Can children be creative?” “Can we see the creative process at work in children?” “If so, what are the developing processes in children that contribute to their creativity?” What are the major developmental approaches to creativity?” “What facilitates creativity and what interferes with it?” Just as there is no one overarching theory of creativity, there is no one comprehensive theory of the development of creativity. Contemporary approaches to creativity view the creative product to be a result of a complex interaction between the person and the environment, and certain processes within the individual assist with this creative output. Different theorists focus on and study different variables of creativity such as the cognitive and affective processes of divergent thinking, problem solving, flexibility of thought, access to emotions and affects in fantasy. Personality variables that are seen to influence creative thought such as self-confidence, risk-taking, openness to experience also form the focus of study. Many of these processes can be observed and measured in children. There is no one overarching theory of the development of creativity as approaches tend to focus on particular variables such as divergent thinking or problem-solving. Theorists caution readers/researchers that when researching children, it must be remembered that the development of the whole child involves a variety of processes and outside influences during creative endeavours. Questions that challenge the study of creativity are how all these processes gel and give rise to the creation of creative products (Russ & Fiorelli 2010).

a) Stage Theory – Piaget

Piaget is well known for his theory of cognitive development which is based on the idea that children pass through various stages of development in a predetermined way. Through active engagement with their environment, children construct meaning as they learn, and this results in conceptual and quantitative change in their cognitive development (Jordan, Carlile & Stack 2008:119; Russ & Fiorelli 2010: 234; Slavin 2006:31). With reference to the area of creativity, Russ and Fiorelli (2010:234) cite the importance to the area of creativity in children from the 2 to 7 age range in Piaget's preoperational stage of development, where children begin to use mental imagery and symbolic representation to represent objects, e.g. where a wooden block being is used to represent a telephone. Runco (2007:44) makes mention of Piaget's theory of adaptation as relevant to the development of creativity. He refers to the theory of adaptation involving the processes of assimilation and accommodation as important development functions in creativity where adaptation is described as the continuous process of using the environment to learn and adjust to changes. Assimilation is described as the process of taking in and fitting information into existing frameworks about the world and accommodation is described as revising one's world view to fit the new information. In order for a state of adaptation to occur, there must be a sense of disequilibrium that will lead the child to action, i.e. some tension or perceived problem or challenge to activate the creative process (Russ & Fiorelli 2010:234).

According to Slavin (2006:33) the term *disequilibration* in Piaget's theory refers to problems encountered in one's life world that cannot be handled by existing schemes of thought. This creates a state of *disequilibrium* or imbalance between what is understood and what is encountered. Balance of thought structures is restored by creating new schemes or adapting old schemes. This process of restoring balance between one's present understanding and new experiences encountered is, according to Piaget, called *equilibration*. The implications for teaching children are that when the equilibrium is upset, children have the opportunity to grow and develop. New thinking about the world emerges and children advance to a new stage of development. This process, whereby children actively build systems of meaning and understandings of reality through their experiences and interactions with their world, represents constructivism, a view of cognitive development.

Piaget's stage theory has been criticized for its broad categories. Arguments against this theory are that children's skills develop in different ways on different tasks and that their experience can have a strong influence on the pace of their development (Slavin 2006:42). In an attempt to address this criticism, neo-Piagetian theorists have attempted to modify the stage theory. They have demonstrated that children's abilities to operate at a particular stage depend a great deal on the specific tasks involved, and on the training and experience, including social interactions which can accelerate children's development (Slavin 2006:43). In the context of this research, the sample group falls within Piaget's third stage of development, namely the Concrete Operational Stage (Ages 7-11). This stage is characterized by children's thinking which is rooted in the world as they see it which according to Flavell (cited in Slavin 2006:38), is one which involves an "earthbound, concrete, practical-minded sort of problem-solving approach." Children at this stage can form concepts, see relationships and solve problems as long as they involve objects and situations which are familiar. They can respond to "inferred reality" where they see things in the context of other meanings and are able to mentally arrange and compare objects, a cognitive skill coined "transivity" (Slavin 2006:38).

The characteristics of Piaget's concrete operational stage of development can be observed during the design process of technology when young learners are actively engaged in the design process of investigating, making, evaluating and communicating problems and their solutions. Knowledge constructed is rooted in active-based, real-life contexts.

b) Continuity of Development – Vygotsky

Vygotsky is well-known for his contributions to developmental psychology. His cultural-historical theory focused on social in learning (Pass 2004:xiii). His theory y of learning contributed to a greater understanding of how children construct their own knowledge. He proposed that the cognitive development of children is strongly linked to the input by others (Slavin 2006:44).

Vygotsky identified the zone of proximal development (ZPD) which describes the difference between the knowledge the child can obtain on his own and the knowledge the child can obtain with the help of a *social other.* The ZPD is the range of development within which more difficult tasks are mastered (Pass 2004: 109-110). Vygotsky defines the ZPD as "... the distance between the actual developmental levels as determined by independent problem solving, and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers." (Cole, John-Steiner, Scribner & Souberman 1978:86).

Classroom applications of Vygotsky's concept of the zone of proximal development is based on the idea that development is defined on what children can do independently and what children can do when assisted by an adult or more competent peer. Teachers should therefore plan activities that children can do independently and activities where children can learn with the help of others (Slavin 2006:46-47).

According to Beghetto (2010:447), with reference to the classroom context, establishing a common curricular goal to develop the creative competence of children is one way to help prepare them for an uncertain future in the light of social, economic and global changes. Psychologists have viewed the development of creative potential as a key educational goal (Guilford 1950 & Vygotsky 1967/2004 cited in Beghetto 2010:447-448). Beghetto quotes Vygotsky, who argued that the main objective of teaching should be the guidance of school children's behaviour in order to prepare them for the future, by using the development and exercise of the imagination as one of the main forces enlisted to attain this goal (Vygotsky 1997/2004 in Beghetto 2010:447-448). In technology, learners are given the opportunity to work on their own and to collaborate with others during the design process.

2.4 PROBLEM-SOLVING AND CREATIVITY ACCORDING TO MATLIN

Matlin (2009:356) identifies four aspects of problem solving namely, understanding the problem, problem-solving strategies, factors that influence problem-solving and creativity. She defines creativity as "finding solutions that are novel, high quality and useful". As an area of problem-solving, creativity like problem-solving requires a person to move from the initial state to a goal state. Matlin's four aspects of problem-solving are discussed below.

2.4.1 Understanding the Problem

In problem-based research the term 'understanding' requires a person to use their previous experience to construct an accurate, mental picture of the problem, based on the given information. Problem-solving relies on other cognitive activities such as attention, memory and decision-making. These cognitive activities highlight the interrelatedness of the cognitive processes in problem-solving (Matlin 2009:358).

2.4.1.1 Paying attention to important information

In an attempt to understand a problem, a person needs to pay careful and undivided attention to important information in the problem. The cognitive task of problem-solving, therefore, also relies on other cognitive processes such as attention, memory and decision-making and underlies the interrelatedness of a person's cognitive processes (Matlin 2009:359).

2.4.1.2 Methods of representing the problem

Selection of an appropriate method to represent the problem is important, and essential information should be shown using symbols, matrices, diagrams or other visual images (Matlin 2009:362-363).

2.4.1.3 Situated cognition and the importance of context

According to Matlin (2009:364) the ability to solve a problem is specifically linked to real-world contexts in which problems are solved. In real life, our cognitive processes make use of an information-rich environment where there is much interaction with others. The situated cognition approach supports the notion that problems are best solved in a particular context. The important implication for education in this approach suggests the need for children to have experiences in solving authentic problems that they are likely to encounter outside of the school setting. The approach is consistent with the notion of ecological validity, i.e. where the conditions in which a problem is solved should be similar to the natural setting where the problem will be applied. An important principle of this approach is that people learn skills within the context of a specific situation, i.e. the environmental and social contexts for problem-solving are important (Matlin 2009: 363-365). This approach supports problem-solving activities that characterize technology education activities in schools.

2.4.2 Problem-solving strategies

According to Matlin (2009: 365), different strategies may be used to solve problems such as algorithms, a method that will always produce a solution although the process may be time-consuming. Research on problem-solvers indicates that heuristics (general strategies) rather than algorithms are more likely to be used to solve everyday problems. Three widely used heuristic methods are analogies, means-end heuristics and the hill-climbing heuristic.

2.4.2.1 The Analogy Approach

In this approach, an analogy or comparison is drawn during problem-solving, i.e. the same strategies employed to solve a previous problem are employed to solve the current problem. Analogies are cited as being prominent in creative breakthroughs in different domains, e.g. the Wright Brothers designed an airplane by drawing an analogy of the wings of a bird and the wings of an airplane. The main challenge of this approach is to determine the real problem to be solved, i.e. to reach the core of the problem and discard superfluous, superficial information. When attempting similar problems of a structural nature, analogy strategies can be effectively used before the target problem is attempted. Exercises in identifying structural similarities can assist people in effective problem-solving (Matlin 2009:366-368).

2.4.2.2 The Means-End Heuristic

The mean-end heuristic comprises two components namely, dividing the problem into sub-problems and then reducing the gap between the initial state of the problem and the end state, by working on the sub-problems. In this approach, a person identifies the *ends* they want to achieve and then work on the *means* they will use to reach those ends. This type of problem-solving heuristic is seen to be effective and flexible. A good, everyday example given is using a stapler to fix the hem of a dress where an object is identified to fix the hem and then the object is located. In this approach there is flexibility in moving from the initial state to the goal state, and then moving back towards the initial state (Matlin 2009:368-369).

2.4.2.3 The Hill-Climbing Heuristic

This is a simple problem-solving strategy where, at every choice point, the person selects the best alternative that will lead to the goal. This strategy however can lead to solving short-term rather than long-term goals (Matlin 2009:371).

2.4.2.4 Individual Differences: Cross-Cultural Comparisons in Problem-Solving Strategies

Matlin (2009:371-373) mentions the study conducted by Güss & Wiley (2007) on university students to examine the relationship between culture and the problem-solving strategies of students in the United States, Brazil and India. Results of the study indicated that cross-cultural differences were relatively small. Differences were noted in Brazilian and Indian students who tended to use the free-production and means-end strategies, whereas American students preferred the analogy strategy. All three groups, however, rated the analogy method as being the easiest to apply. Matlin cautions readers that people may not have accurate insights into their cognitive processes, and may not be aware of the strategies they actually use when encountering problems to be solved.

2.4.3 Factors that influence Problem-Solving

Matlin (2009: 373) focuses on the interplay between bottom-up and top-down processing in problem-solving. Top-down processing refers to the cognitive processes that emphasize the influence of concepts, memory and expectations acquired from past experiences. In contrast, bottom-up processing involves cognitive processing that emphasizes the importance of information from the sensory receptors, i.e. the information that is received via the senses. For effective problem-solving to occur, both types of cognitive processing are required (2009:374). These two types of cognitive processing are discussed below.

2.4.3.1 Expertise

A person with expertise demonstrates consistently good performance on certain tasks within a particular domain due to their knowledge base, memory and problem-solving skills. When encountering problems with their field, they will usually employ the analogy and means-end heuristic approaches to arrive at the solution, using parallel processing, a term used to describe handling two or more items simultaneously. Experts exercise self-monitoring, a component of metacognition, a term used to describe knowledge and thinking about, as well as control of, one's own cognitive processes (Matlin 2009:376 & Glossary G9).

2.4.3.2 Mental Set

Mental set refers to a "fixed mind set" where a person is strongly guided by past experiences and fails to consider more effective solutions to his/her problems. An example is where a person believes that they have a certain level of intelligence and skills that cannot be improved upon for increased performance (Matlin 2009:376-377)

2.4.3.3 Functional Fixedness

Functional fixedness specifically refers to the way one thinks about physical objects. The functions and uses of that object remain fixed due to a person's thought processes involving concepts, expectations and memory, and may hinder the problem-solving process (Matlin 2009:377).

2.4.3.4 Insight versus Non-insight Problems

The concept of insight has been important to Gestalt psychology which emphasizes that humans have the basic tendencies to organize what they see and that the whole is greater than the sum of its parts. Gestalt psychologists argued that parts of a problem may be initially seem to be unrelated until a flash of insight helps to fit them together.

An insight problem is one that initially seems impossible to solve. After taking a break and returning to the problem it is usually able to be solved. This is known as *incubation* (Matlin 2009: 382). The concept of incubation identified by Wallas (1926) as part of his 4-stage model was discussed earlier (cf 2.3.1.2).

In contrast, non-insight problems are problems solved gradually, step by step, using a combination of memory, reasoning skills and a routine set of strategies.

Suggested strategies for solving insight and non-insight problems are to use top-down processing, a process that emphasizes concepts, experiences and memory acquired from past experiences when attempting to solve problems that are similar to previous problems solved. Problems that require insight require bottom-up processing that emphasizes information about the stimulus identified by our sensory receptors. In this case, there are no clear rules to solve the problem and one may need to 'think outside the box', abandon top-down assumptions and search for novel solutions. Metacognition, a term used to described knowledge and thinking about one's own cognitive processes and how to control these processes, will be used differently for insight and non-insight problems (Matlin 2009: 373 & 381-384).

2.4.4. Creativity

Matlin (2009:385) describes creativity as an area of problem-solving. Like the problem-solving tasks mentioned, creativity also requires moving from an initial state to a goal state. It is, however, considered to be more controversial than problem-solving due to its lack of standard definition. Unlike most other topics in cognitive psychology, the amount of actual research carried out on the topic of creativity has lagged behind the amount of research conducted on other topics in the field.

2.4.4.1 Approaches to Creativity

Matlin (2009:385-387) considers two contrasting viewpoints of creativity, namely Guilford's (1967) classic description of divergent production, and a contemporary perspective that focuses on the multiple components of creativity by Lubart and Guinard (2004) and Sternberg and Lubart (1995).

a) Divergent Production

Already mentioned is Guilford's idea of creativity. He proposed that creativity should be measured in terms of divergent production of ideas, i.e. the number of ideas emanating from a test item. This notion of creativity is supported by many contemporary researchers who advocate that creativity requires a divergence of ideas rather than one single best answer. A moderate correlation between test scores and other judgments about creative responses on tests of divergent production has been found. What these tests do not assess are their usefulness, novelty and high quality (Matlin 2009:387).

b) Investment Theory of Creativity

Well known in the field of creativity research is Sternberg who has edited and published books and articles on creativity research. (Kaufman & Sternberg 2010:xiii).

Matlin (2009: 387) makes reference to Sternberg and Lubart's investment theory of creativity. Based on the buy low, sell high investment advice from financial experts, the economic thrust of this theory is that creative people *invest* in and produce a creative idea when no one else is interested in the *investment.* Later, once the idea has become popular, these creative people move on to *invest* in another new creative project. According to Sternberg and Lubart, an analysis of the characteristics of these creative *investors* reveals that they have the following essential attributes:

i. Intelligence
ii. Knowledge
iii. Motivation
iv. Encouraging environment
v. Appropriate thinking style

Should a person have five of these characteristics but is of low intelligence, chances are that this person will probably not produce something creative (Sternberg 2001 in Matlin 2009:387).

Another characteristic of the investment theory is the focus on factors in the external environment. Runco (2007) points out that although people may have creative personal attributes yet lack a supportive work environment, they will not demonstrate creativity in the workplace (Matlin 2009:387).

c) Task Motivation and Creativity

Amabile (1996:3) is another creativity researcher who, as already mentioned earlier in this chapter, is well known for her research in the field of the social psychology of creativity. Matlin (2009:387-389) cites the research undertaken by Amabile and her colleagues in the area of task motivation and creativity, namely intrinsic and extrinsic motivation.

Intrinsic motivation is the ability to work on a task for its own sake due to the interest, appeal and challenge it holds for an individual. In contrast, extrinsic motivation is the motivation to work on a task not due to its interest, appeal or challenge, but due to a promised reward or chance of winning a competition. Intrinsic motivation is believed to be an enhancer of creativity whereas certain kinds of extrinsic motivation are seen to be a decreaser of creativity.

Research demonstrates that students tend to produce less creative work when they are working for external factors such as incentives, rewards, grades and surveillance by an external panel of judges. Their external motivation may be high, but their internal motivation often decreases and, consequently, their creativity is also likely to decrease. More in-depth studies on the role of motivation in creativity by Amabile and other researchers reveal that, although creativity is most often associated with intrinsic motivation and with the notion that extrinsic motivation can interfere with creative work, both can sometimes energize the creative person. It has been found that creativity can be enhanced if the extrinsic factors provide useful information (Matlin 2009:388-389; Runco 2007: 306-307).

According to Matlin (2009:389), however, extrinsic motivation does reduce creativity when it controls and limits choices, and has important implications for education and the workplace.

In the context of this research study it is important that foundation phase learners enjoy their participation in technological tasks, and that the technology teacher carefully plan an external reward system for learners that will not undermine their creative efforts.

2.5 CONCLUSION

Creativity is a topic of wide scope that has generated much research and debate among psychologists, educationists, economists, historians, sociologists, etc. Creativity can refer to people, processes, places and products. It can be found in geniuses and in young children. Although there are many definitions of creativity, most theorists endorse the view that creativity must refer to something new, is must be of high quality and it must be appropriate to the task at hand. Creative responses are, therefore, novel, authentic and relevant. Matlin views creativity as an aspect of problem-solving, a higher order cognitive process. In the context of this research, problem-solving is a key aspect of the technological (design) process in technology education and will be fully explored in the next chapter.

This chapter has explored the notion and nature of creativity as researched by a number of respected psychologists and researchers over the last few decades. An introduction to the basic concepts of creativity, and an analysis of some of the diverse theoretical perspectives on the topic, has been the focus of discussion. Matlin's model of problem-solving and creativity has been highlighted as a springboard for exploring the problem-solving and creativity in technology education.

The focus of the next chapter will be to explore the notion and nature of technology as a school subject, as it is taught in the foundation phase in schools. The value of this subject as a possible catalyst for driving and developing creativity in young learners will also be explored. The diverse theoretical perspectives discussed in chapter two will be used as a springboard for developing a creativity assessment model for technology.

Chapter 3

UNDERSTANDING TECHNOLOGY IN THE SCHOOL CURRICULUM

3.1 INTRODUCTION

The introduction of technology education as school subject in the South African school curriculum in 1998 marked a paradigm shift and breakaway from the traditional education approach which had focussed on passive and rote learning, to a new outcomes-based education (OBE) approach focusing on active learning and the development of critical reasoning and reflection. The subject was seen to relate directly to the goal of the Revised National Curriculum Statement (RNCS), namely to develop citizens displaying competencies and values encapsulated in the critical and developmental outcomes that underpin the RNCS (Department of Education 2002:1; Pudi 2007:13-18; van Niekerk, Ankiewicz & de Swart 2010:191; Stevens 2009:133).

Based on a philosophy of inter alia, constructivism and facilitative teaching, the constitutional underpinnings of the NCS were highlighted in the technology learning area. Aiming to provide learners with the opportunity to acquire and use knowledge in a purposeful way through creative problem-solving within authentic contexts rooted in real life situations outside the classroom (Department of Education 2002:5), this new learning area was seen to encapsulate all the necessary skills needed to prepare learners for the challenges of the 21st century. The philosophy of constructivism premised on the basic tenet that people construct, or give meaning to, the external world based on their experiences and interactions (Wilson 2009:45; van der Walle & Lovin 2006:1), added further credibility to this learning area. Its purpose was, inter alia, to equip learners with entrepreneurial skills which, in the long run, would prepare them for the world of work (Department of Education 2002:5). Drawing extensively on the pioneering of design and technology of the United Kingdom and other commonwealth countries such as Australia and New Zealand, technology was introduced into the South African General Education and Training band (GET) for learners from Grade 1 to 9 using the design process as a key focus, i.e. investigating, designing, making, evaluating and communicating (Stevens 2009:131).

A National Environmental Education Project for General Education and Training (NEEP) that aimed to facilitate environmental learning through the RNCS was introduced to highlight the importance of developing the environmental awareness of learners in schools. This project was in line with the critical outcomes of the South African Constitution, namely “that learners should use science and technology effectively showing responsibility towards the environment” and that they should “understand the world as a set of related systems” (Department of Education 2003a:1). With reference to the technology learning area, its definition was seen to include a consideration of environmental factors, as well as a problem-solving orientation that would significantly contribute to the competence of ‘environmentally -active’ learners (Department of Education 2003b:10).

Research on international developments in the field of technology as a subject in the school curriculum indicates that, although the 1990’s saw an international move to develop curricula in technology accompanied by research programmes and teacher training courses, the gains made seem to have been reduced. Due to constraints placed on educational authorities to balance literacy and numeracy initiatives with other competing subjects in the curriculum, the status of technology as a recognized school subject is fragile. Many countries and educational authorities still view it as a “fuzzy concept” (Jones, Buntting & de Vries 2013:191). Where it has retained a foothold, it has become associated with integrated studies, or part of a subcategory of other subject disciplines (Jones, Buntting & de Vries 2013: 206). This is evident in the refined and modified version of the South African NCS, in the Foundation and Intermediate Phase CAPS documents. (Department of Basic Education 2011e:14-16).

In recognition of the need to produce engineers, technicians and artisans, as well as the need to develop a technologically literate society for the modern world in which we live, the CAPS documentation describes technology as a subject that stimulates learners’ innovativeness and develops critical and creative thinking skills**.** It is defined here as “the use of knowledge, skills, values and resources to meet people’s needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration” (Department of Basic Education 2011d:8).

The focus of Chapter Three will be to discuss the origins and developing philosophy of technology, the nature of technology as a school subject, international developments in technology education and the value of technology as a subject in the Foundation Phase.

3.2 THE ORIGINS AND DEVELOPING PHILOSOPHY OF TECHNOLOGY

Technology has been at the centre of human experience for thousands of years. From the evolution of early humans that commenced with the making of simple tools to meet basic human needs, to the more complex technological innovations that continue to shape the 21st century, technology has influenced, and continues to influence, human life. Throughout history, people have used a combination of knowledge, skills and available resources to develop solutions to meet their needs and wants. (Department of Basic Education 2011d: 8; Headrick 2009: Editor's Preface; Pudi, 2007:44). Broadly speaking, technology may be described as the modification of the natural world for the purpose of fulfilling human needs and wants. (National Academy of Engineering & National Research Council, 2006:19).

The origins of technology can be traced back to the ancient Greeks. According to Hodgkin (1990) cited in Pudi (2007:36-37), the word *technology,* is derived from the Greek terms *tekhne,* which means art or craft, and *logia,* which means area of study. Thus, technology, according to the Greeks, refers to "the study, or science, of crafting". Feenberg (2009:159) draws a clear distinction between science and technology. He states that although they share a similar type of rationality based on "empirical observation and knowledge of natural causality", technology is concerned with usefulness rather than the truth. Technology seeks to control and science seeks to know.

Pudi (2007:159-160) and Feenberg (2009:159-160) further elaborate on the Greek origins of Technology, and describe the Greeks as interpreting the world in terms of the role of humanity in its endeavour to continuously transform nature. Using the distinction between nature and humanity, he cites the Greek terms *physis* and *poiésis*. *Physis* translates as nature, which the Greeks believed creates itself and emerges from itself. Apart from nature, however, other things in the world require human intervention to come into being such as *poiésis,* which translates as the practical activity of human production where artefacts, including products of art, craft and social convention, are created.

As a relative latecomer in education in countries during the last 15-20 years, the development of technology education has stemmed from the need to develop technologically literate citizens who can make a meaningful contribution to society. Living in a technological world has necessitated the need to educate future citizens about the importance of technology in everyday life (Jones & de Vries 2009:1). Countries such as Australia, the United Kingdom, the United States of America, Canada, Europe, South Africa and New Zealand, all include technology in the school curriculum (Jones 2009:13) .

Technological literacy aims to develop a particular kind of literacy that is important for living in a technological society. Not only do people need to be literate in reading and writing (the original meaning of the term ‘literacy’) and numbers (numerical literacy), they also need to be able to use and control technological devices and systems (technological literacy). Although domains in education, other than technology education, can be used to achieve this purpose, technological literacy is a particular focus of technology education (Jones & de Vries 2009:2). This view of technological literacy is endorsed by the South African Department of Basic Education which states that Technology, as a school subject, specifically aims to contribute towards learner’s technological literacy by providing opportunities to develop and apply specific design skills for solving technological problems. It also helps learners to understand the concepts and knowledge used in technology, and to realize the significance of the interaction between people’s values and attitudes, technology, society and the environment (Department of Basic Education 2011d: 9).

Feenberg (2009:159) draws a clear distinction between the philosophy of science and the philosophy of technology. He states that although science and technology share a similar type of rationality based on empiricism observation and knowledge of natural causality, technology is concerned with usefulness rather than truth. “Where science seeks to know, technology seeks to control. Jones, Bunting and de Vries (2013:192-194), elaborate further on the philosophy of technology, by identifying four main categories of interest namely, technology as artefacts, as knowledge, as activities, and as an aspect of humanity. All four categories have relevance for technology in the classroom, as follows:

a) Technology as artefacts

Research has shown that this is the first association that learners make when they hear or read the term ‘technology’. Generally, all project work carried out in technology education requires the making of an artefact or object. The dualistic nature of artefacts include a physical nature that represents the shape, size, weight, structure of number of parts, etc., and a functional nature that represents the functionality regarding its usefulness, usability, aesthetic and ethical correctness (Jones, Buntting & de Vries 2013:193).

b) Technology as knowledge

According to Jones, Buntting and de Vries (2013:193), technology as knowledge is relevant to technology education as it clarifies the nature of technological knowledge as being distinct from other subject knowledge such as the natural sciences. This distinction supports the claims for the need to have a distinct technological domain in the curriculum, as well as the need to develop appropriate teaching and learning strategies to develop knowledge of the subject. The knowing how nature of technological knowledge has implications for teaching, as such knowledge needs to be transferred by showing and doing, as opposed to reading about this knowledge in textbooks Developing learners’ knowledge of artefacts is not about what they do, but what they *ought* and *should* do. A relevant example from the researcher’s own experience in teaching technology to Foundation Phase learners was a Grade 3 project where learners were required to design packaging for a raw egg. The packaging needed to protect the egg, so that it could withstand the force of being thrown from a height of 20 metres. Learners were given the opportunity to investigate different types of packaging, and apply their knowledge of structures, to complete the task. Learners were, therefore, given the opportunity to demonstrate their knowledge of structures in a practical situation. According to Jeffrey and Woods (2009:81), knowledge that is owned is retained for a lifetime.

c) Technology as activities

Another category in the developing philosophy of technology is *technology as activities* (2009:193). Its relevance, in this context, lies mainly in the analysis of the design process which, according to the South African Department of Basic Education (2011d: 12), forms the backbone of technology as a subject in the school curriculum. According to Driscoll, Lambirth and Roden (2012:67), good technological practice includes the following:

- Play and exploration where learners gain knowledge and understanding of materials and their properties and of existing products.
- Short focussed practical tasks where learners acquire new skills.
- The formalisation and making of a design, i.e. making the product.

d) Technology as an aspect of humanity

This category highlights the importance of technology for technology education, as it gives direction to how technology is shaped by, and also shapes, human beings, human culture and society. There are different perspectives on the interaction between humans and technology. Feenberg (In Jones *et al* 2009:194) developed the theory based on the view that technology can be shaped so it contributes to desired social changes. The postmodern view sees technology as the perfect vehicle to blur the boundaries between that which is natural and artificial, living and non-living matter, etc.

All the above aspects of technology are closely intertwined. From the perspective of technology as artefacts, learners investigate already made artefacts to assist them in making their own artefacts. Technology as knowledge, enables learners to reflect on prior knowledge as they learn new knowledge while engaged in technological tasks. Technology as activities assists learners with the process of designing and making. Finally, technology as humanity sensitizes learners to the values that relate to the artefact they are designing and making (Jones, Buntting & de Vries 2013:194).

3.3 INTERNATIONAL DEVELOPMENTS IN TECHNOLOGY EDUCATION CURRICULA

During the last two to three decades, technology education has emerged as a subject in its own right, in many countries around the world. The traditional crafts and skills aspect of the subject have been broadened to include aspects of design and a conceptual understanding of technological literacy. In the majority of countries and/or provinces within countries, technology is offered, at different levels of schooling, in a variety of ways (Jones, Buntting & de Vries 2013:194). Table 3.1 encapsulates the emphasis of technology education, in the elementary and secondary grades, in different countries, including South Africa (Jones, Buntting and de Vries 2013:195).

TABLE 3.1 REPRESENTATIONS OF TECHNOLOGY EDUCATION EMPHASISED IN DIFFERENT COUNTRIES

Finland	**E/S**						
England			**E/S**				
Australia		**S**	**E/S**				
India		**E/S**		**E/S**			
South Africa			**E/S**			**S**	
Canada		**S**		**E**		**S**	**E/S**
France	**E**			**E**			**S**
Mainland China	**E/S**						**S**
USA					**S**		**E/S**
New Zealand							**E/S**
	Skills & gendered craft subjects	**Industrial arts and/or vocation-al training**	**Techno-logy informed by design**	**Techno-logy as applied science**	**STEM**	**Multiple techno-logies**	**Techno-logical literacy**

Code: E: Elementary – Years 1-8; *S*: Secondary – Years 9-12.

Research conducted in the ten countries highlighted above, reveals the identification of seven representations of technology education namely, skills and craft subjects, industrial arts/or vocational training, technology informed by design, technology as applied science, technology integrated with Science, Technology Engineering and Mathematics (STEM), multiples technologies and technological literacy (Jones, Buntting & de Vries 2013:194).

In Finland, technology education is viewed from a practical perspective. To date, the 143 year history of handicrafts education is reflected in Finnish schools. Whilst some schools and teachers have developed teaching in line with current international trends that emphasis the development of technology literacy, the majority still teach according to old models representing old technology. Handicrafts education which embraces the main responsibility for technology education has no national systematic guidance or authorized curriculum (Kananoja 2009:41).

In countries such as France, technology is interpreted as handicraft activities, or applied science at the elementary level, e.g. where learners are required to design and make a product after acquiring scientific knowledge. At lower secondary level, technology is focussed simulating industrial projects, such as analyzing needs, designing, producing and distributing. At senior secondary level, three strands of technology are offered, i.e. an academic programme with an option course of technological literacy, a technological programme with a compulsory technology component to prepare students for fields in higher education such as engineering and a vocational programme that directly links technology to specialist fields such as mechanical technology, components technology or biotechnology (Jones, Buntting & de Vries 2013: 194).

In Canada, there is also considerable variation in what is offered at different levels of schooling and in different provinces and territories. These variations range from a technology curriculum that aims to develop scientific and technological literacy within a 'technological world' to a focus on technological problem-solving, technological systems, history and evolution of technology, technology careers and technological responsibility (Jones, Buntting & de Vries 2013: 95).

The vocational emphasis in technology in some countries is politically driven, e.g. in Australia there is demand for skilled labour in areas of minerals, energy and other raw materials which has resulted in vocation education and training (VET), with a government commitment to include VET centres in all high schools (Jones et al 195).

In India, technology is recognized as a subject discipline with its own autonomy and is not merely seen to be an extension of science although, according to Natarajan and Chunawala (2009:106 & 107), it is within the three disciplines of science education, work experience and vocational education, that education in, and about, technology resides. Despite its recognition as a subject in its own right, According to these researchers, the craft tradition has stayed outside schools and, currently, those who produce wealth by working with their hands, often lack access to formal education (Natarajan & Chunawala 2009:105). Technology education is seen to pose a challenge to the educational community. It is perceived as a fluid and, somewhat ambiguous subject, where creativity and critical thinking are difficult to manage in classrooms and are difficult to assess (Natarajan & Chunawala 2009:115). India is, therefore, an example of a country which has moved towards notions of technological literacy in their rhetoric and curriculum guidelines, but not yet in their classroom practice (Natarajan & Chunawala 2009:105).

In England, design and technology has become a well-established subject in the primary and secondary school curriculum (Benson 2009:23). England has been a pioneer in emphasizing design as part of technology education, and much guidance has been given to schools on delivering the curriculum (Jones, Buntting & de Vries 2013:196). The recent release of the changes to the national curriculum in technology education, highlights the importance of the subject for children's learning, where the aim is to equip primary-age school learners for the future and raise the standards for the subject, e.g. in Key Stage 1, the focus will be to learn about knowledge such as structures and mechanisms and apply this knowledge when designing and making. The new curriculum draft is described as providing a clearer and more accurate picture of the essential characteristics of the subject with a focus on user, purpose functionality and innovation during the designing and making process (Pimley 2013:16).

In the United States of America, the 'Standards for Technological Literacy' clearly spell out what every student knows and should be able to do in order to be technologically literate. Encapsulated in these standards are five categories which include the nature of technology, technology and society, design, developing ability for the technological world, the designed world and a strong call for technological literacy for all. Federal and state rhetoric promote science, technology, engineering and mathematics (STEM), a shift seen as contributing towards economic development (Jones, Buntting & de Vries:196).

In New Zealand, technology education was introduced as a separate subject in 1995, followed by the publication of an enhanced curriculum in 2007. The aim is to develop technological literacy through technological practice, technological knowledge and the nature of technology. The key to successful planning has been the stable funding by the Ministry of Education and the Ministry of Economic Development, for professional development and other educational incentives in teaching the subject (Jones, Buntting & de Vries 2013:196).

3.4 THE NATURE OF TECHNOLOGY IN THE SOUTH AFRICAN SCHOOL CURRICULUM

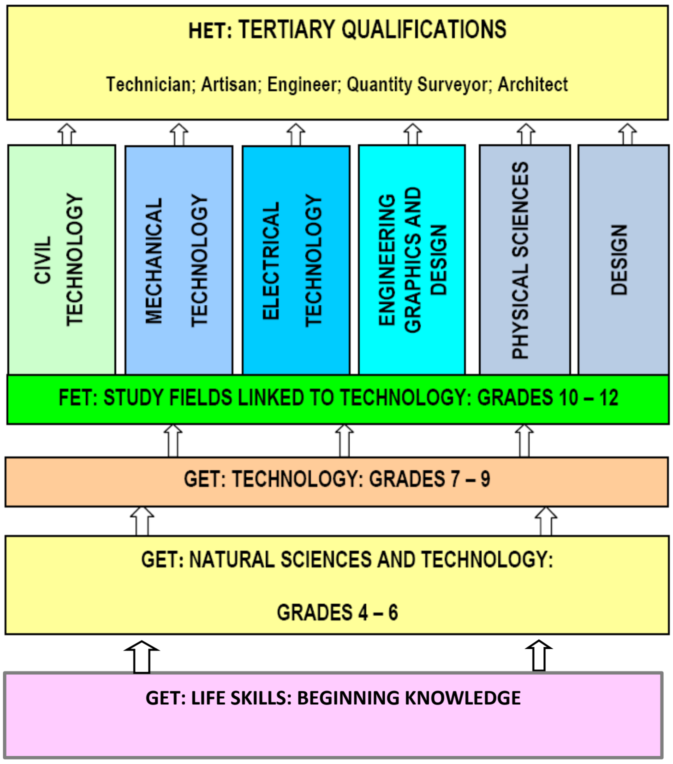
The unique features of technology make it a popular subject with young learners who find it exciting and fun (Driscoll, Lambirth & Roden 2012:67). The Department of Basic Education describes the unique features and scope of the subject as one which provides learners with the opportunity to do the following (2011d: 10):

- solve problems in creative ways;
- learn within authentic contexts that are rooted in real life situations outside the classroom;
- combine thinking and doing by linking abstract concepts with concrete understanding;
- work in collaboration with others;
- engage in practical projects using technological (design) skills such as investigating, designing, making, evaluating and communicating, that incorporate different learning styles;
- acquire and use knowledge in a purposeful way;
- deal with human rights, inclusivity and social and environmental issues during technological tasks;

- use a variety of life skills such as problem-solving, identifying needs, decision-making, critical and creative thinking and cooperation;
- create positive attitudes and perceptions towards technology-based careers.

The facilitation of technology as a subject varies according to the different phases in the General Education and Training (GET) Band (Grades R to 9) and the Further Education and Training (FET) Band (Grades 10 to 12). Figure 3.1 depicts this variation. For the purpose of this research, the diagram has been modified to include technology as an aspect of Beginning Knowledge, one of four areas of study, in the Life Skills subject in the Foundation Phase (Department of Basic Education 2011b:9).

FIGURE 3.1 TECHNOLOGY IN THE SOUTH AFRICAN SCHOOL CURRICULUM



Source: Adapted from the Department of Basic Education 2011d:9

3.4.1 Life Skills: Beginning Knowledge (Grades R to 3)

The Department of Basic Education describes the life skills subject as being "central to the holistic development of learners", i.e. personally, intellectually, physically, emotionally and socially (Department of Basic Education 2011b:8). Comprising four study areas, namely beginning knowledge, personal and social well-being, creative arts and physical education, the life skills subject has been organized to develop learners' foundational concepts, skills and values of early childhood development, as well as the foundational concepts, skills and values of those subjects offered in the Intermediate Phase curriculum.

Life skills is regarded as a "cross-cutting" subject, that aims to support and strengthen the other core subjects offered in the Foundation Phase curriculum, namely Home Language, First Additional Language and Mathematics (Department of Basic Education 2011b:8).

The content and concepts of the beginning knowledge area of study are drawn from the subject disciplines of the natural sciences and technology which are combined and integrated, and the social sciences, comprising history and geography. Key concepts and skills related to the discipline of technology include the technological process skills of investigating, designing, making, evaluating and communicating. Key concepts and skills related to the discipline of the Natural Sciences include the scientific process skills of observing, comparing, classifying, measuring, experimenting and communicating (Department of Basic Education 2011b:8). Instructional time for Beginning Knowledge as a whole is 1 hour per week for learners in Grades R, 1 and 2 and 2 hours per week for learners in Grade 3 (Department of Basic Education 2011b:6).

3.4.2 The Natural Sciences and Technology in the Intermediate Phase (Grades 4 to 6)

In the Intermediate Phase, the subject disciplines of the natural sciences and technology are integrated into one subject with the purpose of developing learners' knowledge and understanding of the natural world and the man-made environment. The purpose is discovery through investigation and the making of products through design, invention and production using investigative and logical processes and practical oriented processes, respectively. In Natural Sciences the knowledge strands comprise life and living, matter and materials, energy and change and planet earth and beyond. In technology the knowledge strands comprise structures, processing and systems and control (Department of Basic Education 2011c:9–10). Instructional time for Natural Sciences and Technology in the Intermediate Phase curriculum is 3.5 hours per week (Department of Basic Education 2011c:6).

3.4.3 Technology in the Senior Phase (Grades 7 to 9)

In the Senior Phase technology is recognized and taught as a subject in its own right. The intention is to introduce learners to the basics of civil technology, mechanical technology, electrical technology and engineering graphics and design, as well as developing their understanding of how scientific principles are applied to solve practical problems. In addition, learners are introduced to the design and production of products involving subjects which are fields of specialization in the Further Education and Training Phase, such as consumer studies and design. Instructional time for technology in the Senior Phase is 2 hours per week (Department of Basic Education 2011d:7).

3.4.4 Technology in the Further Education and Training (FET) Phase (Grades 10-12)

In the Further Education and Training (FET) Phase (Grades 10 to 12), technology is grouped with Engineering as an organized field of learning (Department of Basic Education 2011E4:59). Within this field of study, technology is an elective subject that provides a choice of specialization in fields of study such as Civil Technology, Mechanical Technology, Electrical Technology and Engineering Graphics and Design (Department of Basic Education 2011d:9: Department of Basic Education 2011e:10-11).

Also included in the field of technology specialization in the FET Phase is Design, which forms an area of study in the Culture and Arts field of learning (Department of Basic Education 2011a:8 & e:10). The concept of design is implicit in the design process of investigate, design, make and evaluate in technology (Department of Basic Education 2011d:11). The importance of design is discussed in 3.5 of this chapter.

3.5 TECHNOLOGY AND THE IMPORTANCE OF DESIGN

All manufactured products go through a process of design (2011d:11). Design is described as a creative problem-solving process which involves identifying problems, planning, researching, innovating, conceptualizing new ideas, and experimenting. It equips learners with important life skills such as visual literacy and critical and creative thinking (Department of Basic Education 2011a:8).

Careers such as civil engineering, architecture, structural engineering, etc., all use the process of design in developing solutions to problems, needs or wants. Characteristics of designers are described as, inter alia: the need to understand problems; needs or wants; knowledge of the design process; an ability to sketch initial ideas and develop sufficiently detailed working drawings; practical skills to create a solution and the ability to present solutions to customers/clients (Department of Basic Education 2011d:11).

3.5.1 Technology and the Design Process

According to the Department of Basic Education (2011d:11), the design process of investigating, designing, making, evaluating and communicating (IDMEC), forms the backbone of technology as a subject. They state that the starting point in the design process is the need for learners to be exposed to problems, needs or opportunities. This is followed by the systematic process of developing solutions that solve problems, resolving design issues and satisfying needs. The design process is described as a creative and interactive approach that is used to develop solutions to identified problems or needs. Through this process, the specific aims of technology are realized, namely to develop learners' technological literacy by providing them with the opportunity to do the following:

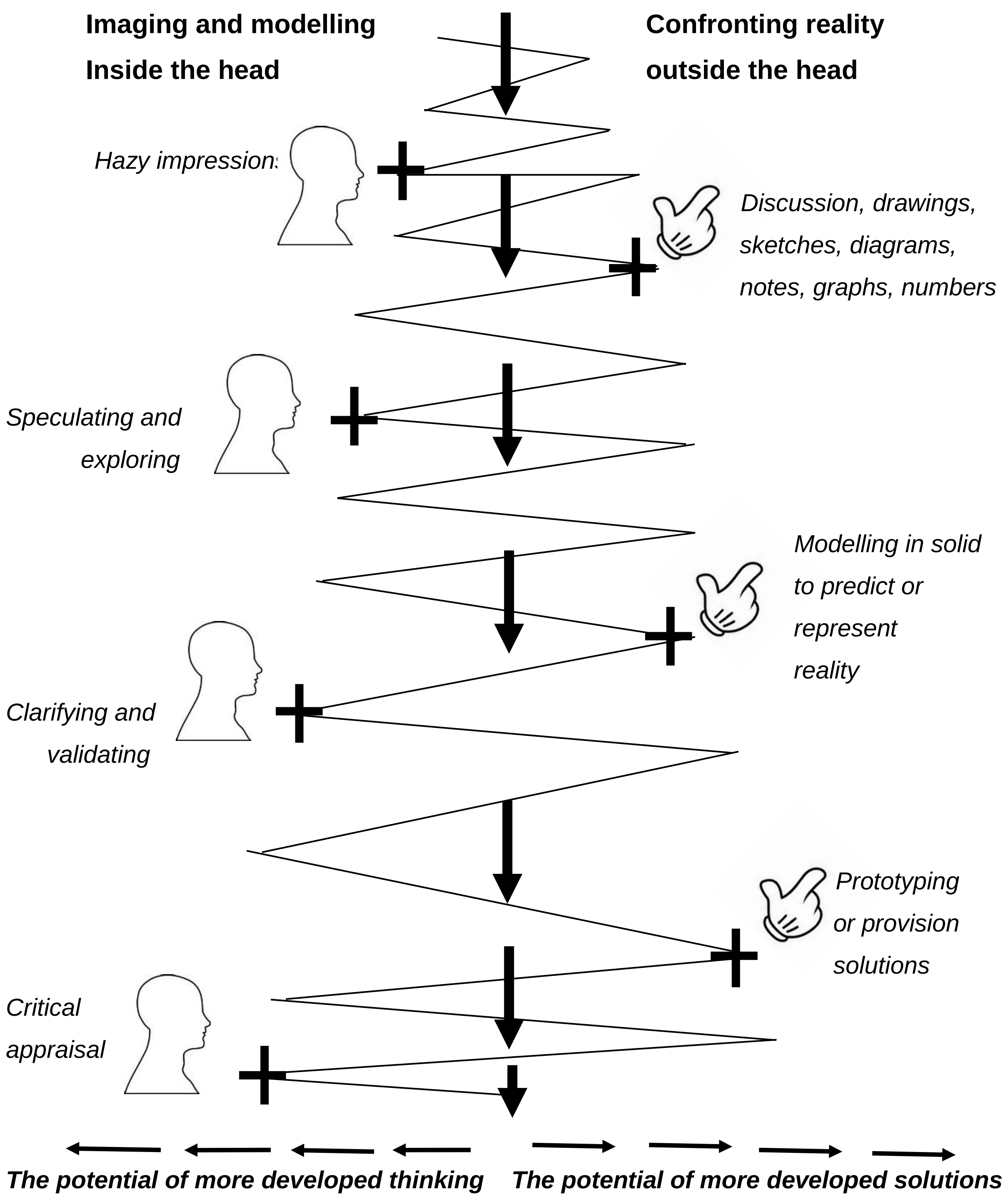
- Develop and apply specific design skills to solve technological problems;
- Develop an understanding of the concepts and knowledge in technology and apply them responsibly and purposefully;
- Appreciate the interaction between human values and attitudes, technology, society and the environment.

(Department of Basic Education (2011d:10 & 74).

The design process, also known as the technological process, is usually regarded as a cyclical (non-linear) process driven by evaluation, i.e. evaluation at each step of the process determines the next step (Department of Basic Education 2011d:10& 67-68 & 74; Mioduser 2009:393; Potgieter 2007:76).

In 2002, design and technology was a relative newcomer to the National Curriculum in the United Kingdom. The cyclical nature of the design process as described by researchers in the field reveals a variety of similar cyclical, iterative process models (Fasciato 2000:29-35). Of note, is the Assessment Performance Unit (APU) model proposed by Kimbell and Stables, in the '90's (Kimbell 1997:20; Stables 2002:132-133). The model is based on a research project undertaken to investigate performance in design and technology. They developed a process model of design and technology that viewed designing as an activity in which steps were governed by responding to the developmental needs in a technological activity, rather than the steps being prescribed in advance. The iteration of thought (the mind) and action (the hand), was proposed as the driving force of technological activity. Through the iteration of the mind', and 'the hand', ideas could be taken from their fuzzy beginnings to a tried and tested outcome (Stables 2002:133). The described this process as iterative, "where ideas are bounced back and forth, formulated, tested against the hard reality of the world and then reformulated." Their model and the research underscored the fact that an iterative process is at the core of design and technology activity. Being able to operate procedurally is seen to be the key to capability in all design and technological endeavours which has implications for pedagogy and assessment if both are to support the development of student capability (Cross 1998:9-10; Kimbell 1997:28-30; Stables 2002:132-134).

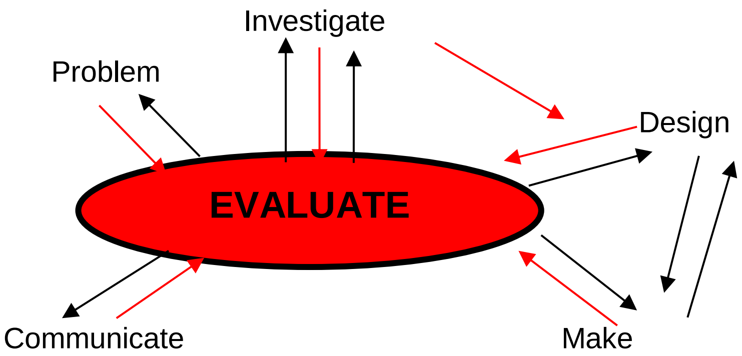
FIGURE 3.2 THE INTERACTION OF MIND AND HAND



Source: Adapted from The APU model of interaction between mind and hand (Kimbell, Stables, Wheeler, Wozniak & Kelly 1991 cited by Stables in Sayers, Morley and Barnes 2002:133).

The model in Figure 3.2 correlates with the design process model developed by the Department of Basic Education (2011d:10 & 74), depicted in Figure 3.3.

FIGURE 3.3 THE DESIGN PROCESS



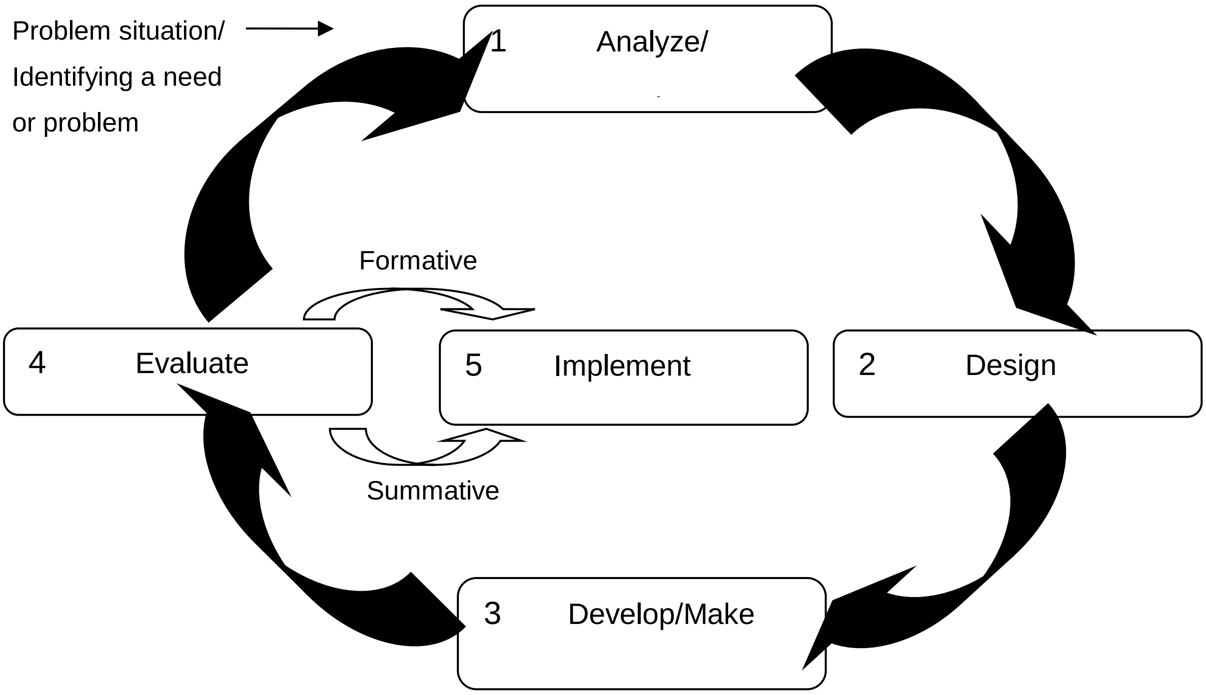
Source: Department of Basic Education (2011d10 & 74)

Mioduser (2009:392-394) states that technological problem-solving (TPS) has been a subject of study for many years. Central to this study is the design process which includes a number of multiple procedures and clearly defined actions that are used generate technological solutions. When facilitating technological tasks with learners the focus of the design process is about thinking, learning, making decisions and finding solutions, i.e. the process embraces a set of cognitive resources and processes. Not only is design about making, but it is also about generating knowledge about how to make, how to solve a problem and how to improve ways to solve the problem. According to Mioduser (2009:394), recent research findings indicate that learners' problem solving is similar to the approach used by expert designers or technology practitioners, e.g. they begin with exploring materials, then they begin building and then they evaluate the results. Learners also appear to engage in continuous reformulation of interim goals while developing a technological solution. Implicit knowledge observed in their actions which cannot be easily verbalized, seems to be developed as they work through the technological process. The whole design process appears to be iterative and cyclical where evaluation is a driving factor for initiating or concluding the design process, rather than linear and ordered. This research supports the design process as outlined by the South African Department of Basic Education (Department of Basic Education 2011d:9 and 11).

Although there are different views on what the different phases in the design process should be, there are certain common elements that can be identified, namely that having identified a problem, learners establish the needs to be met, carry out the investigation, detail specifications and plans, and make the design while evaluating different steps/phases at each stage. These common elements can be classified as a systematic or structured approach to problem-solving. (Fasciato 2000:31; Garratt 1996:96-9; Mioduser 2009:393); Potgieter (2007:76),

Figure 3.4 is an adapted version of the systematic approach of the design process as perceived by Potgieter (2007:77), an approach that includes continuous evaluation and improvement. This systematic approach corresponds to the design process outlined by the Department of Basic Education in Figure 3.3 (Department of Basic Education 2011d:10 & 74).

FIGURE 3.4 THE DESIGN PROCESS: A SYSTEMATIC APPROACH



Source: Adapted from Potgieter 2007:77

3.5.1.1 The Design Process Skills Explained

The researcher has adapted the design process models developed by Potgieter (2007:77-97) for the Foundation Phase.

a) Investigate

In technology, investigation is an important starting point that includes researching or finding out more about the problem to be solved. The systematic design model designed by Potgieter (2007:77) includes the term "analysis", while the design model developed by the Department of Education which is depicted in Figure 3.2 uses the term "investigate" (Department of Basic Education 2011d:12). The latter term will be used in this research.

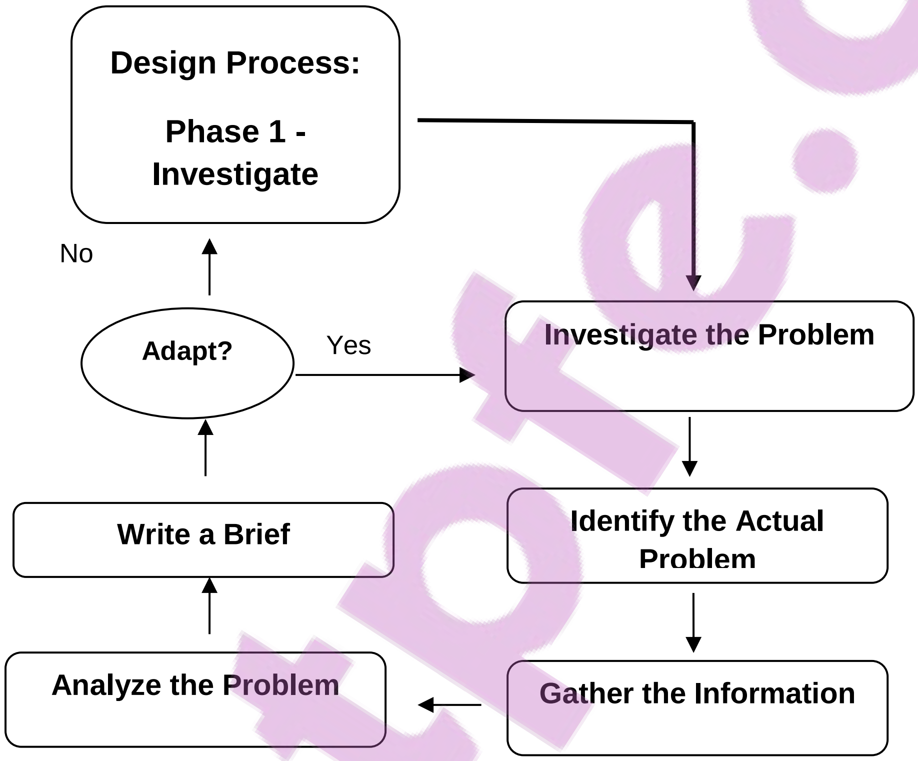
The process of investigating in technology requires learners to investigate everyday problems in the context of their life world, and to identify needs and wants of society. Investigating can happen at any point in the design process, although technological projects usually commence with investigation as the first step in the design process. When carrying out investigative tasks, learners are given the opportunity to investigate key aspects of existing and ready-made designed products and to carry out practical tests to determine their functionality, "fitness for purpose" and suitability against predetermined idea. They are also given the opportunity to explore attitudes and values and develop their own informed opinions about contexts and needs that will assist them in making their own value judgments. It is during this first phase of the design process, namely investigating solutions to problems, that information is gathered, concepts are grasped and investigative skills such as accessing and processing information, recording ideas, predicting outcomes and classifying information are used to gain information. Learners learn about the topic under investigation through collecting information, finding out about new techniques, etc. (Department of Basic Education 2011d:12 & 74; Garratt 1996:10; Potgieter 2007:78-81).

Figure 3.5 depicts phase one of the Design Process, namely investigating the problem, need or want which include the following components:

- Investigating the existing problem.

- Identifying and clarifying the actual problem, need or want.
- Gathering information about the actual problem, need or want.
- Analyzing the problem, need or want.
- Writing a short brief/report stating the problem, need or want and identifying the constraints which may influence decisions made regarding the possible solution.
  (Potgieter 2007:79)

FIGURE 3.5 THE DESIGN PROCESS PHASE ONE- INVESTIGATING THE PROBLEM



Source: Adapted from Potgieter (2007:79).

b) Design (verb)

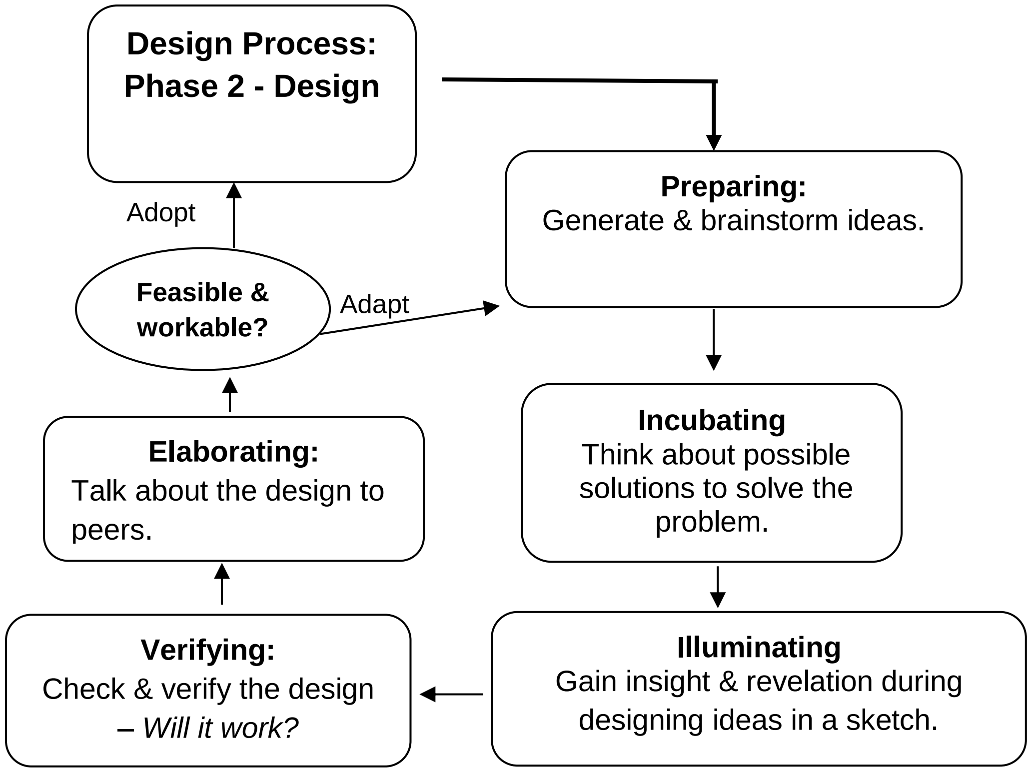
The term "design" implies the generating of solutions to problems. Once a problem has been fully analyzed and researched, learners are required to write a short statement describing how they will go about solving the problem. This may entail developing more than one solution to the problem (Department of Basic Education 2011d:56; Garratt 1996:10; Potgieter 2007:81-86).

During this second phase, solutions are usually sketched on paper. Knowledge of graphics such as the use of colour and rendering techniques such as shading, two dimensional (2D/flat drawings that reflect two dimensions, e.g. length and height, and three dimensional (3D/pictorial drawings that reflect three dimensions, e.g. length, height and depth) drawings, are used to communicate solutions to problems (Department of Basic Education 2011C3:56; Garratt 1996:14; Potgieter 2007:88-89; Termorshuizen, Thatcher and Thomson 1997:160).

Research conducted on the design process support the notion that it is particularly during phase two of the design process, namely “design”, that the complex process of innovative and creative thinking occurs. Finding and generating ideas such as “What might it be?” and “What might it look like?” are examples of the open-ended nature of technology where the pathway to the solution is open. These are the conditions that promote creativity and are seen to be creative thoughts that exist in the imagination (Cropley & Cropley 2010b:345; Davies & Howe 2009:164-165; Hope 2006 cited in Archer 2012:67; Potgieter 2007:82-88).

Phase two of the design process can be depicted as a cyclical and creative process. The design phase developed by Potgieter (2007:92) has been adapted and is depicted in Figure 3.6.

FIGURE 3.6 THE DESIGN PROCESS PHASE TWO - DESIGNING AND PLANNING A SOLUTION TO A PROBLEM



Source: Adapted from Potgieter (2007:83).

Designing and developing solutions to problems as illustrated in Figure 3.5 highlights important aspects of thinking that take place during the preparation phase. Potgieter (2007:83) highlights the research of Starko (1995) who lists the following important aspects in the preparation of designing that need to be emphasized, fostered and supported when generating and examining ideas:

- Fluency, i.e. generating many ideas.
- Flexibility, i.e. thinking of varied ideas.
- Originality, i.e. thinking of unusual ideas.
- Elaboration, i.e. adding to ideas to improve and expand on them.

It should be noted that the above aspects in the preparation of designing are cited in creativity research as criteria for divergent thinking and are, therefore, regarded as important creative skills (Guilford (1950) citied in Weisberg 2006:464; Plucker &

Makel 2010:53). Davies and Howe (2009:165) cite research conducted by Dust (1999) who proposes that at least four phases of creativity may be commonly identified during the creative process. Davies and Howe (2009:165) correlate these phases that children might undertake during the course of a design and technology (D & T) project, as follows:

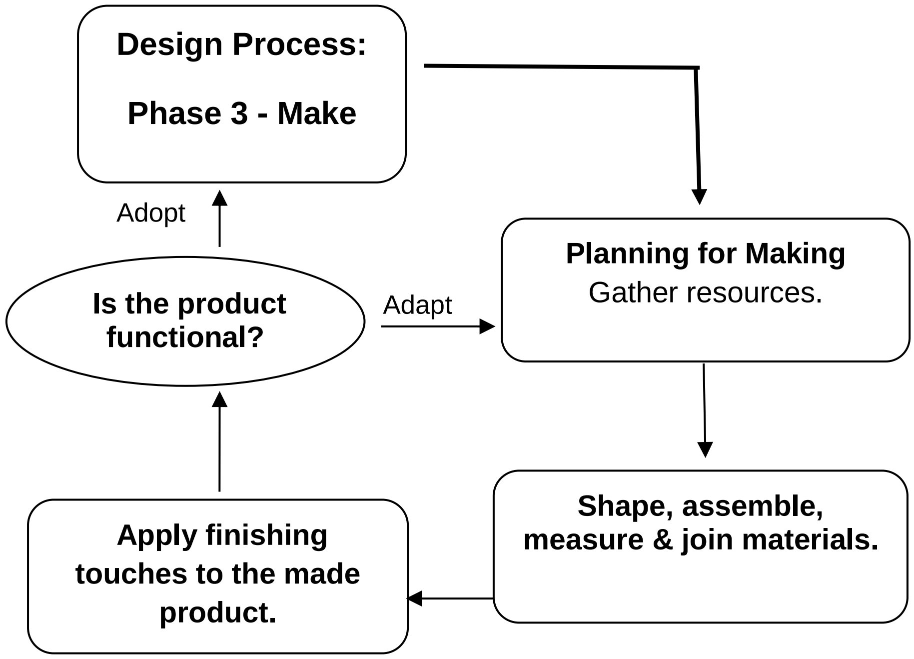
- *Preparation* – Investigating a problem and gathering information, e.g. primary school learners investigating the workings of many vacuum cleaners to measure their loss of suction as the vacuum cleaner bag fills up with dust and dirt.
- *Incubation* - A subconscious stage that involves learners' time away from the task and doing unrelated tasks. Their minds are still aware of the problem, and they will seek to connect everyday activities with the problem task .e.g. observing water flowing down plug hole in a bath.
- *Illumination* – This is the insight and revelation to the problem – a moment of creation, e.g. learners making mini-tornadoes, one inside the other, which would suck air into a vacuum cleaner.
- *Verification* – This is the testing of the outcome with peers or others in the field, e.g. making a prototype and communicating their findings with the rest of the class.

It is also appropriate to mention here that Matlin (2009:382) cites incubation as an aspect of problem-solving which is regarded by many people as helping them solve problems creatively. People who support this view believe that by taking a break after being unsuccessful in solving a problem and then returning to the problem, one is more likely to solve the problem creatively, as opposed to working on a problem without interruption. It is also worth mentioning Wallas' four stage theory research on creative processes (1926) cited by Richards (2007:201). These stages of creative thought correlate to Dust's research (1999) cited by Davies and Howe in the previous paragraph.

c) **Make (verb)**

In this phase of the design process, learners use tools, equipment and materials to make and develop their solutions to the identified problem. As they make and build their product according to the design brief, they evaluate and modify their creations accordingly. Learners learn how to cut, join, shape, combine, assemble, measure etc., and work safely in a healthy environment (Department of Basic Education 2011d:68). Figure 3.7 depicts phase three of the design process, namely making the product.

FIGURE 3.7 THE DESIGN PROCESS PHASE THREE – MAKING A PRODUCT OR PROTOTYPE OF THE SOLUTION



Source: Adapted from Potgieter 2007:92.

In the making phase, learners are required to plan how they will make their product/prototype. Their work needs to be organized and appropriate materials and tool and techniques for making need to be selected and they need to work safely. Learners need to handle, assemble and join materials and apply finishing touches, while aiming at a high level of precision to ensure that their products are durable and functional (Newton 2005:31-35).

d) Evaluate

What has been made needs to be evaluated, and learners need to evaluate their actions, decisions and results during the design process. Although learners continually evaluate what they are designing and making during the design process, a final evaluation of the completed product is undertaken during the evaluation stage. Changes and improvements are suggested, and evaluations are made in the light of suggestions that are given or self-generated, using probing questions, careful analysis and testing (Newton 2005:36; Department of Basic Education 2011d:68).

Continuous (formative) evaluation is integral to the design process and occurs during all stages of the design process. The evaluation process should be directed at positive outcomes such as striving for quality, continuous improvement of the design and adapting alternative methods to changing circumstances. Summative evaluation is the evaluation procedure applied at the end of the project when the product/prototype is completed (Potgieter 2007:93). Evaluation is an important part of the design process for young learners who need to learn to reflect on what they have done and appraise their own work, as well as the work of their peers (Davies & Howe 2009:164-165; Newton 2005: 36-38).

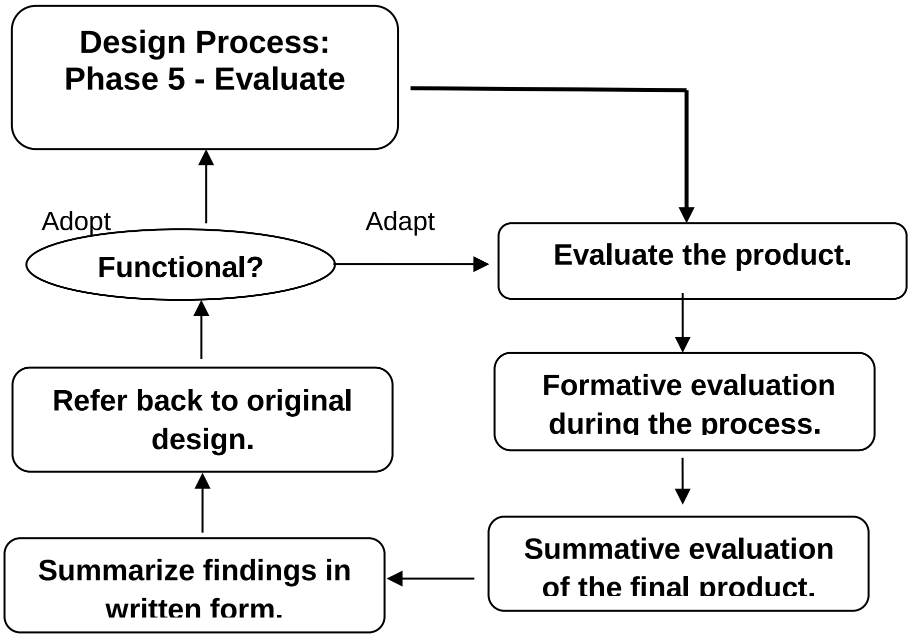
A few aspects to consider during the evaluation process are the following:

- Appropriateness – Does the design meet the requirements of the problem, need or want?
- Functionality – Does the design meet the operational criteria?
- Aesthetics – Is the design appealing to the eye?
- Ergonomics – Is the design efficient and safe for people?
- Ecological factors – Does the design pose a threat to the environment?
- Energy usage – Does the design make economical use of energy resources?
- Recyclability – Does the design make use of recycled materials?
- Cost – Is the design cost effective and relative to market needs?

(Garratt 1996:17-21& 39-43; Potgieter 2007:94-95)

Figure 3.8 depicts phase four of the design process, namely evaluating the made product.

FIGURE 3.8 THE DESIGN PROCESS PHASE FOUR - EVALUATING THE MADE PRODUCT



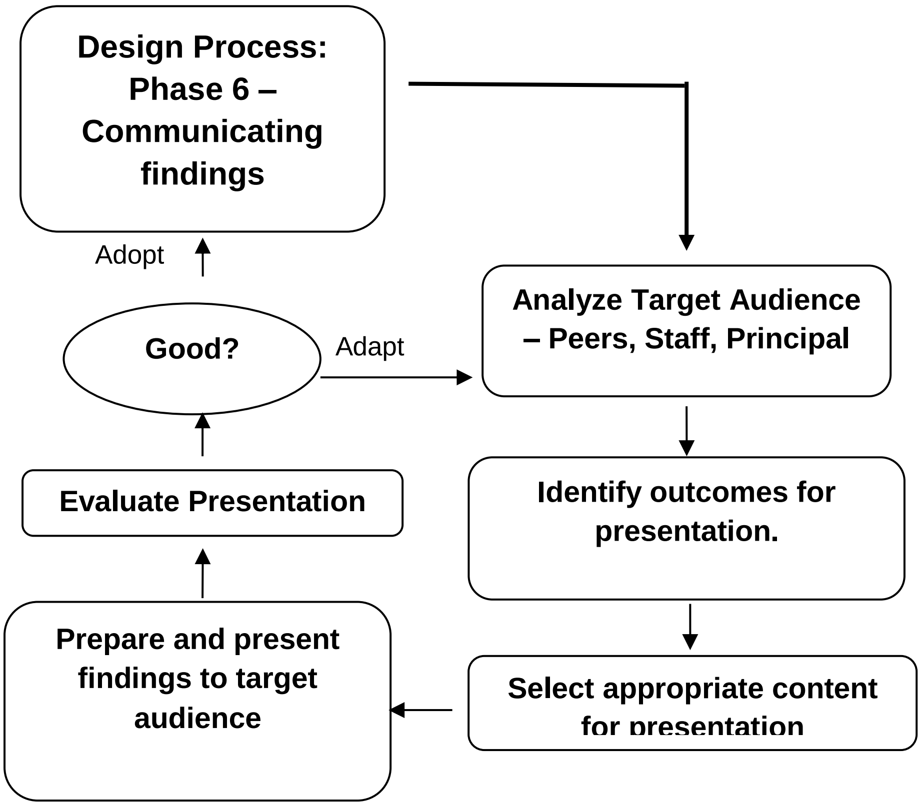
Source: Adapted from Potgieter (2007:95).

e) Communicate

Communication is the last phase in the design process where learners are given the opportunity to communicate and share their findings with others. In this stage of the design process, assessment evidence is provided by learners, i.e. the ability to analyses, investigate, plan, design, draw, evaluate and communicate. Learners may communicate their findings through various modes of feedback, i.e. oral, written or electronic. Other records such as a project portfolio that records the design process from start to finish, i.e. the conceptualization of the problem to its solution, may also be used to communicate findings (Department of Basic Education 2011d:68-69).

Figure 3.9 depicts the final stage of the design process, namely communicating.

FIGURE 3.9 THE DESIGN PROCESS: PHASE FIVE – COMMUNICATING THE FINDINGS



Source: Adapted from Potgieter (2007:97).

According to Potgieter (2007:97), there are a number of presentation techniques and media that can be used to communicate information to others such as posters, transparencies, pamphlets, brochures, drawings and diagrams. However, they all do need to be carefully planned and presented for effective communication. In the Foundation Phase learners are quite capable of communicating to their peers and teachers regarding their evaluation of products made in the form of oral presentations, posters, drawings and diagrams. In the Foundation Phase, learners can prepare a short talk to their peers and teacher highlighting key aspects of their findings during the different stages of the design process.

3.6 CONCLUSION

This chapter has attempted to explore the notion and nature of technology as school subject in the South African School Curriculum from Grades R to 12, as well as the developing field of technology in other countries. In the context of the South African school curriculum, the notion and nature of creativity which was explored in the previous chapter, has been briefly alluded to in this chapter, as being an inherent factor in the design process of technological endeavours.

The next chapter will focus on the aims of the research project, the research design and methods used to carry out the research project. The development of a Creativity Assessment Model for Technology, based on Matlin's problem solving and creativity theory (2009:355-391), will be used as a springboard to identify and measure the variables of creativity that appear to be inherent in the design process. The proposed model will be discussed in chapter five.

Chapter 4

RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The preceding chapters have attempted to provide an important background to the investigation in this research. Chapter Two examined the notion and nature of cognition and creativity and highlighted the key concepts in the field of creativity research. Matlin's Model of Cognition has been used as a springboard for exploring the mental process of problem-solving and the role of creativity as an aspect of the problem-solving process. Chapter Three examined the nature of the subject technology in the South African school curriculum. The subject was described as one which develops learners' creative and critical thinking skills by providing them with the opportunity to solve problems in creative ways.

Chapter Four presents a description of the research methodology and research design used in this investigation

4.2 A THEORETICAL BASIS FOR QUALITATIVE RESEARCH

McMillan and Schumacher (2010:8) define research as "the systematic process of collecting and logically analyzing data (i.e. evidenced-based) for some purpose." Research methods or methodology are the ways in which data is collected and analyzed in order to acquire knowledge that is reliable and verifiable. Research methodology is purposeful and systematic, and is a design whereby the researcher selects procedures for data analysis and collection to investigate a particular research problem.

Cohen, Manion and Morrison (2011:3) state that in the search for truth, people have, focussed for many years on trying to come to grips with their environment in order to understand the nature of phenomena perceived through their senses. This they do through experience, reasoning and research. The layman's personal experience which is based on common sense knowledge is in stark contrast to the scientist's rigorous, systematic and empirical testing of hypotheses, where explanations are rooted in fact. Cohen, Manion and Morrison (2011:4) cite three types of reasoning that are used by people to comprehend their world, namely the Aristotelian model of deductive reasoning, Bacon's model of inductive reasoning and a combined deductive-inductive approach. Deductive reasoning may be described as applying general principles to make specific predictions, whereas inductive reasoning may be described as using specific observations to develop generalizations. A combined deductive-inductive approach, therefore, uses both methods of reasoning where the researcher is involved in a reciprocal process of deduction (from the hypothesis to its implications) and induction (from observation to hypothesis). By using the combined approach to reasoning, hypotheses can be rigorously tested and, if necessary, revised. The final quest in the search of truth is research which combines both experience and reasoning and thus makes it the most successful approach in uncovering the truth.

According to Corbin and Strauss (2008:16), reasons for opting to do qualitative research is to move beyond the known and to enter into the world of the participants in order to see the world from their perspective, and make discoveries that will contribute to the development of empirical knowledge

According to Maree (2007:50-51), qualitative research has become an important research paradigm based on the emerging world-view that research is more than just a means of verifying or refuting theory. It is a means whereby theory can be generated and developed. According to Maree (2007:51), qualitative research as a research methodology focuses on understanding social and cultural contexts and processes that underpin various patterns of behaviour patterns in society. This it does by observing and interacting with participants in their natural environment. The focus is on meanings and interpretations gained, with an emphasis on depth and quality of information gathered. It is more subjective than quantitative research which is more objective and nomothetic (focussed on general laws), and adopts a constructivist approach, which are concerned with the uniqueness of particular situations (idiographic). Qualitative research focuses on understanding phenomena within their naturally occurring setting, i.e. within a naturalistic context, and seeks to "through the eyes of the participant".

According to Given (2007:xxix), qualitative research methods are central to conducting research in education, nursing, sociology, anthropology, information studies as well as in the humanities and social and health sciences disciplines. Different methods are selected to examine the human elements of a particular topic selected such as how people experience and perceive their world.

Qualitative research is about working with text. Methods used to collect data such as interviews or observations require the recording and transcribing of information into text which is then analyzed. In a nutshell, the qualitative research process is described as representing "a path from theory to text" and "as another path from text back to theory", with the point of intersection being the collection of verbal and visual data (Flick 2009:4). It is an in-depth study that uses face-to-face or observation techniques to collect data from people (McMillan & Schumacher 2010:489). The collection, analysis and interpretation of extensive narrative and visual data are used to gain insights into particular phenomena of interest to the researcher in a naturalistic setting. Due to the fact that qualitative researchers conduct research in a naturalistic setting, it may also be referred to as naturalistic research. The nature of this type of research requires its users to use qualitative methods that require in-depth probing and close participation with a small number of participants. Time-intensive data collection methods such as interviews and observations are used, and data analysis is inductive, i.e. it involves the researcher developing generalizations based on the observations of a limited number of related events or experiences. Inductive analysis involves the researcher categorizing and organizing information into patterns to produce a descriptive and narrative synthesis (Gay, Mills & Airasian 2009:7).

4.2.1 Selecting Case Study as a Qualitative Research Method

The case study is one of several methods of conducting social science research. Other methods include experiments, surveys, histories and archival analyses (Yin 2009:2 & 8). There are many definitions and descriptions of case study as a research method. Yin (2009:18-19) defines the case study research method as an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and one which uses multiple sources of evidence.

Creswell (2012:465) states that the term “case study” is often used in conjunction with ethnography which literally means “writing about groups of people.” (Creswell 2012:461). Case study researchers focus on in-depth exploration of the actual “case” (Yin 2008: In Creswell 2012:465). The “case” may be a single individual, several individuals separately, or in a group, and may represent a process consisting of a series of steps, e.g. a curriculum process that forms a sequence of activities Creswell 2012: 465). The case study research method has been used for a number of years across a variety of disciplines to answer “how” and “why” questions. It opens the opportunity to give a voice to the powerless and is deemed essential for researchers in their task of gainer a deeper understanding of the dynamics of the situation at hand Nieuwenhuis 2009:75).

Yin (2009:14-16) cites the traditional prejudices against the case study method of research with the greatest concern being levelled at the perceived lack of rigour of this method of research where systematic procedures have not been followed or where biased views have influenced the direction of the findings and conclusions. Another criticism levelled against the case study method is that it provides little basis for scientific investigation, e.g. a frequently raised question is: “How can you generalize from a single case?” A third concern is that they are time-consuming, especially participant observation. The fourth objection to case studies is the renewed emphasis on “true experiments” which aim to establish causal relationships, i.e. where a particular “treatment” has effectively produced a particular “effect”. Non-experimental methods such as the case study method cannot directly address this issue. Yin (2009:16) argues that case studies can offer important evidence to complement experiments, as they can offer to explain the “how” and “why” of research and should therefore be valued as “adjuncts” to experiments rather than alternatives to them.

Cohen, Manion and Morrison (2011:289-290) cite several hallmarks of case study research as described by Hitchcock and Hughes namely that is that it is concerned with; the rich and vivid description of events; providing a chronological narrative of events relating to the case; blending the description of events with analysis; focussing on individual groups and seeking to understand events; the integral involvement of the researcher; the linking of study to the personality of the researcher; attempting in to portray the richness of the case in writing up the research report.

The single case study design, one of four case study designs identified by Yin (2009:46) has been selected for the research project. The single-case design can focus on a critical case, an extreme case, a unique case, a representative or typical case, a revelatory case which researches a case not yet researched, or a longitudinal case. The single case study which focusses on the representative or typical cases has been selected to capture the circumstances and conditions of an everyday commonplace situation. In the case of the research project technology as a school subject has been selected as a topic for investigation in a particular school setting. It is hoped that the findings of this case study investigation will underscore the value of technology as having the potential to develop learners' creative potential for meeting the needs of the 21st century.

4.3 THE RESEARCH DESIGN

It has been the intention of this research project to use the case study method to investigate the value of technology as a catalyst in developing creative thinking in foundation phase learners. Elements of naturalistic enquiry as described by McMillan & Schumacher (2010:321-322), have been incorporated into the study and include: the study of learners' behaviour as it occurs naturally during technological activities both indoors and outdoors in the school; direct collection of data by the researcher in interaction with the participants; the recording of rich visual and audio narrative descriptions on video; and the recording of conversations during semi-structured interviews. These elements of naturalistic enquiry are deemed to have assisted the researcher in contributing to the understanding of learners' thinking skills during their engagement in the design process.

4.3.1 Key Characteristics of the Research Project

Key characteristics of qualitative educational research have been incorporated into this research project and are as follows:

4.3.1.1 Sensitivity

According to Corbin and Strauss (2008:32), researchers today have brought their own particular paradigms, perspectives, knowledge and biases into the research process. Traditionally, qualitative research called for objectivity when collecting and analyzing data which, according to McMillan and Schumacher (2010:9) is characterized by the lay person as being "unbiased, open-minded and not subjective". In research, objectivity is characterized by reasonable interpretations that can be made from data collection and analysis, and refers to the quality of procedures that control for bias or take elements of subjectivity into account

Standing in contrast to objectivity is "sensitivity", a characteristic of the researcher that requires immersing oneself in the data in an attempt to see issues and problems from the perspective of the participants. If the researcher cannot achieve objectivity in qualitative research it is suggested that he/she can have sensitivity (Corbin & Strauss 2008:32 & 41). Based on the belief that human actions are strongly influenced by the environment in which they occur, the researcher needs to be acutely aware of social, cultural, gender-based, technological and other factors as this is the "lens" through which behaviour is interpreted. This is referred to as "context sensitivity" (McMillan & Schumacher 2010:322). When it comes to writing up the findings of research, the same sensitivity enables the researcher to present the participants' viewpoints from a balanced perspective of abstraction, detailed description and feeling (Corbin & Strauss 2008:41).

In this study, the researcher has transcribed video-taped and audiotaped conversations held during participant observations and individual interviews, verbatim, in an attempt to take elements of subjectivity from the researcher's perspective into account, and to present the participants' viewpoints from a balanced perspective while preserving their viewpoints. Thus, the characteristics of both objectivity and sensitivity have been taken into consideration.

4.3.1.2 Precision

Precision refers to the accuracy of a research study where technical language is used to convey exact meanings. Technical expressions such as validity and reliability, and technical procedures such as research design and sampling, are used to describe the study as precisely as possible so that it may be replicated and the results used correctly (McMillan & Schumacher 2010:9).

The researcher has, as far as possible, exercised precision in this study.

4.3.1.3 Verification

In order to develop knowledge, researchers attempt to design and present a study that allows for verification, i.e. where the results can be confirmed or revised in follow-up research. In most qualitative studies, results are not verified as such, but descriptive interpretations are provided about the selected case at hand. These interpretations cannot be verified as such, but can be extended by conducting further research (McMillan & Schumacher 2010:9).

This study has attempted to develop knowledge that is based on a descriptive interpretation of data which the researcher believes can be extended in subsequent, follow-up research in the field and which is, in a sense, verifiable.

4.3.1.4 Empiricism

Empiricism refers to knowledge gained through the senses using inductive reasoning, i.e. specific knowledge gained in order to form general conclusions (Walliman 2011:17). The term “empirical” is used in scientific practice to refer to what is verifiable by observation, direct experience and evidence (Cohen, Manion and Morrison 2011:9; McMillan & Schumacher 2010:486).

To the researcher, “empirical” means being guided by the evidence which has been obtained from systematic methods of research. An empirical attitude is one which temporarily suspends one’s personal experience and beliefs in favour of logical interpretations based on evidence (McMillan & Schumacher 2010:9). In this context “empirical” means “that which is verifiable by observation and direct experience.” (Barratt 1971) cited in Cohen, Manion and Morrison (2011:9).

In this study, the researcher has gathered data based on systematic methods of research such as observations and interviews, using mediated data such as visual and verbal recordings, to support and verify, as far as possible, the research findings of the project.

4.3.1.5 Natural Setting

The researcher studies the behaviour of participants as it occurs naturally. Neither the setting nor the behaviour of the participants is manipulated and there are no externally-imposed constraints (McMillan & Schumacher 2010:321). In support of this key characteristic, Lankshear and Knobel (2004:68-71) describe the role of the researcher as one which stresses the importance of collecting information in real-life and natural settings. These settings are where the '*action'* happens, e.g. in playgrounds, classrooms, community settings and the likes.

In this study, research was conducted indoors, in the school's technology classroom and outdoors, in the school's conservancy. The 'action' of investigating, evaluating and communicating findings occurred in the real-life, natural setting of the school's outdoor environment.

4.3.1.6 Inductive Data Analysis

The inductive analysis of research data involved the researcher collecting evidence based on specific observations and events which were analyzed before generalizations about the observations and events were made (Gay, Mills & Airasian 2009:16). Data is therefore gathered using an inductive process of synthetizing information in order to progressively generalize specific findings (McMillan & Schumacher 2010:323).

In the context of this research, theory has been developed from the *bottom up* during the research process, thus enabling the researcher to remain open to new ways of understanding young learners' thinking during the design process. Specific findings have been progressively generated during the data collection process which corresponds to the inductive process of gathering data according to Gay, Mills and Airasian (2009:16) and McMillan and Schumacher (2010:323).

4.3.1.7 Validity and Reliability

Validity and reliability are important aspects to consider when undertaking educational qualitative research. Validity may be described as the degree of accuracy of the data which the researcher is trying to measure (Gay, Mills & Airasian 2009:608), or the degree of correspondence between the explanations given by the researcher and realities of the world (McMillan & Schumacher 2010:330). Claims of validity therefore rest on the techniques used in data collection and data analysis. By using a combination of strategies, qualitative researchers aim to enhance the validity of their research.

Reliability in educational qualitative research is described as the degree to which the data consistently measures what it is intended to measure (Gay, Mills & Airasian 2009:605). Claims of reliability in educational research are made based on the techniques used to gather data. Researchers, therefore, need to ask themselves whether the same data collection techniques used over time would yield the same results (Gay, Mills & Airasian 2009:378).

4.3.1.8 Triangulation

In qualitative research the practice of triangulation is the process of using more than one method of collecting data in order to obtain a more complete picture of what is being studied and a cross-reference of information. The strength of qualitative research is to collect information in many ways rather than relying on one particular method. In this way, the weakness of one method is compensated by the strength of using another method., e.g. interviews can be used to contribute to what has been observed (Cohen, Manion & Morrison 2011:195; Gay, Mills & Airasian 2009:376; Silverman 2011:369).

Maree (2007:81) states that qualitative research is not about the testing of hypotheses. Exceptions found in qualitative research do not automatically lead to the theory being rejected, but could lead to modifications of the theory. He suggests the term “crystallization” rather than triangulation, which views qualitative research from a constructivist perspective by focussing on an emerging reality that is constantly changing. He quotes Richardson (2000) who proposes that we crystallize rather than triangulate, so that we are provided with a complex and deeper understanding of the phenomenon under study.

In this study, semi-structured interviews, unstructured interviews and participant observations have been used to triangulate data collected during the design process.

4.3.2 The Sampling Frame

The research population comprised a sampling frame of 95 Grade 2 learners at an independent school in KwaZulu-Natal, where the researcher has been employed as a specialist technology teacher in the Foundation and Intermediate Phases of education.

4.3.3 The Sample

In research, there is no clear cut answer to the question as to how large a research sample should be. The size of the sample depends on the purpose of the study and the nature of the population under investigation (Bless, Higson-Smith & Kagee 2007:107; Cohen, Manion & Morrison 2011:144; Gay, Mills & Airasian 2009:136; McMillan & Schumacher 2010:328). There are, however, occasions where the researcher can access the whole population, rather than a sample (Cohen, Manion & Morrison 2011:143).

In the researcher's case, it was initially decided to access the whole of the Grade 2 population of learners for the research project. Three sets of sample groups, one sample set per term, for three school terms of the academic year were initially selected. It was decided to structure the sample groups into phases, i.e. Phase 1: Sample Group 1; Phase 2: Sample Group 2 and Phase 3: Sample Group 3. Each phase was colour-coded and corresponding animated face stickers were placed on learners' portfolio files to designate each phase group for easy identification by the researcher. The research population was later reduced to a smaller sample of six learners. The reasons for the selection of a reduced sample are discussed in section 4.3.6 of this chapter.

4.3.4 Access to the Sample

According to Cohen, Manion and Morrison (2011:152), negotiating access is a key issue in research. In many cases, it is guarded by "gatekeepers', e.g. in schools this might be the principal, school governors or even grade teachers.

In this study, negotiating access to the sampling frame was a straightforward process. As an employee of the school and a former founding pre-primary principal of a school on the same campus, verbal consent was received by the managing director of the schools' division of the company who own this particular group of independent schools. Verbal consent was also received by the school principal of the school, the deputy-principal, the head of department of the foundation phase and the foundation phase teachers. Individual letters were sent to all Grade 2 parents informing them of the proposed research project at the beginning of the academic school year. Consensus was received by 87% of the Grade 2 parent population. The Grade 2 participants themselves were keen and excited about being involved in the study. Those learners whose parents did not wish their children to be involved in the study engaged in the normal technological activities, as per the allocated technology lessons in the school timetable, and were not made to feel excluded or different in any way.

4.3.5 The Sampling Method

4.3.5.1 Purposive, Non-Probability Sampling

The researcher fully acknowledges that by targeting a particular group of learners at an independent school, that it does not represent the wider population of learners in the KwaZulu-Natal province. As stated by Cohen, Manion and Morrison (2011:155), small scale research such as this often uses non-probability samples despite the disadvantages that may arise from their non-representativeness. Patton (1990) cited in Cohen, Manion and Morrison (2011:231) states that there are no rules for the sample size in qualitative research. The size of the sample depends on what one wishes to know, the purpose of the research, what will be useful and credible, and what can be done with the available resources such as time, people and support.

It is acknowledged that, due to the researcher targeting a particular group of learners within a particular grade in an independent school, a method of non-probability sampling has been used in the full knowledge that it does not represent the wider learner population in schools in the KwaZulu-Natal Province. According to Gay, Mills and Airasian (2009:135), the primary goal in selecting a sample is to select participants who can best contribute to an understanding of the phenomenon under study, not participants who necessarily represent some larger population. The target group for the project was therefore selected based on the fact that they had been taught technology as a specialist subject in Grade 1 and would therefore be able to contribute to the research project.

4.3.5.2 Systematic Sampling

The systematic sampling procedure described by Cohen, Manion and Morrison (2011:153), which is a modified form of simple random sampling and, which involves selecting participants from a population list in a systematic way, was used to select the sample groups for the study.

Using a simple statistical formula suggested by Cohen, Manion and Morrison (2011:153-154) where the total population being represented is divided by the sample size required for the study, the sample groups were systematically selected class lists which ranked learners' names in alphabetical order. This statistical procedure was repeated three times across all four class lists to coincide with the three school terms and three phases of the pilot study. A sample of approximately 27 learners per term, and per phase, for each of the three school terms were selected the pilot study.

4.3.6 The Pilot Study

A small-scale trial run of the study conducted before the full-scale research study to identify problems with the research plan, was carried out for three school terms, which is equivalent to approximately seven months of the academic school calendar. The study was divided into three phases to correspond with the three school terms. At the end of phase one, it became apparent that to carry out a pilot study with a different sample group of learners for each of the three terms of the school year, would not yield sufficient in-depth data for analysis, due to the large sample of participants in the study as a whole. It was, therefore, decided to reduce the research sample to six learners for the duration of the pilot study and to retain this same sample for the actual research study.

The selected sample group for the balance of the pilot study was selected from the original sample group from phase one, using the same statistical sampling procedure mentioned in 4.3.5. This time, boys and then girls were selected to ensure an even gender balance, i.e. three boys and three girls. The pilot study continued for the balance of the school year with the six respondents.

4.3.7 The Research Project

The actual project commenced at the start of the academic year, following the pilot study, when the sample group had progressed from Grade 2 to Grade 3. With permission from the school management, it was agreed that the sample group, in addition to the their normal technology lessons, be given additional time with the researcher to participate in a special technology project that linked in with schools' conservancy initiative that involved the research group in assisting with the development or the recently established conservancy on the school premises. Hourly-sessions once every eight weeks in the primary school's timetable were created for the researcher and the sample group to engage in the research project. The project commenced in term one of the school year and was concluded mid-way in term four.

4.4 DATA COLLECTION

According to Yin (2009:68), collection of case study data requires a skilled investigator. Preparing and asking good questions during the research project, and being able to interpret the answers given by the research group, required careful listening that was not influenced by the researcher's preconceptions of the design process. As information was collected, the evidence was reviewed against the developing creativity assessment model. The creativity descriptors were continually revisited and modified in the light of the emerging patterns that arose from the collected data. Flexibility and adaptability were exercised and this enabled the researcher to retain a firm grip of the issues under investigation. As far as possible, the research endeavoured to remain unbiased by preconceived notions, including those derived from creativity and technology theory. The required skills for preparing to collect case study evidence as stated by Yin (2009:69) have been complied with.

An eclectic approach was used where data collection techniques such as participant observations, field notes, interviews, artefacts, video recordings, audio-recordings, etc., are chosen according to their relevance for a particular study (Cohen, Manion & Morrison 2011:235). The data collection techniques selected for this study represent 'fitness for purpose' and are as follows:

4.4.1 Observation

Observation as a method of research to observe learners in the classroom and outdoor environment in order to gather data from naturally occurring situations *in situ* have enabled the researcher to systematically gather and record information during the research process.

The distinctive feature of observation as a technique of data collection is that information is gathered *"live"* (Cohen, Manion & Morrison 2011:456). The focus is on observing the physical setting, i.e. the environment; the human setting, i.e. the individual or groups of individuals; the interactional setting, i.e. the interactions that take place between participants; and the programme setting, i.e. the organization of resources and the curriculum itself. In addition, non-verbal behaviour is also observed (Cohen, Manion & Morrison 2011:457). The observation of learners has taken place outdoors in the conservancy area of the school grounds, and indoors in the classroom. Outdoors, learners were observed evaluating their made products, i.e. hanging the birdfeeders they made from the branches of indigenous trees, and collecting litter using the litter bins they had made. Indoors, learners were observed designing and making their birdfeeders and litterbins. Both indoor and outdoor observations were videotaped and video footage includes interactive conversations between the learners and the researcher and between learners themselves, as well as the non-verbal behaviour of learners as they evaluate their products.

4.4.1.1 Participant Observation

Participant observation is commonly used in qualitative research and is defined by Denzin (1989), cited in Flick (2009:226), as a strategy that combines document analysis, interviewing of respondents, direct participation and observation and introspection. Participant observation should be seen as a process where the researcher gains access to the field and the participants, and where the observation moves through a process of becoming progressively concrete and concentrated on the essential aspects of the research questions. Flick (2009:227), cites Spradley (1980) who distinguishes between three phases of participant observation as follows:

- Descriptive observation which occurs at the beginning of the research and aims to provide the researcher with an orientation to the study, and to develop further research questions and clarify vision.
- Focused observation which narrows the researcher's perspective of the research.
- Selective observation which occurs towards the end of data collection and seeks to find additional evidence to support the findings in the second step.

Jorgensen (1989) cited in Flick (2009:226) highlights seven features of participant observation as follows:

- A focus on human meaning and interaction from the perspectives of participants.
- A focus on the here and now of everyday life situations.
- Developing theory that underscores understanding and interpreting human existence.
- A logical and open-ended, flexible and adaptable process of enquiry.
- An in-depth qualitative case study approach.
- A participative role that involves establishing a rapport with participants.
- The use of direct observation as well as other methods of gathering information.

Flick (2009:226) states that openness is essential when collecting data that is based on communicating with the observed. In this study, participant observation has formed an important aspect of data collection, and the researcher was able to develop a close rapport with participants in an open and flexible environment. This process of data collection is supported by Gay, Mills and Airasian (2009:366), who states that the emphasis of participant observations has been for the researcher to develop an understanding of learners in their natural environment by interacting with individual participants while observing and recording information.

Observations made have been video-taped. This has enabled the researcher to reflect on visual images and conversations held between the researcher and the participants, and to transcribe conversations verbatim onto the computer.

4.4.2 Video-Taped Recordings

Flick (2009:282) states that mediated data such as photo, film, video, written documents and use of the internet, i.e. visual data, are becoming more relevant in qualitative research. In addition to using verbal data which is captured through audio-recordings, the researcher may have a need to go beyond the spoken word and to record and analyses the actions themselves as they naturally occur. In addition, the researcher can merely observe without intervening, or observe, participate and intervene and then observe the consequences of the intervention. Transcribed information from video-taped observations also enables the researcher to produce text as empirical material (Flick 2009:282).

Video-taped recordings which capture both the visual and auditory aspects of observation have been used to collect data. The auditory aspects of the observations have been transcribed verbatim in order to capture data *in situ.* These recordings capture the sample group engaged in the design process of investigating, designing, making and evaluating and communicating their findings. As Flick states (2009:252), video analysis is not a stand-alone method of data collection. It needs to be used in conjunction with additional interviewing and observation beyond the camera.

4.4.3 Interviews

McMillan and Schumacher (2010:205) refer to the interviews in qualitative research as “oral questionnaires.” The interview technique is flexible and adaptable although its downfall is its potential for subjectivity and bias.

Generally, interviews may be seen as the purposeful interaction between the researcher and the respondent, where the researcher is able to obtain information from the respondent which cannot be acquired from observations alone. Interviews are distinguished by their degree of formality, i.e. informal and unplanned, or formal and planned. Interviews may be structured, with a certain set of questions to be asked, or unstructured, with questions arising from the flow of the interview itself. Semi-structured interviews combine both the structured and the unstructured approaches (Gay, Mills & Airasian 2009:370-371). Interviewers have three choices for collecting their data using the method of interviewing: i.e. they can take notes during the interview, write notes after the interview and audio-tape or video-tape the interview. Audio and video-taping the interview provides a verbatim account of the interview sessions. Following taped data collection is useful for transcribing tape recordings. Transcriptions can be compared to field notes for interview data and can be reviewed against the tape for accuracy (Gay, Mills & Airasian 2009:371-372).

When interviewing children, it is important to understand the child's world through his/her own eyes as they differ in cognitive and linguistic ability, concentration span, ability to recall and in what they consider to be important. All these factors have a bearing on the interview. The researcher, therefore, needs to establish a relationship of trust and make the interview enjoyable and non-threatening, using straightforward language which is understandable by the child. In addition, the researcher needs to phrase questions that are appropriate for the age level and give children enough time to think. It is also important that children are given the opportunity to reveal what they really think, and not what they think the researcher wants to hear (Cohen, Manion & Morrison 2011:433).

Group interviews with children can be useful, as it encourages interaction between the respondents and appears less intimidating. The environment in which the interviews are held are important, and should be held in as natural an environment as possible. Hence, the interview should be as informal as possible. Individual interviews are also invaluable as young children are giving the opportunity for a one-to-one conversation with the researcher. Open-ended questions should be used to avoid monosyllabic responses (Cohen, Manion & Morrison 2011:433).

4.4.3.1 Semi-Structured and Unstructured Interviews

Lankshear and Knobel (2004:202) comment on the advantages of the semi-structured and unstructured interviews, which they state allow teacher researchers to probe interviewees' responses. No interviews are repeated in exactly the same way with each interviewee, and different responses can be compared to the same question.

Gay, Mills and Airasian (2009:371) refer to the unstructured interview as little more than a casual conversation. The aim of this method of interviewing is not to receive answers to predetermined questions, but rather to probe and find out more from the participants. According to Corbin and Strauss (2008:27), the most data intense interviews are those that are unstructured as they are not dictated by any predetermined set of questions.

Semi-structured and unstructured interviews have been used in this study using both open-ended, i.e. divergent and closed, i.e. convergent questions. Closed questions have allowed for brief 'yes' and 'no' responses, whereas open-ended questions have allowed participants to give a more detailed account of their thought processes, to reflect on their actions while engaged in technological tasks, to predict outcomes and to suggest changes to their designs . Individual interviews were conducted during the planning, making and evaluating stage of the design process, and provided the researcher with important information in developing a model to assess creative thinking during the technological (design) process. The interviews were transcribed verbatim to capture authentic conversations between the interviewer and the interviewee.

Lankshear and Knobel (2005:202) comment on the advantage of the semi-structured and unstructured interviews which they state allow teacher researchers to probe interviewees' responses. No interviews are repeated in exactly the same way with each interviewee, and different responses can be compared to the same question. Their viewpoint supports the researcher's findings during the interview process.

4.5 DATA ANALYSIS

According to Cohen, Manion and Morrison (2011:537), qualitative data analysis involves organizing, substantiating and explaining data from the participants' perspective of a situation, noting patterns, themes and categories. There is no single or correct way to analyses and present data, and it is suggested that researchers use the term "fitness for purpose" as a guideline to clarify exactly what it is they want the data to do, as this will determine the kind of analysis that is undertaken. Cohen, Manion and Morrison (2011:537) state that transcriptions can provide important detail and accurate verbatim for data analysis, although non-verbal aspects may be omitted. Transcription conventions such as, inter alia, giving the speakers a pseudonym, recording hesitations, voice inflections and group speakers speaking at the same time, as suggested by Cohen, Manion and Morrison (2011:537 -538). The researcher has taken all these factors into account when analyzing transcribed data captured directly from video-taped and audio-taped recordings.

Gay, Mills and Airasian (2009:448-449) describe qualitative research as an inductive and continuous process which begins after the researcher's initial interaction with participants, and continues throughout the entire study. They describe the analysis of data as ongoing, reflective and forming a natural part of qualitative analysis. Data can consist of interview transcripts, participant observation field notes, video footage, artefacts, etc. (Saldaña (2009:3).

Corbin and Strauss (2008:66) refer to data analysis as *"coding"*. This is described as a process of taking raw data and lifting it to a higher conceptual level of understanding. *"Coding"* is the verb and *"codes"* are the names given to the concepts derived from the process of coding. Coding is seen to be more than just a process of noting concepts from field data or from computer programme analyses of data. It is described as the deeper analysis of information that goes beyond the surface to reveal the underlying meaning of information.

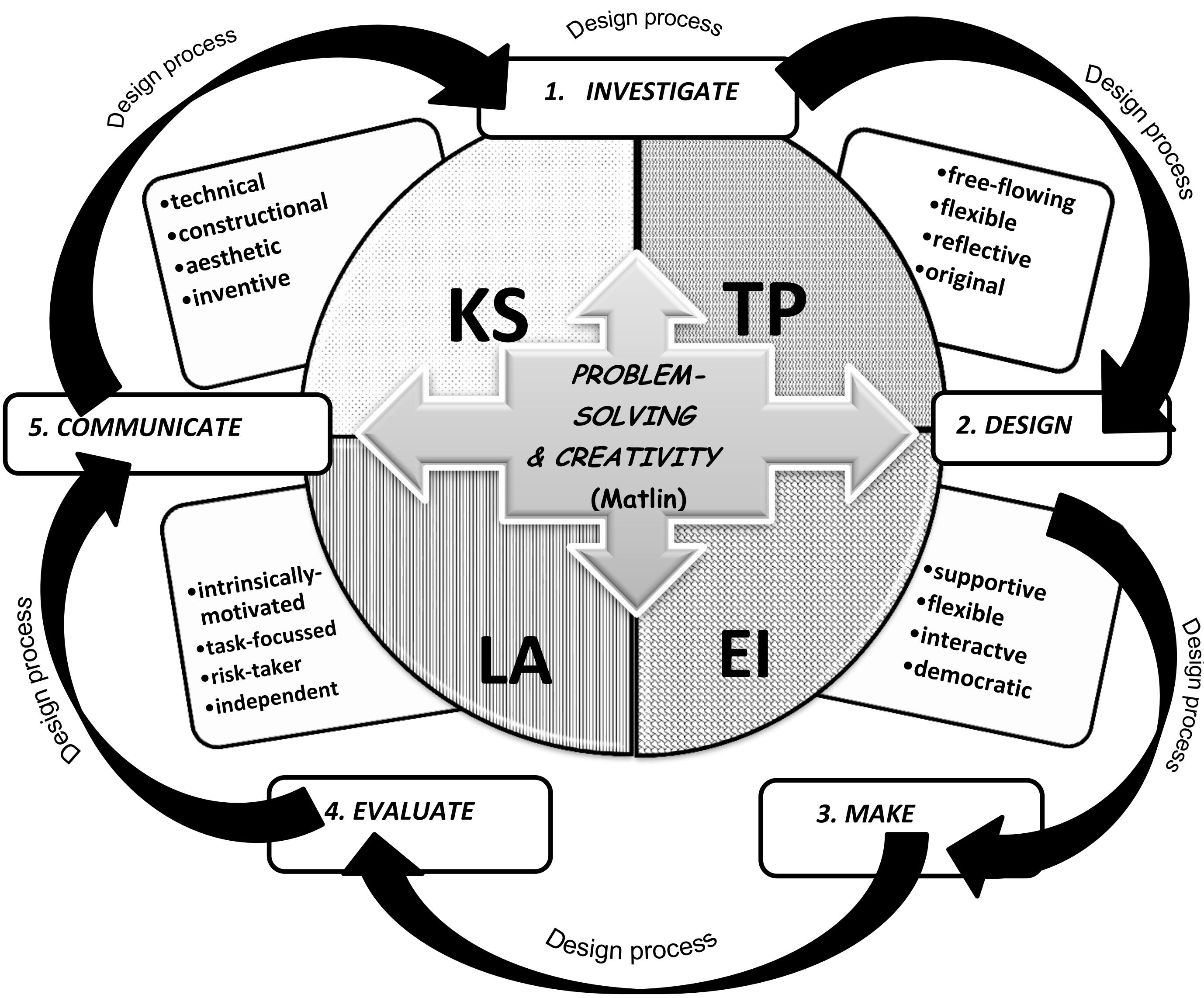
Silverman (2011:58) suggests several guidelines for data analysis which include getting down to analysis of data as early as possible, initially analyzing small amounts of data intensively before testing out findings as a whole, avoiding making hypotheses too early, trying out different theoretical approaches and focussing on sequence, i.e. talk, written material and interaction.

Qualitative enquiry is not a neutral activity, but one where researchers have their own values, biases and world views which may be viewed as lenses through they look at and interpret the already interpreted world of their participants. Researchers therefore need to acknowledge and disclose their own selves in conducting their research and seek to understand their influence on, and the role in, their research. Cohen, Manion and Morrison (2001:225) Cooley (1902) cited in Cohen, Manion and Morrison (2011:225) refers to this as the "looking glass self." The researcher acknowledges that, due to her background in technology research which involved piloting technology as a subject for inclusion in the school curriculum prior to the introduction to Outcomes-Based Education, she developed an increasing interest in the potential of this subject as a catalyst for creative learning and teaching. Thus, the researcher is aware of the ways in which her selectivity of the research project, background and inductive processes and paradigms, have shaped the research. Careful monitoring of her interaction with her participants and her own reaction, role and bias in the project have been taken into account when assessing the nature of creativity in technology according to the creativity assessment model for data analysis.

4.5.1 Developing a System of Coding and Framework for Data Analysis

The analysis of data commenced early in the study. Using an inductive approach to construct a theoretical framework for assessing the nature of creativity in technology, a system of coding evolved and developed that identified four conceptual categories. The conceptual categories encapsulate the key elements of the design process of technology, Matlin's model of problem-solving and creativity, and selected aspects of early creativity research conducted by Guilford (1950) and Rhodes (1960). Raw data collected during video-taped recordings and audio-taped recordings of learners engaged in conversation with the researcher, during and after the design process, were transcribed verbatim. The researcher used a line-by-line process of open coding in order to probe the meaning of recorded actions and words during the iterative process of data collection and data analysis, mentioned in paragraph 4.2.1. Key words and actions were highlighted as conceptual patterns began to emerge that linked with Matlin's model of problem-solving and creativity (2009); the influences of early creativity research conducted by Guilford (1950), Rhodes (1961) and Wallas (1926) as discussed in Chapter Two, paragraphs 2.3.1.1 and 2.3.1.2, and the design process of technology discussed in chapter three, paragraph 3.5.1.1. Figure 4.1 depicts the conceptual framework.

FIGURE 4.1 A CONCEPTUAL FRAMEWORK FOR DATA ANALYSIS



4.5.2. The Conceptual Framework Explained

4.5.2.1 The Design Process

The systematic design process reflected in chapter three, Figure 3.3 which was adapted from Potgieter in Pudi (2007:77), is indicated in the outer area of the model in Figure 4.1, using directional arrows and numbered stages of the design process. The design process is central to the analysis of data in this study and will be used to present, describe and analyse the collected data in light of the proposed model.

4.5.2.2 Categories and Sub-Categories

a) Domain-relevant skills (Coded KS)

The first category that has been selected for the model is domain-relevant design skills. This category has been coded KS. Domain-relevant knowledge and skills in the subject technology reflect the core knowledge and skills that learners are required to develop and master such as a knowledge of the design process; the skills of the design process, namely investigating, designing, making, evaluating and communicating; and the core content areas of the subject such as structures, processing, mechanical and electrical systems and control (Department of Basic Education 2011d:10).

In a discussion on creativity in subject domains, Loveless (cited in Wilson 2009:28-29) states the argument that creative individuals within subject domains demonstrate knowledge and understanding of the concepts and traditions of the subject while knowing how to *"break the rules"* in order to present original combinations of ideas.

In the context of this study, the participants have been exposed to the core concepts of technology at an elementary level and are familiar with the design process, having engaged in technological tasks from Grade R (the Reception Year). It was, therefore, anticipated that the participants would be able to *'break familiar ground'* and produce original, novel, yet functional ideas.

Four qualifiers that the researcher believes best reflect the knowledge and skills relevant to the technology domain have been identified, namely conceptual, technical, constructional and aesthetic. These qualifiers are briefly described as follows:

i. Conceptual

Conceptual understanding of a subject (in this case technology), enables people (learners) to make decisions about the appropriate use of materials and tools to support and explore creative processes of being imaginative and original, pursuing for a purpose and judging value within a field. There is a relationship between subject knowledge and creative processes where people (learners) can draw out a deeper conceptual understanding of what they are doing (Loveless in Wilson 2009:29). Forming concepts may be regarded as the building blocks of thought (Solomon, Redin and Lynch (1999) cited in Robinson-Riegler and Robinson-Riegler (2008:189) and are, therefore, important in peoples' everyday thinking. Concepts allow for quick and efficient understanding of phenomena, allowing people to go beyond the present moment. Concepts also support new learning and are important for communication where ideas are generated, combined and expressed through language (Robinson-Riegler & Robinson-Riegler 2008:189).

In technology, conceptualization of knowledge and skills involve the iterative process between *"the mind and the hand*", i.e. between thought and action, as ideas are bounced back and forth. Ideas may be conceptualized through drawings/sketches, diagrams and notes (Stables 2002:133).

In this study, conceptual skills refer to the learners' conceptualization of ideas as they engage in the design process. Language forms a key focus of the generation of ideas, as all conversation has been transcribed verbatim from the video-taped and audio-taped observations and interviews and coded in the proposed model.

ii. Technical

According to Jeffrey and Woods (2009:71-72), technical skills gained through creative learning are those which include some feature of operation, risk taking, experimentation and problem-solving. The development of the skill is gained through "the repetitive reproduction of the artefact, movement or plan." These skills are used by learners to develop their products. The technical skills gained from the hands-on activities are seen as being important in the development of technical skills for life, the nurturing of which takes place through "hands-on" and "real projects".

In this study, technical skills refer to the learners' physical capability in manipulating materials, i.e. measuring, marking out, cutting, shaping and joining or combining various materials such as cardboard, wood, plastic using tools such as glue guns, staplers, hammers and nails, etc., in novel ways to make an original and functional product.

iii. Constructional

The term 'constructional' has been selected as a qualifier in the knowledge and skills domain as it relates to the making aspect of the design process. Davies and Howe (2009:164) make reference to design and technology as a hands-on activity in which children make real tangible objects. It is a balance between thinking and doing and reflection and action. Through making, children develop their creative ideas. By handling objects such as materials children develop their knowledge of the properties of the materials, and imagine how the materials such as paper, card, clay, etc. might be put to good use in their envisaged product (Davies & Howe 2009:173). The Department of Basic Education (2011d: 68) refers to the process of making in the design process as involving building, testing and modifying a product or system in an attempt to develop a solution to the problem.

It is acknowledged that there is a close link between the technical skills described in sub-paragraph ii above, which involves the use of physical skills in making a product. For the purpose of this research, technical skills will be assessed within the context of the creative use of physical skills to join, glue, etc., and constructional skills will be assessed within the context of the creative use of building skills to construct a functional product that is unusual and novel.

iv. Aesthetic

The aesthetic appeal of product refers to the learners' attention to the visual appearance of the product in terms of its shape, size and colour and texture. According to Garratt (1996:21& 280), while it is essential that a design is functional, it is also important that it 'looks good'. The qualities which make a design attractive to look at and appreciated are its aesthetic appeal through the senses of sight, touch, hearing, smell and taste. The Department of Basic Education (2011d: 68) describes the term *'design'* as referring to a plan, sketch, model or drawing that reflects the intention of the proposed solution. The term '*aesthetics'* is described as characterizing a product or system that looks *"beautiful and attractive*" (Department of Basic Education 2011d:66). *'Design'* is also described as adding value to life by creating products that have a purpose, are functional and have aesthetic value (Department of Basic Education 2011a:8).

In the context of this study, the aesthetic appeal of a product will relate to its function and appeal in a natural environment setting.

b) Thinking patterns (TP)

The second category that has been selected for analyzing data in the model is thinking patterns. This has been coded TP. Based on research in the field of creativity discussed in chapter two, four qualifiers have been selected for analyzing data with respect to learners' thinking patterns. These qualifiers are briefly described as follows:

i. Free-flowing

This qualifier has been selected to refer to the number of different ideas generated by learners as they work through the problem-solving process of designing and making a product for a particular purpose. Guilford (1950) used the term fluency to describe the number of ideas generated. The more ideas generated, the greater chance of producing creative and useful outcome (Weisberg 2006:464). Csikszentmihalyi (1990 & 1996) proposed that a highly intrinsically motivated state is achieved when people engage in an activity that matches their level of skill. He describes a state of "flow" as an experience of optimal involvement in an activity where an individual reaches a psychological "high". It is during these "flow" experiences in a particular domain that people will search for more challenging problems with which to continue to experience "flow" (cited by Collins and Amabile in Sternberg 1999:301 and Kaufman, Plucker & Baer 2008:5).

In this model, the term "free-flowing" has been selected to assess learners' ability to focus on and pursue solutions to problems when engaged in the design process. Learners would appear to engage in a 'flow' of thought as they continuously grapple with, and find solutions to, problems relating to the making and evaluating of their products. The open-ended nature of the design process is seen to encourage free-flowing and fluent thinking processes. According to Scott, Jean-François and Urbano (1996) cited in Beghetto and Kaufman 2010:77), open-ended tasks encourage fluency and develop creative ability in learners.

ii. Flexible

Guilford's research (1950) also cites the importance of flexibility, a term which refers to the different ways a person will think in order to come up with novel ideas. (Weisberg 1996:464).

In this model, the term "flexible" has been selected to show how learners use flexibility of thinking when solving open-ended tasks. During the design process, learners need to continually reshape and rework their designs and plans in order to seek new ways of solving problems encountered.

iii. Reflective

In the light of research readings on cognition, the researcher has included the qualifier *"reflective*" to refer to learners who think about their own thinking, a term which is coined by a number of researchers in the field of psychology as *"metacognition"* (Matlin 2009:G9; Robinson-Reigler & Robinson-Reigler 2008:71; Runco 2007:32; Slavin 2006:192-193; Sternberg & Sternberg: 2012:534). The qualifier refers to an individual taking control of the processes in learning and thinking where they reflect on their own thinking and are aware of themselves as thinkers and how they create knowledge through the learning process (Fisher 2005:210-211; Pritchard 2009:27).

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iv. Original

A term coined by Guilford (1950), is "*originality"* which refers to a person who produces original ideas and who is therefore likely to produce creative solutions to problems (Weisberg 1996:464).

In the context of this research, the concept of originality is used in the model to denote a new, fresh or novel design that is different from others. Eaude (cited in

Wilson 2009:59) makes reference to relative originality where a child takes an approach or arrives at an outcome which is original compared to other children's approaches or outcomes. In this context, individual originality relates to the child's previous work, so that the trying out of unfamiliar ways of discovering something new, is seen as original, i.e. making a new discovery that is original to oneself and requires imagination and divergent thinking.

Gabora and Kaufman (cited in Kaufman & Sternberg 2010:279) described divergent thinking as "automatic, intuitive and diffuse", and it occurs during the generation of ideas. This is the type of thinking that moves in divergent directions and may, therefore, be regarded as original (Runco 2010:415).

c) Environmental Influence (EI)

The third category that has been selected for analyzing data in the model is environment influence. This has been coded EI.

Amabile (1996:203-208) cites educational environments as contributing factors to creativity where the environment is "open". Open environments are characterized by a flexible style of teaching that allows for flexibility of space, choice , richness of learning materials, integration of curriculum areas, and more individual or small-group rather than large group instruction. Open classroom environments are also characterized by "an atmosphere of developing critical inquiry, curiosity, exploration and self-directed learning without grading or authoritative teaching".

Vygotsky's social constructivist theory is well known for its scaffolding of learners' development in a supportive learning environment (Jordan, Carlile & Stack 2008:61). The development of the ZPD model discussed in paragraph 2.3.1.5 is particularly relevant to the environmental category identified in the researcher's model. Russ and Fiorelli (2010:235) mention the research of Vygotsky (1978) and Piaget (1932), both of whom believed that interaction through peers fosters problem-solving and play development. Fisher (2005:28) states that children need to feel secure enough to try out new things and be given the freedom to do so within bounds. In a creative environment, children value originality, rather than conformity and different, rather than the same, ideas.

Over the years, there has been greater interest shown in the field of creativity research and the impact of the environment on creative behaviour. Of note is Amabile's research in this area, mentioned earlier in this section.

In this category, four qualifiers have been selected for analyzing data with respect to the influence of the environment in supporting the creative thinking of young learners, namely supportive, contextual, free and flexible and interactive. These qualifiers are briefly described as follows:

i. Supportive

In technology, products made or in the making are always on show, i.e. due to their physical size, they are placed on top of cupboards or shelves for all to see. Research carried out by Howe, Davies and Richie (2001:27), shows that the role of the teacher is important in providing the right amount of support to the different learners in his/her class. Within a culture of supportiveness and belonging, individuality can be nurtured and respected. Their findings indicate that all children can be creative given the opportunity and support (ibid 29). Research conducted by Craft, Cremin and Burnard (2008:171) on creativity and different cultures, highlights the role of a nurturing environment, particularly for young children, in developing their creative thinking.

Vygotsky's concept of the scaffolding of children's learning in his ZPD model discussed in paragraph 2.3.5.1 is particularly relevant to this supportive sub-category of the researcher's model.

ii. Contextual

Driscoll, Lambirth and Roden (2012:71) make reference to contexts for learning within design and technology. Contextual learning in technology refers to using real-life situations in identifying and solving problems. The term "real" refers to the learners' life world that is used as a point of departure when selecting topics for designing and making that learners can relate to in terms of their own experience. Contextual learning, therefore, engages the learner and increases the effectiveness of teaching and learning. Learning is more purposeful and is internalized and remembered (Driscoll, Lambirth & Roden 2012:72).

iii. Free and Flexible

For young learners to be creative they require structure and freedom. They require both the guidance and the opportunity to generate their own ideas, ask questions and solve problems. They need to be encouraged to find new ways of doing things, take risks and to realize that mistakes will occur. They need to engage in open-ended activities that involve using different approaches and making unusual connections. They need the opportunity to "play" and be "playful" in their quest for finding solutions to problems. They also need to have the "space", be it physical and/or emotional, as an individual, or as a small group, in order to reflect carefully on problems and solutions (Eaude 2009:66).

Piaget, the pioneer of constructivist thought, believed that children's active engagement with their environment leads to their construction of meaning and learning. Play is a vital ingredient as this is when they actively explore their world, and conceptual change occurs as a result of interactions between existing cognitive structures and the assimilation and accommodation of new experiences (Pritchard 2009:19; Jordan, Carlile & Stack 2008:57).

iv. Interactive

Research conducted by Fleer, Jane and Hardy (2007:152-153) highlights the importance of an interactive approach to facilitate the teaching of science in the primary school. They state that the role of the teacher, inter alia, is one of affirming learners' contributions, accepting their ideas, clarifying their understandings and being a non-dominating facilitator and guide. The interactive approach promotes extensive and intensive discussion between the learners and the teacher and amongst the learners themselves. Conceptual change of knowledge is considered important as new knowledge experienced by the learners needs to connect or interact with prior knowledge. They also highlight the importance of the teacher's role in facilitating the assimilation and accommodation of new knowledge with prior knowledge in the interactive approach (Fleer, Jane & Hardy 2007:187).

Followers of Piagetian theory regard the child as an active learner who interacts with his environment and forms increasingly complex structures of thought. Given the appropriate contexts, the child is able to solve fairly sophisticated problems. Language plays a key role in the child's mental growth (Fisher 2005:112). In the context of this study, Piaget's constructivist theory plays a key role.

In view of the combined nature of the natural sciences and technology in the South African curriculum, this approach is seen to be relevant and appropriate to the nature of this research.

d) Learner attributes (LA)

The fourth category that has been selected for analyzing data in this model is learner attributes. Research on creativity and personality reveals that there is a link between certain personality traits and creative output. Whilst it is acknowledged that creativity is difficult to measure and quantify, there is a general consensus among creativity researchers in their definition of the concept, namely that "*creative behaviour must be both novel/original and useful/adaptive"* (Feist 2010:114), When attempting to define personality, psychologists refer to the unique and relatively consistent set of behaviours, feelings, thoughts, motives, etc., that characterize an individual (Feist 2010: 114).

Qualifiers selected for the fourth category of the model are based on the research of personality traits that are seen to be most consistently connected to creativity. With relevance to this research these traits are clustered into cognitive, social and motivational-affective groups (Feist 2010:120). Four qualifiers have been selected for analyzing data relating to this category, namely: learners who are intrinsically-motivated, those who are open to experience, risk-takers and those who are independent. These qualifiers are briefly described as follows:

i. Intrinsically-motivated

Research indicates that it is the inner drive and determination, i.e. intrinsic motivation that is important for creativity. In technology, the teacher needs to intervene and motivate learners to engage in the design process. Intervention needs to be at the right time (Howe, Davies and Ritchie 2002:21-22).

Research on children conducted by Picariello (1992) and Ryan and Grolmic (1986), cited in Amabile (1996:230), indicate consistent findings between a warm (caring) teacher and intrinsic motivation and creativity. Although there are individual differences regarding preferred environments, creativity is seen to flourish where there are opportunities for exploration and independent work, and when originality is supported and valued (Kozbelt, Beghetto and Runco 2010:25). The role of the teacher using creative strategies is, therefore, important in encouraging intrinsic motivation and providing opportunities for choice and discovery (Kim, Crammond and VanTassel–Baska 2010:404).

In technology, pleasure and excitement in working through the design process are seen to promote energy and drive in learners to succeed in reaching the desired outcome. Intrinsic motivation as a qualifier for learner attributes in the model is seen to be relevant and appropriate.

ii. Open to Experience

Cognitive traits according to Feist (2010:120) include those traits that deal with how people think and process information, solve problems and respond to new situations. Within this cognitive trait domain, openness to change correlates highly with the creative personality, and is mediated by intrinsic motivation, another attribute linked to creative behaviour. Creative behaviour appears to be at its highest when participants who are open to change, work more creatively in free and flexible environments.

Openness to experience has, therefore, been selected as one of the qualifiers for the researcher’s model, as the very nature of technology encourages learners to develop openness to experience.

iii. Risk-taker

The concept of risk-taking regularly features in research on creativity. Considered one of the personality variables, risk-taking is seen to be intrinsic to creative behaviour (Jeffrey & Woods 2009:23; Kaufman, Plucker and Baer 2008:3; Russ & Fiorelli 2010:233). Beghetto and Kaufman (2010:246) define risk-taking as being unusual and unconventional in social settings. Tolerance of risk is seen to make it easier to find and consider a wide range of ideas, a common trait identified in creative individuals (Beghetto & Kaufman 2010:246). For children to be creative they need to take risks (Howe, Davies & Ritchie 2001:27).

Proctor and Burnett (2004) cited in Kaufman, Plucker and Baer (2010:91) describe a risk taker as a student who, inter alia, is one who will reason, challenge, question, devise a plan and make a choice between alternative solutions. Kaufman, Plucker and Baer (2010:3), make reference to creative persons taking appropriate risks.

In technology where the solution is unknown, learners show moderate forms of risk-taking where they need to judge, question, devise a plan of action and make choices.

iv. Independent

Research conducted in the field of social personality traits and creativity highlights independence as one of the traits of creative people. Creativity is seen to flourish when people are given opportunities for exploration and independent work within a supportive environment that values originality (Feist 2010:121; Kozbelt, Beghetto & Runco 2010:25).

Independence as a qualifier of learner attributes has been selected by the researcher due to the need for the sample group to design and make their own individual products whilst working alongside their peers.

Whilst it is acknowledged that creativity is enhanced by social interaction with others, this research is focussed on individual projects completed by the research group, rather than group tasks which are also a feature of technology projects conducted in schools. It should also be mentioned that in light of the researcher’s experience as teacher of technology, Foundation Phase learners prefer individual tasks to group activities. The informal social working environment that is characteristic of technological endeavour, would seem to provide the necessary scaffolding of learning by the teacher, and between learners themselves. As the researcher noted, they are willing to assist one another despite being involved in individual tasks.

4.5.2.3 Problem-Solving and Creativity according to Matlin

People use problem-solving when they want to reach a particular goal and need to find a way to reach that goal. Matlin considers four aspects of problem-solving Namely; understanding the problem, problem-solving strategies, factors that influence problem-solving and creativity. These aspects of problem-solving were discussed in Chapter Two (cf 2.4). With reference to technology, these four key concepts of her model are discussed with reference to the analysis of data in this study.

a) Understanding the Problem

Understanding the problem, according to Matlin's theory requires a person to form a mental representation of that problem, based on the information provided and the person's previous experience. Close attention needs to be paid to the relevant information, before the problem can be represented either by using symbols or visual images. The ability to solve a problem is specifically related to real-world contexts in which problems are solved. This enables people to make use of an information-rich environment in interaction with others (cf 2.4.1).

In the study the problem was introduced to the participants during the design process of investigation, where the school principal, the researcher and the participants took a walk through the school conservancy, a designated area on the school campus. In line with Matlin's theory, participants used their previous experience of the problem-solving process to construct a mental picture of the problem to be solved. In this case, two main problems were identified, namely litter and lack of water to attract bird life in the conservancy.

b) Problem-solving Strategies

Three problem-solving approaches based on heuristics, i.e. a shortcut that produces the correct solution, are discussed by Matlin. The first approach is the analogy approach, where current problems are solved on the basis of experience with similar previous problems. The second approach is the means-end heuristic approach, where the problem is broken up into sub-problems and each sub-problem is solved; and the third approach is the hill-climbing heuristic, where at every point of choice, the alternative that is perceived to directly lead towards the goal, is selected (cf 2.4.2.).

In the case of this study, participants identified the problems and their possible solutions based on their previous experience of solving contextually-based tasks. Where choices arose during the design process, the alternative that was perceived to directly lead towards the goal, was selected. The analogy and hill-climbing heuristic approaches were those problem-solving strategies selected by the participants during the design process.

c) Factors that influence problem-solving

Matlin mentions the different factors that influence problem-solving namely: expertise, mental set, functional fixedness and insight versus non-insight problems (cf 2.4.3).

Based on their experience of engaging in the design process, the participants in the study were perceived to be fairly knowledgeable and insightful when working through the design process, demonstrating a degree of expertise and insight when engaging in task at hand.

d) Creativity

The fourth aspect of problem-solving according to Matlin's theory is creativity. She considers different viewpoints of creativity, namely Guildford's divergent thinking theory, Sternberg and Lubart's investment theory and Amabile's task motivation and creativity (cf 2.4.4). These theories and other selected aspects of creativity research theories, discussed in chapter two, form the basis of the development of the proposed creativity assessment model in Figure 4.1.

4.5.3 Presentation of Data

Collected data will be presented using the different stages of the design process in technology, as observations and interviews made during the course of the study correspond to the different stages of the design process. The proposed creativity assessment model which incorporates Matlin's theory of problem-solving and creativity, the design process and selected aspects of creativity research, will be used to answer the research questions outlined in chapter one in order to determine whether, or not, technology acts as a catalyst in developing Foundation Phase learners' creative thinking skills.

4.6 CONCLUSION

This chapter has described the research design and research methodology used in this investigation, namely a qualitative study using data collection methods of observations and interviews. It has also included a conceptual framework that is proposed as a means of analyzing the collected data. Chapter Five will present and analyses the data collected in the light of the proposed creativity assessment model presented in this chapter.

Chapter 5
PRESENTATION AND ANALYSIS OF DATA

5.1 INTRODUCTION

The preceding chapters have formed an important background to the investigation contained in this thesis, namely the investigation into the nature of creativity in Chapter Two, the nature of technology in the school curriculum in Chapter Three and a description of the research design, methodology and proposed model for the assessment of creativity in technology in Chapter Four. Chapter Five of this study presents and analyses the data collected using a proposed creativity model based on Matlin's theory of problem-solving and creativity; selected aspects of early creativity research developed by Guilford (1950), Rhodes (1961) and Wallas (1926); and the design process of technology (cf Chapter Two and Chapter Three, respectively). The development of the proposed model is to assess the value of technology as a catalyst in developing Foundation Phase learners' creative thinking skills.

All data collected during the study has been transcribed verbatim during observations of and follow-up interviews with participants using video-taped and audio-taped recordings. As mentioned in Chapter Four, paragraph 4.5, data collection and data analysis went *hand-in-hand.* The conceptual framework for data analysis presented and discussed in Chapter Four, Figure 4.1 and paragraph 4.5.2. respectively, evolved early in the study using a process of initial coding to sort and categorize information. As more data was collected, greater in-depth analysis occurred which resulted in the researcher identifying the emergence of new patterns regarding participants' domain-related knowledge and skills, thinking patterns, personal attributes and the influence of the environment on their engagement in the design process.

The focus of Chapter Five is to present the analysis and interpretation of data within the framework of the proposed creativity assessment model for technology introduced in Chapter Four, section 4.5. Implicit in the analysis and interpretation of data in the proposed model, is Matlin's theory of problem-solving and creativity (Matlin 2009), and selected theories of early creativity researchers by Guilford

(1950), Rhodes (1960) and Wallas which are encapsulated in the main categories and sub-categories selected for the model. Whilst the focus of this study has been on Grade 3 learners in the Foundation Phase at an independent school, the proposed model reflects themes and concepts that can be used to assess creativity across all ages and phases of education.

The presentation of the data will be preceded by a brief discussion on assessment as perceived by the Department of Basic Education in the Technology Curriculum and Assessment Policy Statement (CAPS) (2011d:38-40). It will also include Amabile's theory on the consensual assessment technique (CAT) as it pertains to the assessment of creativity (Amabile 1996:41-67).

5.2 THE NATURE OF ASSESSMENT IN TECHNOLOGY AND CREATIVITY

The Department of Basic Education (2011d:38) defines assessment in technology as "a continuous, planned process of identifying, gathering and interpreting information about the performance of learners, using different forms of assessment." Assessment is described as being informal, i.e. assessment *for* learning and formal, i.e. assessment *of* learning. Due to the practical nature of a subject like technology, the knowledge needed for designing solutions to problems to satisfy needs or wants, as well as the skills needed to implement practical solutions to these problems, are central to the assessment process. Assessment of technology, as an integrated component of Beginning Knowledge which forms part of the content of the Life Skills subject in the Foundation Phase, is informal and ongoing (Department of Basic Education 2011b:66). As per the Department of Basic Education's policy on the assessment of technology in the Senior Phase, assessment can be based on short practical assessment tasks (mini-PAT) which cover aspects of the design process such as designing and making, or it may include a full capability task that covers all aspects of the design process (IDMEC) (Department of Basic Education 2011d:41). In this study the full capability task that includes all aspects of the design process has been used to collect and analyses data.

Amabile (1996), well-known for her research in the assessment of creativity, suggests that creativity is contextually-based and socially defined. Her consensual definition of creativity, and her assumptions about the nature of creativity assessment and the requirements of an appropriate methodology for a social psychology of creativity, generated the development of a consensual assessment technique (CAT) model. Amabile advocates that creativity cannot be explicitly defined, but that a product can be considered to be creative when appropriate judges agree that it is. Appropriate judges are those people who are deemed to be familiar with the field of creativity, and are considered to be experts in the field. In selecting appropriate tasks for the assessment of creative products, three requirements are needed. These requirements are that tasks must be such that they are available to appropriate judges for assessment; they must be open-ended enough to permit flexible and novel responses; and they should not depend heavily on certain special skills such as drawing ability or verbal fluency (Amabile 1996:41; Kaufman, Plucker & Baer 2008:52-53). Beghetto and Kaufman (2010:264-265) refer to Lubart and Sternberg's *"Investment Theory of Creativity"* as being central to integrating creativity theory and classroom assessment of creativity. Lubart and Sternberg's Investment Theory conceives creativity as a confluence of six components, namely intellectual skills, knowledge, styles of thinking, personality, motivation and environment. It should be noted that the investment theory of creativity is also included in Matlin's theory of problem-solving and creativity referred to in Chapter Two (cf 2.4.4.1).

Kaufman, Plucker and Baer (2008:158-62), state that creativity has many facets, appears in different forms, and is understood and assessed in different ways. For this reason, there is no full-proof way to assess creativity as its assessment is complex and difficult. Creativity assessment is therefore a work in progress, as far less is known about creativity and its measurement than researchers would like to admit.

The researcher agrees that there is no full-proof way to assess creativity. In the context of the research project, the researcher through in-depth reading on the nature of creativity, has developed a creativity assessment model that includes key aspects of creativity that are identified in the sample group's knowledge and skills of technology, their thought patterns and attributes and the impact of the environment in developing their creative thinking. A simple frequency count of coded data in each of the four domains, has been used to assess the frequency of responses during the design process. This is explained in the next section of this chapter.

5.3 A SYSTEMATIC ANALYSIS AND PRESENTATION OF DATA

It is important in data analysis to maintain a sense of holism of data, as there can be a tendency to fragment it into different elements and lose the synergy of the whole (Cohen, Manion & Morrison 2011:555). Miles and Huberman (1994), cited in Cohen, Manion and Morrison (2011:555), suggest a number of tactics for generating meaning from transcribed data. A few of these tactics which have a direct bearing on this study are highlighted as follows:

- Counting the frequency of occurrences.
- Noting patterns and themes.
- Clustering items into categories, types, behaviours and classifications.
- Identifying and noting relationships between variables.
- Building a logical chain of evidence: making inferences and noting causality.
- Making conceptual coherence which leads to a theory to explain the phenomena.

The importance attached to the coding of data is seen by Miles and Huberman (1994) as a way of reducing data overload from qualitative data (In Cohen, Manion & Morrison 2011:555). Saldanã (2009:49) states that depending on the qualitative coding method that a researcher employs, the choice of coding may have numeric conversion and transformation possibilities. He further states that researchers should keep themselves open to numeric representations when appropriate, as these representations provide a supplementary heuristic strategy for data analysis.

The coding method used by the researcher was used to correspond to the category and sub-categories descriptors in the development of a creativity assessment model for data analysis. A numeric calculation of the average frequency counts therefore seemed to be an appropriate analytical tool for analyzing the coded data.

5.3.1 A Tabulated Creativity Assessment Framework for Data Analysis

A creativity assessment table that organizes the four main key categories and sub-categories of the proposed creativity assessment model presented in Figure 4.1, has been developed to assist the researcher in analyzing the data using a system of open and axial coding to generate theory. Four of the tactics suggested by Miles and Huberman (1994) cited in Cohen, Manion and Morrison (2011:555) to generate meaning from transcribed data namely: counting the frequencies of occurrences include: noting patterns and themes; and building a logical chain of evidence, by noting causality and making inferences, have been taken into consideration in the development of the tabulated model. According to Gay, Mills and Airasian (2009:304), scoring self-developed instruments is a complex task, especially if open-ended items are involved, due to the researcher's need to develop and refine a reliable scoring procedure.

In preparing the data for analysis, the researcher transcribed and coded the behavioural responses of the participants according to a creativity assessment table presented in Table 5.1. The table details the coding of categories, related sub-categories and related category descriptors (characteristics), as well as frequency count of occurrences for each of the four main categories and sub-categories. In addition to assigning a numeric score to the frequency counts in each category and sub-category during the design process, a numerical average score and average percentage has also been calculated to indicate the distribution of sub-category scores in each of the four categories. According to Gay, Mills and Airasian (2009:306-307), counting the frequency of each value of a variable does not usually effectively summarize the outcomes. A calculation of the overall average therefore provides a better descriptor indicator than a frequency count.

In the case of this research project, a comparative analysis between the different stages of the design process, according to the four main categories and sub-categories presented in Table 5.1, has been made to determine whether or not any one stage has a discernible influence on the learners' creative thinking patterns.

TABLE 5.1 A CREATIVITY ASSESSMENT MODEL FOR DATA ANALYSIS

CATEGORY & SUB-CATEGORIES	CODE	CATEGORY DESCRIPTOR
DOMAIN-RELEVANT KNOWLEDGE & SKILLS	**KS**	**The Design Process: Investigate, design, make, evaluate and communicate**
Conceptual	**KS1**	The learner conceptualizes solutions to problems either verbally, graphically or during construction. Ideas are original and/or novel. Knowledge of the natural environment and technological knowledge enables learners to conceptualize, solve and modify solutions to problems.
Technical	**KS2**	The learner shows physical proficiency when manipulating materials, tools and equipment in novel and functional ways.
Constructional	**KS3**	The learner applies his/her knowledge & skills to construct a functional, original and novel product.
Aesthetic	**KS4**	The learner uses elements of colour, shape, form and texture creatively, to enhance the appearance and/or effectiveness of a product.
THINKING PATTERNS	**TP**	**Developing Ideas**
Free-flowing	**TP1**	The learner expresses ideas fluently. There is a clear *flow* of thought.
Flexible	**TP2**	The learner views problems in different ways & explores alternative solutions in order to reach a desired outcome.
Reflective	**TP3**	The learner ponders and reflects on and/or incubates ideas when attempting to solve problems.
Original	**TP4**	The learner combines old ideas into new ideas, and shows unique & novel ways of creating a product, i.e. the learner puts a *new stamp* onto an existing product.
ENVIRONMENTAL INFLUENCES	**EI**	**The Learning Environment**
Supportive	**EI1**	The environment supports individuality, encourages responsible risk-taking and experimentation.

		The environment provides affirmation and a sense of belonging, and scaffolds learning.
Contextual	**EI2**	The environment is used to investigate problems and develop solutions using real-life contexts.
Free & Flexible	**EI3**	The environment provides learners with the freedom and flexibility to exercise choices and develop a sense of ownership.
Interactive	**EI4**	The environment encourages hands-on, active learning, and the assimilation and accommodation of new knowledge. The environment provides the opportunity for interaction between the teacher and the learners and between individual learners.
LEARNER ATTRIBUTES	**LA**	**The Learner**
Intrinsically-motivated	**LA1**	The learner shows intrinsic motivation and perseverance when engaged in the design process. .
Open to experience	**LA2**	The learner is willing to accept help and advice, and is able to adjust and respond positively to new experiences, and change when attempting to solve and rework solutions to problems.
Risk-taker	**LA3**	The learner is prepared to experiment with new ideas when attempting to solve problems and is not afraid of failure.
Independent	**LA4**	The learner shows independence when engaged in the design process

5.3.2 Background to the Technology Project

The nature of the technology project was an environmental one which required participants to become involved in the school's conservancy project. The conservancy is well known to all learners at the school and was pioneered by the school principal and a parent of the school. It was, therefore, deemed appropriate that an environmental investigation that required the participants to identify solutions to problems in the conservancy and to design and make an artefact that would solve the problem, be carried out.

All participants were exposed to technology and natural sciences from their early years of schooling at the pre-primary school at the same campus. The conservancy is known for its contribution towards preserving the natural environment in the coastal area of Durban, in KwaZulu-Natal.

5.3.3 Analysing the Design Process

All collected data has been transcribed and analyzed in a step-by-step process that corresponds to the five stages of the design process, namely investigate, design, make, evaluate and communicate. This process was discussed in paragraph 3.4.1 and explained in paragraph 3.4.1.1. All transcribed data is in the form of dialogue recorded during the design process, with additional qualifying phrases here and there to contextualize the information.

5.3.3.1 Coding of Data and Participant Names

All transcribed data collected from the video footage and audio-taped recordings were manually coded using coloured highlighting pens to identify the responses of the different participants as they interacted with the researcher, as teacher, and, in some cases, with the school principal and with each other. Different coloured ballpoint pens were used to identify and record the different codes deemed to correspond to the participants' responses and identified descriptors in the respective categories and sub-categories of the table.

As per Saldaña's suggestion for a small scale study (2009:22), the researcher deemed the method of manual coding worthwhile, as it provided the opportunity to reflect on participants' responses, and assign the relevant code/s from the proposed table.

In order to protect the anonymity of the participants, the researcher selected the first letter of their names, and assigned numbers ranging from one to six. Participants have been referred to as R1, L2, C3, E4, K5 and K6 in Tables 5.2 to 5.5.

5.3.3.2 The Design Process: Investigating the Problem

The investigation of the problem commenced with the school principal, the participants and the researcher taking a walk through the school conservancy to identify perceived problems in the conservancy, and to suggest possible solutions. Investigation of the conservancy comprised a triple lesson period of an hour and a half duration.

The informal walkabout in the open environment triggered spontaneous discussion and interaction between the participants, the researcher and the school principal. Three main problems were identified and solutions posed: namely lack of water and the designing and building of a dam; litter and the designing and making of fixed and portable litter bins with lids; and the designing and making of hanging bird feeders to attract the birds.

Audio-taped and video-taped information was transcribed to reflect recorded dialogue between all three parties during and after the nature walk. A sample of the transcribed information that includes the conversation held between the participants, the researcher and the school principal in the school conservancy, is included. Codes have been assigned to the transcript as per the information presented in the assessment model in Table 5.1.

a) Sample of Transcribed Data: Investigating Problems and Identifying Solutions: Conservancy Walkabout with the Research Group

R1: Could we create some water for the birds? **EI2**

R1: If we had to then we could. **TP1; KS1; TP3**;

R1: We need to think about where a good place for a dam would be. **EI2**

E4: Maybe over there... (pointing) **TP3**

P: Why? Why do you think so, E3? Why do you think it would be a good place? **EI4**

C2: I think it could be by those two bushes. **TP3**

R1: Do you think this is hollow enough for a dam?

R1: Yes because when the floods came, it took in the water naturally (gesturing). **TP1**.

P: Shall we go a bit lower down. Then you'll be able to see the whole area. What we can do is we can see what everybody else thinks about it & get their ideas, because we've got the video camera & we've got pictures and we can record your ideas. **EI2; EI4**

P: Let's just stop here & look up that valley. R, you will remember quite well because you came onto the campus as a baby boy, many, many times. Now tell the group again, why you think this area here would be a good place for a dam. There are obvious reasons, children, as to why a dam should be put right here where you are looking. R, you start & C you can add on. **EI4**

R1: Because it is like a hollowed place & you could probably put a lot of water here ….. **EI3**

P: C3 what do you think? **EI1**

C3: I just found this plastic (litter) **LA1**

P: Hold onto that. We've already found litter. (Turns back to R1)**EI1;**

R1: R1 is absolutely right. **EI1**. This area here (turning camera) right in front of us here. Do you see how it forms a very big saucer? **EI3**

(All nodding) **LA1**

P: Like the saucer of a cup or a soup plate. Why do you think a saucer or a soup plate is shaped the way it is? **EI4**

L2: So it can hold water. **TP1; KS1**

P: So it can hold water. **EI1** So that if there's a spilling of the coffee or the tea, it won't spill out onto the table, it'll be held in the saucer & it's shaped that way to hold the liquid. This is exactly the same shape (referring to the conservancy basin). Boys and girls this is exactly the same shape. We've really got two of them because if you look beyond that ridge there. Can you see the ridge up there? **EI2**

(All nodding) **LAI**

P: Let's think carefully, if you're going to put water in here – referring to immediate area. If we don't construct it or build it in a special way, won't the water eventually just seep away? **EI4**

AlL2: Yes. **LA1**

P: So what do we do? **EI4**

L2: You put like cement at the bottom to keep the water in, in a similar way that we would do to a swimming pool. **TP1; TP4; KS1**

P: If we didn't want to use concrete because it was very expensive or gunite that we use in a swimming pool. How else could we do it? **EI4**

L2: Like plastic …. put plastic underneath. **TP1; TP3; KS1**

P: Now try to picture in your minds that in four or five months' time we've got water in these two valleys, the smaller one at the top & the bigger one down here. **EI2**

R1: Are we going to have two dams? **EI4**

P: Yes, two dams. The R wants you to think about how we can work with that water and the area around the water, to protect our fauna & flora. What could you do in technology to protect that? What are the things you could do or make? **EI4**

K6: You could put up some signs. **TP1**

R1: You could put up some signs & what would those signs do K5? **EI4**

K6: They would tell the students what to do at the dam. **TP1**

P: Excellent. **EI1** What else did we say this morning about the mongooses? **EI4**

AlL2: They were frightened of noise. **TP1; KS1**

P: What signs could we put up for that? **EI2; EI4**

R1: We could put up a sign that said: "Please be quiet". **TP1; TP4**

R1: Yes, what else? **EI3; EI4**

C3: We could make bird feeders. **TP1; TP4 (**referring to protection of the flora and fauna … attracting birds for cross pollination)

R1: What would the bird feeders do? **EI4**

C3: They'd make the birds come more and more. **TP1; TP4**

R1: Yes, they'd make the birds come more and more and attract the birds. We would need to think about what sort of feeders we would need. Would they be hanging or standing from the ground? **EI1; EI3; EI4**

C3: I think they'd be hanging**. TP1; TP3**

R1: We could make them hang & maybe hang them over the dams so that the birds could feed & then drop down to the dam for water.**EI4; EI2** I think we need to go into the valley now & see where the mongoose family are so that can get some idea of where the other dam is going to be as well. Any other ideas about what we could do? **EI4**

L2: We could put grass around the pool. **TP1**

R1: And what would that do? **EI4**

L2: It would attract more animals to making the … what's it called … **TP3**the environment so that they won't know it's a pool there. So like if they come down, and people who don't really know about the environment and don't care, they won't even see the pool (suggestion of camouflage). **TP1; TP4**

R1: They won't even see the pool. **EI1**; **EI4**

R to K6: You started to say something there….. **EI4**

K6: If you make grass grow around the dam, you might get some nests. **TP1;**

R1: You might get some nests. **EI1** How do birds make their own nests?

K6: Twigs & mud. **TP1**

R1: Good for you. **EI1**; **EI4**

L2: We had a dried nest in our trees from the Hadedas & it was made out of big thick, thick, sticks. **TP1**

R1: Did you? Have you still got part of that nest left? **EI4**

L2: Yes, a little bit. **TP1; TP3**

R1: Perhaps you could bring it to school & give it to P. We could look at it & analyze it to see how the birds made that. **EI1**; **EI4**

L2: It might be a bit hard, because it's 80 years old. It's very old and it's in the tree which is very, very high. **TP1; TP3; KS1**

R1: Oh is it still in the tree? **EI4**

L2: Nodding … It would've broken if it had've dropped because it's too high. If it fell to the ground it would've just broken into pieces.

R to R1: Tell us about the litter bin. **EI1**

R1: I think we should make a closed bin so that the mongooses don't climb up and eat out of the rubbish bin. **TP1; TP4**

R1: So you close it up so that the mongoose can't get in and they don't eat it (the food) up. **EI1; E14**

R1: Ya, so they don't eat the plastic and that sort of thing. So they don't die or anything. KS1

R1: I think it's a good idea. **EI1; EI3** Also what would the wind do if the bin didn't have a lid? **EI4**

R1: It will blow it (the litter) away into the bush**. TP1; KS1**

R1: And it would spread the litter, wouldn't it? **E4**.

R1: Yes. **TP1**

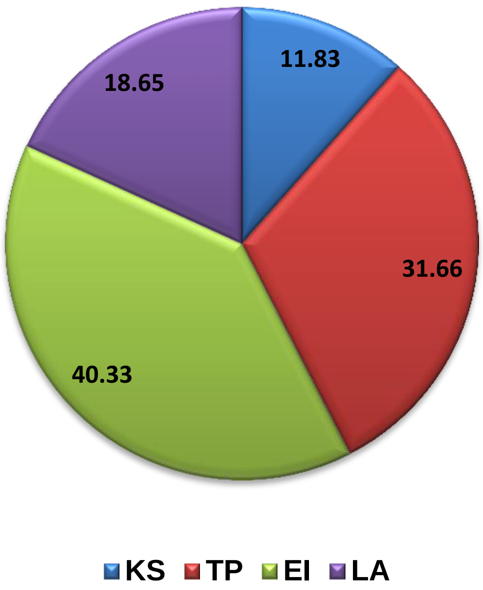
TABLE 5.2 INVESTIGATING THE PROBLEM: TABULATED FREQUENCY COUNTS REPRESENTED IN NUMBERS

Table 5.2 reflects the capturing of all the transcribed information during the investigative stage of the design process. The investigation stage was concluded in the classroom, and required participants to verbally reflect on their experiences in the conservancy.

Code	Individual Frequency Counts						Total Frequency Count	Average Frequency Count
	Knowledge & Skills							
	R1	L2	C3	E4	K5	K6		
KS1	25	22	7	7	5	5	71	11.83
KS2	No physical task required relating to technical, constructional or aesthetic variables during the investigation.						N/A	
KS3								
KS4								
Total							71	11.83
	Thinking Patterns							
TP1	29	35	9	14	12	13	112	18.67
TP2	1	4	0	2	1	0	8	1.33
TP3	8	11	4	1	7	3	34	5.66
TP4	7	12	3	5	5	4	36	6.0
Total							190	31.66
	Environmental Influence							
EI1	Collaborative whole group effort during the investigation.						66	11.0
EI2							47	7.83
EI3							35	5.83
EI4							94	15.67
Total							242	40.33
	Learner Attributes							
LA1	10	10	12	10	11	10	63	12.16
LA2	10	5	3	3	3	2	26	4.33
LA3	0	0	0	0	0	0	0	0
LA4	2	2	2	3	2	2	13	2.16
Total							102	18.65

FIGURE 5.1 INVESTIGATING THE PROBLEM: CATEGORICAL ANALYSIS OF DATA ACCORDING TO AVERAGE FREQUENCY COUNTS REPRESENTED IN NUMBERS

Figure 5.1 depicts a categorical analysis of data captured during the investigating stage in each of the key areas identified in the creativity assessment model presented in Figure 4.1 and discussed in 4.5.2 namely: domain-relevant knowledge and skills (coded KS); thinking patterns (coded TP); environmental influence (coded EI) and learner attributes (coded LA).



b) Discussion of the Investigation

i) Domain-Relevant Knowledge and Skills

Participants' knowledge of the natural environment and technological capability enabled them to conceptualize and generate and verbalize possible solutions to problems. Responses indicated a good general knowledge of the natural environment. Technical, constructional and aesthetic knowledge and skills were not noted or coded as these skills pertain to the actual making of a product.

ii) Thinking Patterns

Participants' responses reflected free-flowing and original thought regarding the identification of problems in the conservancy and possible solutions. Verbalized solutions to problems indicated a level of reflection and a high level of originality.

Flexibility of thinking patterns is reflected during the making and evaluation stages of the design process.

iii) Environmental Influence

The importance of the environment as a contributing factor to creativity was discussed in 4.5.2.3 (c). Jackson and Aston (2013:1), state that school grounds can be places for rich learning experiences in urban, suburban or rural settings. The outdoor classroom is seen as an extensive environment for purposeful activities that develop skills, understanding and knowledge in design and technology. The school grounds stimulate learning and provide links to other curriculum areas such as science.

In this study, the conservancy in the school grounds was used as an outdoor resource to engage the participants in identifying problems and proposing solutions to problems, by means of designing and making an artefact/product. There was much interactive discussion during the conservancy walkabout. The school principal accompanied the participants and the researcher during the case study investigation of identifying problems and the suggestion of possible solutions for the conservancy. Analysis of data reveals a high level of supportiveness and interactiveness between all parties during the conservancy walkabout. Frequency counts of all sub-categories of the environmental influence were tallied as a whole, and not individually counted per participant.

iv) Learner Attributes

Learner attributes such as intrinsic motivation were noticeable. Participants were motivated and keenly interested in identifying problems. They offered their opinions spontaneously and there was much verbal interaction, as to how problems could be solved. The investigation was a collaborative group effort. Learner attributes such as openness to experience, risk-taking and a sense of independence, were noted during the analysis of the transcribed information and the actual video footage. .

5.3.3.3 The Design Process: Designing and Planning

Following the feedback discussion with the participants after their investigation in the conservancy, participants were required to select one of the problems identified, and design and plan a solution to the problem by means of an annotated sketch. Participants were free to design and plan an artefact/product of their own choice, and to think of materials they would need to make their artefact/product. Simple annotated pencil sketches were drawn and discussed individually with each of the participants in a small group setting. The designing and planning process was video-taped and audio-taped to capture participants' thinking patterns as they transferred their ideas onto paper. This stage of the design process was completed over two separate double lesson periods comprising an hour per each double lesson.

A sample of transcribed video-taped and audio-taped information is included as an example of participants' involvement in the designing and planning of their artefacts/products. Based on the investigation of the conservancy and the follow-up discussion thereafter, participants were given the freedom to select a problem of their choice and to design their solution on paper. As per the investigative stage of the design process, the transcribed information was coded according to the assessment model presented in Table 5.1.

a) **Sample of Transcribed Data**: **Designing and Planning Solutions to Identified Problems**

C3: A Birdfeeder

R1: C3 was going to talk to me about the plan for her feeder. Would you like to show me on your plan what you're going to do? **EI4**

Is that a water bath? (pointing). Would you like to tell me what you've done there? **EI4**

C3: It's quite simple to make one of these. **KS1; KS3; TP1:** It's not really for water, but sometimes you can use it for a tree (meaning the feeder). **TP4; LA1; LA4**

R1: I see you've got a bird feeder there. Can you tell me how you're going to put it together? **EI4**

C3: I'm going to put it on one of the trees that are quite low down. **TP1; TP4**

R1: To attract the birds? **EI4**

C3: Nodding.

R1: When the bird flies to the feeder how will it stay on the feeder? Are you going to put anything for it (the bird) to sit on? **EI4**

C3: Like I said, when he (referring to L2) went somewhere, he saw one like that. .

That was one of my ideas. I'm going to put sticks. **TP1; TP4; KS1; KS3**

R1: Just show me (on the plan) where they can rest their feet & what you're going to use**. EI4** What could we use for that … (pointing to plan) real sticks, or could you use ….? **EI4**

C3: Real sticks that sometimes you buy marshmallows with. **TP1; TP4; KS1; KS3**

R1: Oh yes, like a skewer. **EI; EI2; EI3; EI4**

K5: A Litterbag

R to K5: Let's see what you've done there**. EI4** You've got an original idea there. What are you going to make? **EI4**

K5: Like a basket so when you go you can pick up the rubbish and put it in a basket so you can put the rubbish in when you go on a trail. **KS1;TP1; TP4**

R1: Any ideas on what you're going to make your basket from? **EI4**

K5: Cardboard & string & buttons. **KS1; KS3; TP1; TP4**

R1: And if you use material do you think that would work? **EI4**

K5: Not really. **TP3**

R1: And when you say cardboard … Are you going to use a ready-made box? **EI4**

K5: No, I'll make my own box. **TP1; KS3**;

E4: A Birdfeeder

R to E4: Can you just tell us something about your design there? **EI4**

E4: Well, I'm going to be using a coke bottle & few sticks. **KS1; KS3; TP1**; **TP4**

R1: And what will you be making? Tell us. **EI4**

E4: I'll be making a birdfeeder. **KS1;TP1**

R1: A birdfeeder. Where will you place it? **EI4**

E4: Maybe I'll place it in a high tree. **TP3**

R1: Good. **EI1; EI3**; What made you decide to use plastic? **EI4**

E4: Plastic – It won't really let water in unless it's got holes. **KS1; KS3; TP1; TP4**

R1: Do you think it will last? **EI4**

E4: Yes. **TP1**

R1: Well, I look forward to seeing that. **EI1; EI3**

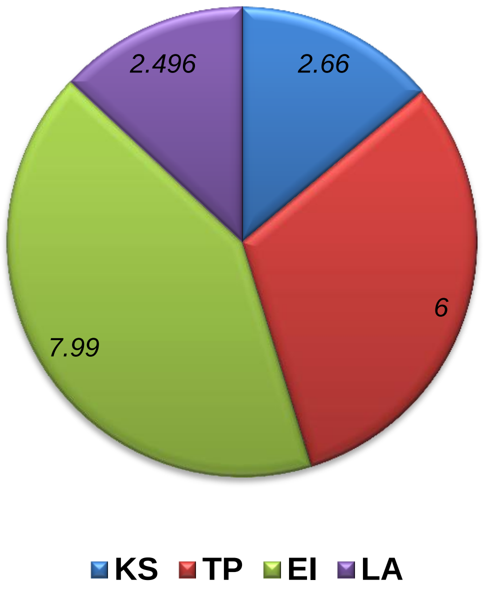
TABLE 5.3 DESIGNING AND PLANNING: TABULATED FREQUENCY COUNTS REPRESENTED IN NUMBERS

Table 5.3 reflects the capturing of all the transcribed information during the designing and planning stage of the design process. The designing and planning took place in the classroom and required participants to reflect verbally and graphically on their solutions to problems identified in the conservancy.

Codes	Individual Frequency Counts						Total Frequency Count	Average Frequency Count
	R1	L2	C3	E4	K5	K6		
KS1	1	2	1	3	1	2	10	1.66
KS2	1	1	1	1	1	1	6	1.0
KS3	0	0	0	0	0	0	0	0
KS4	0	0	0	0	0	0	0	0
Total	2	3	2	4	2	3	16	2.66
TP1	3	2	4	2	3	2	16	2.67
TP2	2	1	0	0	2	0	5	0.83
TP3	0	1	0	2	2	1	6	1.0
TP4	1	1	4	2	1	0	9	1.5
Total	6	5	8	6	8	3	36	6.0
EI1	1	1	1	1	1	1	6	1.0
EI2	1	1	1	1	1	1	6	1.0
EI3	5	1	1	1	3	2	13	2.16
EI4	4	1	8	2	4	4	23	3.83
Total	11	4	11	5	9	8	48	7.99
LA1	1	1	1	1	1	1	6	1.0
LA2	1	0	0	0	0	0	1	0.166
LA3	1	0	0	1	0	0	2	0.33
LA4	1	1	1	1	1	1	6	1.0
Total	4	2	2	2	2	2	14	2.496

FIGURE 5.2 DESIGNING AND PLANNNING: CATEGORICAL ANALYSIS OF DATA ACCORDING TO AVERAGE FREQUENCY COUNTS REPRESENTED IN NUMBERS

Figure 5.2 depicts a categorical analysis of data captured during the designing and planning stage in each of the key areas identified in the creativity assessment model presented in Figure 4.1 and discussed in 4.5.2 namely: domain-relevant knowledge and skills (coded KS); thinking patterns (coded TP); environmental influence (coded EI) and learner attributes (coded LA).



b) Discussion of Designing and Planning

i) Domain-Relevant Knowledge and Skills

Participants' conceptualizing of solutions to problems during the designing and planning stage showed good insight into how they reflected on what they envisaged making.

ii) Thinking Patterns

Free-flowing thought patterns were high as participants verbally explained their designs and plans to the researcher. Novel and original ideas of how they envisaged making their structures and what materials they were going to use, were spontaneously discussed.

iii) Environmental Influence

Interactive conversation between the researcher and the participants was on-going as the researcher engaged in conversation with each member of the research group. Participants were given the freedom and flexibility to exercise a choice of materials and equipment they would use to make their structures.

iv) Learner Attributes

Motivation levels were high and participants worked independently on their designs and plans. They freely shared their ideas with the researcher and engaged in descriptive dialogue of what they envisaged making.

5.3.3.4 The Design Process: Making

The making process comprised several double lesson periods. During this process, participants were given the freedom to select materials from a wide range of waste materials and wood which the participants and researcher had collected, once the participants' designs and plans had been completed. Problems with joining materials, waiting for adhesives to dry and refining workmanship for more stable products were par for the course. Although each participant was responsible for making his/her own product, the researcher noted that there was much collaboration between individuals in the group as they helped each other during the making process. Anticipated problems with designs and plans during the making process were re-evaluated and products were modified accordingly.

A sample of transcribed video-taped and audio-taped information is included as an example of participants' involvement in the making stage of the design process. As per the previous stages of the design process, the transcribed information has been coded according to the assessment model presented in Table 5.1.

a) **Sample of Transcribed Data**: **Making**

During this process, the researcher observed participants at work and intervened to find out more about their thoughts on how they were going to make their artefacts/products.

R1: Making a Litterbag

R1: Carefully stapling newspaper **LA1; LA4**

R1 to R1: I've taken one of these bags (Ronnie Bin paper waste plastic type- sacking bag) and put newspaper around to basically protect it. **KS1; KS2; KS3**

R1: Is that going to be outside or inside? **EL4**

R1: Outside.

R1: What made you use that part of the bag for the inside (referring to waste bag)?

R1: Well, I wanted the newspaper to protect it. **KS3**; **TP1; TP3; TP4;**

Later ...

R1: Let's take a look at your bag. **EI4**

R1: What I've done here is taken the (litter) bag …. (opening the top and showing the inside of the bag). I've put another layer of the newspaper around it, so it can protect it and when I want to throw it (the litter) in, I open up the bag, open up the rope and throw the litter in & close up the back with the rope**. KS1; KS2; KS3; TP1; TP3; TP4**

R1: That's quite a big bag there. What made you decide to use the newspaper? **EI1; EI4**

R1: Just for protection. **TP1; TP4**

R1: Now, obviously, if you were going to collect litter in the conservancy, you wouldn't go on a rainy day, would you? **EI4**

R1: No I wouldn't do that. **TP1**

R1: Is it waterproof inside? **EI4**

R1: Umm …. (feels inside with one hand). Yes, kind of. **TP3**

R1: That means if you get cans with water in (coke cans, etc.), the inside of the bag is waterproof and the water won't make it (the bag) soft on the outside. How did you join the sides together? **EI4**

R1: I stapled them. **KS1; KS3**

R1: Is it quite secure there do you think? **EI4**

R1: (Looking & feeling) ….. Yes. **TP3**

K5: Making a Litter Box

K5: Using a ready-made box (originally decided to make a box) **LA1; LA4**

R to K5: Do you need help there? Talk to me about what you're doing.

R1 turning to K5 (participant to participant): You should've thought about what you're going to do in the rain. **KS1; EI4**

K5 to R1: Well, I'll put plastic over it. **TP3; TP2**

R1: Do you think you'll go out in the rain or will you wait for a dry day? **EI4**

K5: I'll wait for it (the day) to dry. **TP1**

R1: Explain to me how you're going to make that & then I can try and help you. **EI1; EI4**

K5: I want to make this flat here (referring to inside flaps of box). K5 has a piece of cardboard to place over. **KS1; KS3; TP1; TP4**

R1: You don't want to tape it from the bottom …? Flip it on the other side and use some duct tape. **EI4**

K5 flips it over to take a look. **TP3**

R1: So, do you just want to make it firm at the bottom? **EI4** Let's look for something to seal that with. **EI1** What could you use to seal it? **EI4**

K5: The glue gun. **KS2:** K5 waits for E4 to finish using the glue gun.

R to R1: Are you helping K5? **EI4**

R1: Yes. **EI1**

R1: Are you completely finished? **EI4**

R1: Yes.

E4: Making a birdfeeder

R to E4: How did you make that hole? **EI4**

E4: With scissors **KS2; KS3**

R1: Jolly good. **EI1; EI4**

Later …

R1: What are you trying to do with the gun? **EI4**

E4: Seal the stick so that it's firm in there. **KS1; KS2; KS3**

R1: Have you though **[thought]** above how you'll fill it up with seed? **EI4**

E4: Umm … through the top (indicating the screw lid on the top). **TP3**

R1: Will you keep the label on or take it off? **EI4**

E4: I'll definitely take it off. **TP1**

L2: Making a birdfeeder

R observing L2: L2 is carefully joining wood. **KS2; KS3; LA1; LA4 (**Off - cuts are all the same size except for base).

L2: I don't know if it's going to be stabilized enough. **TP3**

R1: If it's not strong enough what can you use? **EI3; EI4**

L2: We'll find a way**. LA2; LA3**

R1: Observation of L2. Careful use of glue. **LA1; LA4**

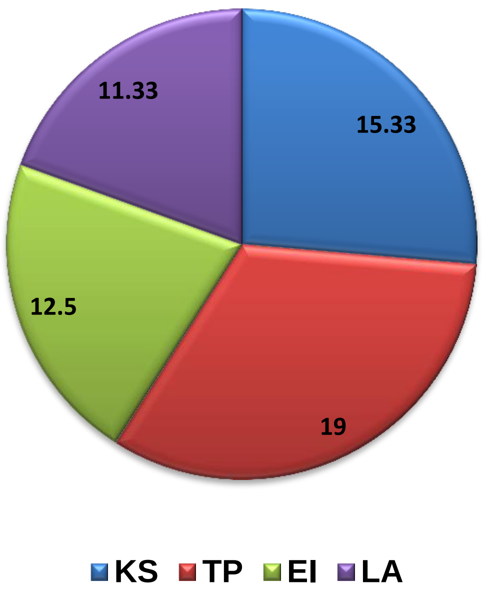
TABLE 5.4 MAKING: TABULATED FREQUENCY COUNTS REPRESENTED IN NUMBERS

Table 5.4 reflects the capturing of all the transcribed information during the making of the design process. The making process took place in the classroom.

Codes	Individual Frequency Counts						Total Frequency Counts	Average Frequency Counts
	R1	L2	C3	E4	K5	K6		
KS1	6	4	3	13	6	3	35	5.83
KS2	5	5	2	5	6	4	27	4.5
KS3	5	4	2	5	7	4	27	4.5
KS4	0	0	1	0	1	1	3	0.5
Total	16	13	8	23	20	12	92	15.33
TP1	7	5	3	12	5	4	36	6.0
TP2	4	4	3	9	6	3	29	4.8
TP3	3	3	1	10	5	4	26	4.3
TP4	3	2	2	8	7	1	23	3.8
Total	17	14	9	39	23	12	114	19.0
EI1	4	3	1	7	5	4	24	4.0
EI2	1	1	2	6	3	1	14	2.3
EI3	1	2	2	4	3	1	13	2.16
EI4	4	3	2	6	5	4	24	4.0
Total	10	9	7	23	16	10	75	12.5
LA1	4	4	2	4	3	3	20	3.3
LA2	1	4	2	3	2	3	15	2.5
LA3	2	4	2	4	2	1	15	2.5
LA4	3	4	2	4	3	2	18	3.0
Total	10	16	8	15	10	9	68	11.33

FIGURE 5.3 MAKING: CATEGORICAL ANALYSIS OF DATA ACCORDING TO AVERAGE FREQUENCY COUNTS REPRESENTED IN NUMBERS

Figure 5.3 depicts a categorical analysis of data captured during the making stage in each of the key areas identified in the creativity assessment model presented in Figure 4.1 and discussed in 4.5.2 namely: domain-relevant knowledge and skills (coded KS); thinking patterns (coded TP); environmental influence (coded EI) and learner attributes (coded LA).



a) Discussion of Making

i) Domain-Relevant Knowledge and Skills

Overall, participants demonstrated good conceptualization of the problems they needed to solve while making their artefacts/products. They were able to apply their knowledge of structures in terms of strength, stability and durability to use their physical skills to construct a functional artefact/product. Aesthetics in terms of visual appeal and attractiveness did not appear to be a priority, as the focus was on building a sturdy and long-lasting artefact.

ii) Thinking Patterns

Expression of thoughts flowed freely as participants chatted about the artefacts/products they were making. Ideas were original and there was much reflection as they used their physical skills to construct their ideas.

iii) Environmental Influences

Interactive dialogue between the researcher and the participants enabled the researcher to probe participants' thoughts as they tackled problems while constructing their designs and persevered to find workable solutions. Collaboration between participants was observed as they helped one another solve technical and constructional problems.

iv) Learner Attributes

A high level of motivation and independence was observed. Participants were prepared to take risks during the construction of their designs, and were open to experience when given advice.

5.3.3.5 The Design Process: Evaluating and Communicating Findings

The evaluation and communication stages of the design process took place in the school conservancy. Participants carried their artefacts/ products to the conservancy to try them out. Extra materials such as glue, tape, etc., were taken along by the participants in the event of products needing modification. Artefacts such as birdfeeders were left in the conservancy and re-evaluated two weeks later to observe their strength and durability in the outdoor environment. Those participants who made litterbins evaluated their products there and then by taking a walk through the conservancy to collect litter. Once again, the researcher noted the collaboration between participants, i.e. those that made litter bags/bins assisted those who made birdfeeders, position and stabilize their feeders.

A sample of transcribed video-taped recording of the participants' engagement in the evaluation and communication stage of the design process is included in this section. As per the previous stages of the design process, the transcribed information has been coded according to the assessment model presented in Table 5.1.

a) Discussion of Evaluating and Communicating Findings: A Visit to the Conservancy

Two of the three participants who made birdfeeders selected a prominently placed tree overlooking the potential site for the building of one of the dams. The tree was situated in the middle of a hollow in the conservancy.

E4: Birdfeeder

E4 selected a different tree, higher up on the bank of the conservancy. She hung her feeder from a branch using thick string which she looped over the branch and fastened using a double knot. **KS1**; **KS2; KS3**; **LA1; LA4**

L2: Birdfeeder

L2 has wedged his house in the trunk of the tree at the base of two branches which form a V-shape. He decided that no fastening was needed as the birdfeeder was securely wedged. **KS1**; **KS2; KS3; EI3; LA1; LA3; LA4**

C3: Birdfeeder

C3 hung her feeder from another branch of the same tree. She, too, had used thick string which she looped over the branch and fastened using a double knot. **KS1**; **KS2; KS3**; **LA1; LA4**

K5: Litterbox

K5 put on latex gloves taken from the first aid box in the technology Room. She carefully adjusted her litter box on the ground. The latex gloves were selected by the participant for hygiene purposes to keep her hands clean. **KS1; KS2; KS3; LA1; LA4**

K5 to R1: Look what’s happened here... (indicating). The string has come away from the box. **TP1**

R1: How are you strengthening it? **EI4**

K5: With sticky tape. **TP1**

L2: Birdfeeder

L2 to R1: It’s stable – (referring to birdhouse feeder). **KS1**

R1: Do you think it can stay on its own here? **TP3; EI4**

L2: Maybe, but I want to get it in. **TP1**; **TP3; TP4; LA3**

K5: Litterbag

Later ………

R1: Have you found any litter? **EI4**

K5: I found a packet of litter. **TP1; LA1; LA4**

Later ….

R to K5: What have you collected there? **EI4**

K5: I've collected a cup, 2 packets, a piece of packet and some polystyrene. **LA1; LA4**

R1: So your litter bag was quite big enough? Where do you think the weak link was? **EI4**

K5: The string. **TP1**

R1: Litterbox

R1: Is busy putting on latex gloves too. Slings bag over shoulder. **LA1; LA4**

R1: Are you putting that on your shoulder? **EI4**

R1: Yes, it's comfortable. (Off he goes to look for litter) **TP1; LA1; LA4**

L2: Birdfeeder

R to L2: What you're **[are you]** doing there? **EI4**

L2: I'm making sure it doesn't fall back & it doesn't fall forwards. **KS1:TP1; TP4; LA1; LA4**

R1: What are you securing it with there? **EI4**

L2: Wire. (anticipated this and had put wire in his pocket). Ties wire and knots it to a branch of the tree. **KS1; KS2; KS3; LA1; LA4**

E4: Birdfeeder and birdhouse

E4: Took her structure down from the branch of the tree she selected and went to find another spot to place it. **LA1; LA4**

R1: What made you decide to move your feeder? **EI4**

E4: Cause it's an open space there & birds don't like that open space. (Is only carrying the base of the feeder). **TP1; TP3**

K6: Birdfeeder

R1 helped K6 to place his bird house at the base of a thorn tree up on the bank. They wedged it in at the base of the thorn tree. **KS1; LA1; LA3; LA4**

Back in the classroom modifying made products/artefacts

C3: Birdfeeder

R to C3: What are you going to do with the net here (alongside is a foil dish)? **EI4**

C3: I'm going to make an extra water supply. When the seeds start growing, instead of growing all ways, they'll start growing through this net (referring to the vegetable netting bag). Can you see them; they'll start growing through the holes? **KS1; KS2; KS3;TP1;TP2;TP3;TP4;LA1; LA4**

R1: Yes, I can, I collect those. What do you think that's made from? **EI1**;

C3: I think it's made from plastic. **TP1**

R1: Do you think it's quite strong? **EI4**

C3: Ya. **TP1**

R1: Tell me what you're doing. (C3 busy cutting a hole through the lid of a plastic cake container) **KS1; KS2; KS3; EI4; LA1; LA4**

C3: I'm going to make a nest for my feeder. **TP1; TP4**

R1: That looks really interesting. **EI1; EI4**

E4: Birdfeeder

R to E4: Tell me what you're doing there. **EI4**

E4: Well, I'm trying to stick this on here (referring to half a yoghurt cup – arc shaped). I'm trying to attach this to side of feeder so the seed will fall into the container and won't all pour out like the last time. **KS1; KS2; KS3; TP1; TP4; LA1; LA4**

R1: What can you use to attach it (has already applied bostik)? **EI4**

E4: Sticky tape …. once the glue's dry. **TP1; KS2; KS3; TP4; LA1; LA4**

C3: Birdfeeder

Back to C3: has placed straw inside the cake container with 3 upright sucker sticks protruding from the base up through the hole in the lid. **KS1; KS2; KS3; TP4: LA1; LA4**

R1: I see you've got sticks there. Explain to me what you've done & why you've done it. **EI4**

C3: I'm gonna put sticks there so I can put a roof - indicating. So if it starts raining, none of this will get wet. This is where the bird will be resting on (indicating the opening & pressing down onto the straw). **KS1; KS2; KS3; KS4; TP1; TP4**

R1: And the straw that you've used – What made you decide to use that**? EI4**

C3: I just maybe thought that it would be comfortable. **KS4; TP1; TP3; TP4**

R1: And what are you going to call that? **EI4**

It's going to be a bird's home. **TP1; TP4**

R1: Are you going to connect it to your feeder or keep it separate? **EI4**

C3: I think I'll keep it separate & put it next to it. **TP1**

R1: Where are you going to place it? **EI4**

C3: I'm going to place it on the ground somewhere, next to the island ….. the lowest part of the tree (thinking perhaps that the ground is not such a good idea). **KS1; TP1; TP3; TP4**

E4: Birdfeeder

R To E4: Can I give you a hand to hold it (she has secured the hollow dish onto the stick)? **EI4**

R; Tell me what happened the last time? I know you've changed things now. What was the problem with your feeder? **LA2; EI4**

E4 talks as she's working ….. Last time, it kept on …. I didn't realize I had to have something to keep it here – indicating to dish so all the seed falls into something. **TP1; TP3**

R1: Oh yes, I know what you're saying. **EI1; EI3; EI4**

E4: So when they eat it just keeps filling up. **KS1; TP1: TP4**

R1: Are you going to do more than one little feeder (dish) there? **EI4**

E4: Ya, I think I'll do a few of these. Carries on *sticky taping*. **TP1; TP3; TP4; LA1; LA4**

R1: Your original plan ….did you stick to it? **EI4**

E4: I stuck to it. **TP1; LA1; LA4**

R1: I'm just looking at your plan here – Once we've finished here, it might be an idea to show me in your diagram here, what you've done, so that we can have a look. **EI1; EI4**

C3: Birdfeeder

R1: Are you almost done there (has taken a cocktail drink umbrella & is debating whether to place it on top of the nest as a roof)? **KS1; KS2; KS3; EI4; LA1; LA3; LA4**

R1: Tell me about that umbrella. **EL4**

C3: …Maybe with this umbrella I could see how it's made. Then maybe I could make a bigger umbrella & hook it on like that (showing how) **KS1; KS2; KS3**; **TP1; TP3; TP4**

R1: What material do you think would be better for that? **EI4**

C3: I think soft material ….. see it's breakable (has torn the paper umbrella). Looks for material. **TP1; TP2; TP3; TP4; LA1; LA2; LA3; LA4**

E4: Birdfeeder

E4: Still busy sealing her holes & joins. (**KS2; KS3; LA1; LA4)**

R1: Are you going to do something with the base? **EI4**

E; Yes, I think I'll stick it on again. **TP1; TP3; LA3**

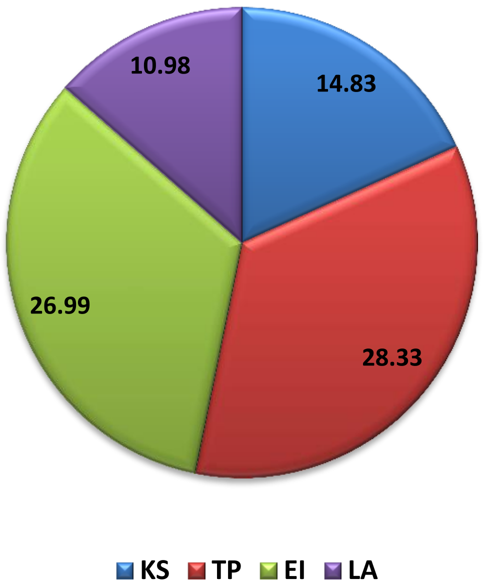
TABLE 5.5 EVALUATING AND COMMUNICATING FINDINGS: TABULATED FREQUENCY COUNTS REPRESENTED IN NUMBERS

Table 5.5 reflects the capturing of all the transcribed information during the evaluative and communicative stages of the design process. For the purpose of this research, these two stages of the design process have been combined for the Foundation Phase respondents. Evaluation and communication took place in the conservancy and in the classroom.

Codes	Individual Frequency Counts						Total Frequency Counts	Average Frequency Counts
	R1	L2	C3	E4	K5	K6		
KS1	1	6	21	4	1	3	36	6.0
KS2	1	2	14	4	3	1	25	4.16
KS3	1	1	14	4	3	1	24	4.0
KS4	1	0	3	0	0	0	4	0.67
Total	4	9	52	12	7	5	89	14.83
TP1	2	6	33	8	7	3	59	9.83
TP2	1	3	15	4	5	3	31	5.16
TP3	0	3	20	5	8	2	38	6.33
TP4	1	4	22	11	3	1	42	7.0
Total	4	16	90	28	23	9	170	28.33
EI1	0	4	32	2	3	1	42	7.0
EI2	0	1	13	1	1	1	17	2.83
EI3	1	1	18	2	2	1	25	4.16
EI4	0	7	50	10	6	5	78	13.0
Total	1	13	113	15	12	8	162	26.99
LA1	1	3	7	3	4	1	19	3.16
LA2	0	1	10	2	2	1	16	2.66
LA3	0	2	3	1	0	0	6	1.0
LA4	1	3	10	5	5	1	25	4.16
Total	2	9	30	11	11	3	66	10.98

FIGURE 5.4 EVALUATING AND COMMUNICATING FINDINGS: CATEGORICAL ANALYSIS OF DATA ACCORDING TO AVERAGE FREQUENCY COUNTS REPRESENTED IN NUMBERS

Figure 5.4 depicts a categorical analysis of data captured during the evaluating and communicating stage in each of the key areas identified in the creativity assessment model presented in Figure 4.1 and discussed in 4.5.2 namely: domain-relevant knowledge and skills (coded KS); thinking patterns (coded TP); environmental influence (coded EI) and learner attributes (coded LA).



a) Discussion of Communicating and Evaluating

i) Domain-Relevant Knowledge and Skills

Verbal conceptualization of solutions to problems encountered was relatively high. At a glance, it would seem that C3 dominated the conversation due to the high frequency counts recorded through each of the four main categories. This was not the case, as the participant concerned encountered problems with her structure which required her to rework her final product more than once in order to make it more functional and stable. This required additional time needing to be spent in the classroom modifying the birdfeeder structure by using stronger materials and adhesive in order to solve the strength of the hanging feeder carrying a load of birdseed.

Technical and constructional knowledge and skills were used in functional and novel ways, and participants applied their knowledge of the elements encountered in the natural environment to evaluate the possibility of their products being durable and Table 5.5 reflects the capturing of all the transcribed information during the evaluative and communicative stages of the design process. For the purpose of this research, these two stages of the design process have been combined for the Foundation Phase respondents. Evaluation and communication took place in the conservancy and in the classroom.

Surprisingly, the aesthetic value of their products in terms of their visual appeal was not a factor considered by the participants. Participant C3 made reference on a few occasions to comfortable materials being selected for the interior of her birdhouse, so that in the event of rainy weather, the birds could enter the house and rest in comfort.

ii) Thinking Patterns

Free flowing thought was observed as the researcher questioned the participants about the structures they had made and were evaluating in the conservancy. The birdfeeder structures required careful manipulation for the purpose of either hanging them from different branches of the same tree, or wedging the feeder at the base between two v-shaped branches.

iii) Environmental Influence

There was a high level of interaction between the researcher and the participants and between the participants themselves during the final stage of the design process. Those participants who had tested out their bird and litter structures helped those who required help with modifying their structures. A supportive environment was characterized by two-way dialogue between the researcher and individual participants in order to encourage the development of participants' higher-order thinking skills. The contextual nature of the evaluation and communication process required the participants to use the real-life context of the conservancy to evaluate realistically their designed and made structures over time and not just on the day.

iv) Learner Attributes

All participants were motivated during the evaluation and communication stage of the design process. They were excited to be given the opportunity to test out their structures. R1 required very little assistance with his novel litterbag which proved to be stable and functional. Once he had finished evaluating his bag, he offered his assistance to K6 who was battling to wedge his feeder amongst the thorn bushes.
An element of risk was noted, although the frequency count recorded is not high. A high level of independence was evident as participants focussed on evaluating their own structures.

5.3.3.6 A Discussion of the Stages of the Design Process

a) Investigating Problems and Conceptualizing Solutions

During the investigative stage of the design process participants were required to identify problems in the conservancy and suggest solutions to these problems. Technical and constructional aspects did not feature in this stage, neither did the aesthetic component. Overall, conceptualization of problems and solutions was very high, and participants demonstrated a very good knowledge of the natural environment, problems in the conservancy and possible solutions to overcome these problems.

A high level of knowledge and skills was evident during the designing and planning, making and evaluating and communicating stages of the design process. Problems encountered were verbally communicated, and the knowledge of the natural environment and of the subject itself in terms of building stable and functional structures, was evident.

The aesthetic appeal of structures was hardly considered by the participants whose focus was on designing and making a functional product that would effectively address the conservancy problems identified.

b) Thinking Patterns

During all four stages of the design process, free-flowing thought was evident. Participants freely discussed their thoughts and problems encountered during the making and evaluating stages. Flexibility of thought was exercised when alternative solutions to problems needed to be addressed. With regard to the structures made, all products/artefacts were deemed to be original for each individual.

c) Environmental Influence

An interactive environment characterized by a high level of involvement by the researcher and the participants contributed towards effective problem-solving and finding solutions to problems encountered during the design process. Whilst the contextual statistics are not high, the whole project itself was contextually based using the conservancy to investigate problems, evaluate and communicate solutions to problems.

d) Learner Attributes

Overall, levels of motivation were high throughout the design process, especially during the investigative stage which set the scene for the project. Where problems were encountered, participants were open to experience and they modified and adjusted their structures for greater functionality and durability. Some degree of risk-taking was evident where participants needed to make choices where they were uncertain about outcomes. Participants worked independently and were very task-focussed. Those participants who were satisfied with the outcomes of their endeavours readily assisted those participants who were struggling during the making and evaluating stages of the design process.

5.3.3.7 The Design Process: A Comparative Analysis

Table 5.6 represents a comparative analysis between the main categories of the creativity assessment model and the different stages of the design process.

TABLE 5.6 THE DESIGN PROCESS: A COMPARATIVE ANALYSIS OF THE DIFFERENT STAGES OF THE DESIGN PROCESS ACCORDING TO THE MAIN CATEGORIES OF THE CREATIVITY ASSESSMENT MODEL REPRESENTED IN NUMBERS

Main Categories	**The Design Process**			
	Investigate	**Design**	**Make**	**Evaluate & Communicate**
Knowledge & Skills	**11.83**	**2.66**	**15.33**	**14.83**
Thinking Patterns	**31.66**	**5.67**	**18.9**	**28.32**
Environmental Influence	**40.33**	**5.48**	**12.46**	**26.99**
Learner Attributes	**18.65**	**2.49**	**11.3**	**10.98**

In order to identify whether, or not, particular stages of the design process influence and contribute to learners' creativity, the researcher has compared the different stages of the design process with the main categories of the creativity assessment model presented in Table 5.1.

An analysis of the results in Table 5.6 highlights the importance of the investigation stage in providing the opportunity for the research group to think creatively within a supportive and interactive learning environment. Learner attributes such as intrinsic motivation featured prominently during the investigation.

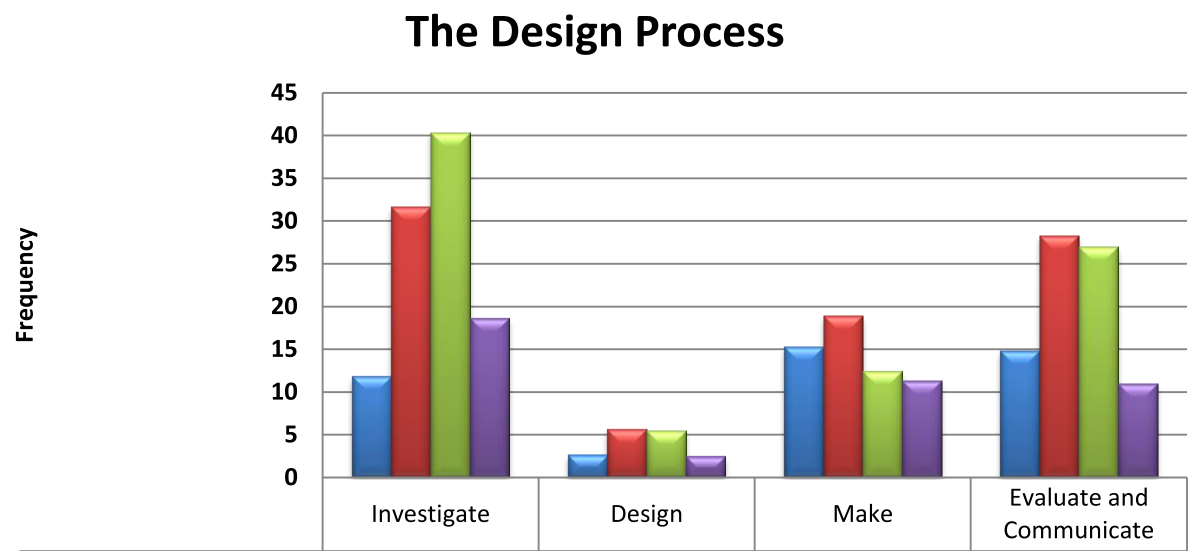
The evaluation and communication stage of the design process also reflects a high level of creative thought within a supportive and interactive learning environment. It is also interesting to note that both the investigative, evaluative and communicative stages of the design process required the research group to verbalize their thoughts and actions.

The making stage which required the interaction of mind and hand reflected the importance of domain relevant knowledge and skills which are required to make a functional product.

The designing stage which required the research group to sketch their thoughts and ideas on paper, did not appear to yield high results due to Foundation Phase learners, generally, not wanting to spend time planning and designing their ideas in written/graphical form. Due to the active-based nature of learners within this age-category, active learning that reflects the interaction between verbalized thoughts and actions was indicative of the research groups' approach to designing and making products/artefacts.

Figure 5.5 provides clearer analysis of the importance of the investigative and evaluative and communicative stages of the design process.

FIGURE 5.5 A COMPARATIVE ANALYSIS OF THE DIFFERENT STAGES OF THE DESIGN PROCESS ACCORDING TO THE MAIN CATEGORIES OF THE CREATIVITY ASSESSMENT MODEL REPRESENTED IN NUMBERS



	Investigate	Design	Make	Evaluate and Communicate
Knowledge & Skills	11.83	2.66	15.33	14.83
Thinking Patterns	31.66	5.67	18.9	28.32
Environmental Influence	40.33	5.48	12.46	26.99
Learner Attributes	18.65	2.49	11.3	10.98

An analysis of the results in Figure 5.5 highlights the importance of the investigative stage of the design process where participants were given the opportunity to explore the school conservancy, identify problems and pose possible solutions to these problems. Environmental influences such as the supportive, interactive, free and flexible and contextual nature of the investigation motivated the participants to suggest creative and original solutions to problems.

The evaluative and communicative stage of the design process enabled the participants to openly and carefully reflect on the designing and making process. Whilst some participants met with success in making their artefacts, others did not, and needed to go back to the drawing board to redesign, remake and re-evaluate.

From experience, the researcher has found that generally Foundation Phase learners do not spend much time designing their thoughts on paper. They prefer to discuss their thoughts and begin making their creations. When they do graphically represent their thoughts on paper, their final products seldom represent their original design, as they tend to redesign their ideas while making. From experience in teaching technology, young learners prefer to move away from the pen and paper tasks required in other subjects such as language and mathematics. With reference to Figure 5.5 this may explain the low frequency counts reflected.

Technical and constructional knowledge and skills reflected during the making and evaluating and communicating stages of the design process reveal almost the same degree of knowledge and skills required during making, evaluating and communicating one's findings.

5.4. CONCLUSION

Chapter Five has focussed on the presentation and analysis of the findings of this study. The different stages of the design process, namely investigating, designing, making and evaluating and communicating, have been presented and analyzed. A comparative analysis of the different stages of the design process has been presented and discussed.

In Chapter Six, recommendations that emanate from the generated data will be presented.

Chapter 6
SUMMARY, FINDINGS AND RECOMMENDATIONS

6.1 INTRODUCTION

Chapter Six provides an overview of the investigation. The preceding chapters have formed an important background to the investigation contained in this study. The study has aimed at analyzing the nature of creativity and the nature of technology as an area of focus in the Foundation Phase curriculum. Matlin's theory on problem-solving and creativity was used to analyses the nature of the research groups' engagement in the design process, i.e. how they understand the problem, what strategies they employ, what factors influence problem-solving and the nature of creativity in technology (cf 2.4). A conceptual framework for data analysis was proposed as a means of analyzing data collected in the study (cf Figure 4.1). A creativity assessment table that included the coded categories, sub-categories and category descriptors was presented as a means for data analysis (cf Table 5.1). A sample of coded transcribed data for each of the stages of the design process that corresponded to the coding system presented in Table 5.1 was presented in the analysis. An analysis of frequency counts of the sample group's responses for the different stages in the design process was presented to compare information between the different categories and sub-categories of the proposed model (cf Table 5.2, Figure 5.1, Table 5.3, Figure 5.2, Table 5.4, Figure 5.3, Table 5.5, and Figure 5.4). Finally, a comparative analysis was made between the different stages of the design process to compare the frequency levels of different categories and to identify patterns and relationships that have emerged from the data analysis.

6.2 OVERVIEW OF THE INVESTIGATION

One of the primary objectives of this investigation has been to investigate the nature of technology, as a school subject, as a vehicle for developing and enhancing Foundation Phase learners' creative thinking skills. In order to do this, the nature of creativity, as researched by well-known scholars in the field of psychology and creativity research, with particular reference to Matlin's theory of problem-solving and creativity, has been used to develop a creativity assessment model for technology that encapsulates the essence of Matlin's theory, and also includes key features of creativity research. Subsidiary objectives such as the influence of the outdoor classroom as a creative catalyst, the social environment as a supporting mechanism for creative thought and the teacher's role in facilitating technological tasks and activities, have also formed part of the study.

6.2.1 THE NATURE OF TECHNOLOGY IN THE SCHOOL CURRICULUM

The design process forms the backbone of technology in the school curriculum (cf 3.4.1). Starting with the investigative process of identifying everyday problems in the context of their life-world, learners were required to identify problems, design a solution to the problem, make an artefact/product, evaluate their solution and communicate their findings (cf 3.4.1.1). Research conducted on the design process, shows that the open-ended nature of finding solutions to problems, promotes creativity in learning (cf 3.4.1.1).

In the South African Curriculum and Assessment Policy Statement (CAPS), the subject disciplines of technology and the natural sciences are combined with Social sciences (geography and history). These disciplines are grouped under beginning knowledge, one of four areas of study that comprise the life skills subject in the Foundation Phase. The teaching time allocated to beginning knowledge, is one hour per week for learners in Grades R to 2**,** and two hours per week for learners in Grade 3 (cf 3.2.1).

The backbone of technology as a subject in its own right is the design process which comprises the process of investigating, designing, making, evaluating and communicating (cf 3.4.1). Design is described as a creative problem-solving process which involves identifying problems, planning, researching, innovating, conceptualizing new ideas and experimenting (cf 3.4) The interactive nature of the design process as researched by Kimbell, Stables, Wheeler, Wozniak & Kelly (1991) cited in Stables 2002:133), is seen as an iterative process between mind and hand, as ideas are bounced back and forth. This interactive approach correlates with the design process model developed by the South African Department of Basic Education (cf 3.4.1).

The second stage of the design process involves designing and developing solutions to problems. This stage highlights important aspects of thinking that takes place as learners prepare their solutions to problems. Potgieter (2007) highlights important aspects of thinking such as fluency, flexibility, originality and elaboration that need to be developed and supported during the designing phase of the design process (cf 3.4.4.1). These aspects are cited in creativity research to highlight the importance of divergent thinking in the creative process (Figure 3.5).

6.2.2 MATLIN'S THEORY OF PROBLEM-SOLVING AND CREATIVITY

Matlin's theory of problem-solving and creativity (2009:355-391) has relevant links to the problem-solving nature of the design process in technology (cf 3.4). Matlin highlights the fact that, in order to understand a problem that needs to be solved, people use their previous experience to construct an accurate and mental picture of the problem, based on information they have been given (cf 2.4.1). Other cognitive processes such as paying attention, relying on memory and making decisions are also relied upon, thus showing that there is an interrelatedness of the cognitive processes when engaged in the problem-solving process (cf 2.4.1).

Matlin's theory of problem-solving and creativity also highlights the fact that the ability to solve a problem is specifically linked to real-world contexts in which problems are solved. Her situation cognition approach supports the notion that problems are best solved in a particular context (cf 2.4.1.3).

Different strategies may also be used to solve problems. Matlin's research on problem-solving highlights the tendency by people to use heuristics (general strategies), rather than algorithms, as more likely to be used when solving everyday problems (cf 2.4.2). She cites the analogy approach, one of three widely used heuristic methods, as prominent in achieving creative breakthroughs in different domains (cf 2.4.2.1) The means-end heuristic, which is based on identifying the goal and then pursuing the means to reach that goal, is another flexible and effective method of problem-solving according to Matlin (cf 2.4.2.2). The hill-climbing heuristic is another simple strategy, more for short-term solutions, where people choose alternative routes at different points of the problem-solving process in order to reach their goal (cf 2.4.2.3). Based on research conducted with university students of different cultures, Matlin states that little difference was noted in the problem-solving strategies used, and that the analogy method was cited as being the easiest to apply (cf 2.4.2.4).

Many cognitive processes rely on both bottoms-up and top-down processing. According to Matlin (2009:373-374), factors that influence problem-solving include the interplay between bottom-up processing and top-down processing. Bottom-up processing includes information received via the sensory receptors and requires a low-level of sensory analysis. In contrast, top-down processing in problem-solving requires a higher level of cognition and emphasizes the influence of concepts, memory and expectations based on past experiences. For effective problem-solving to occur, a blend of both types of cognitive processing is required (cf involved in problem-solving (cf 2.4.3).

Concepts such as expertise are identified when a person demonstrates consistently good performance on certain tasks within a particular domain due to their knowledge base, memory and problem-solving skills. Experts usually employ parallel processing by simultaneously using the analogy and means-end heuristic approaches to arrive at a solution. They also exercise self-monitoring, a component of metacognition (cf 2.4.3.1).

Other factors, identified by Matlin as influencing problem-solving, are having a fixed mind (mental) set and functional fixedness. With regard to having a fixed mind, past experiences strongly guide a person's thought processes when attempting to solve a current problem (cf 2.4.3.2). With regard to functional fixedness, one is hindered from effectively solving a problem, due to one's fixation on the function of a physical object based on one's conceptual understanding, expectations and memory of that object (cf 2.4.3.3)

With regard to insight versus non-insight problems, Matlin states that problems involving insight are best solved after taking a break away from a problem and then returning back to it. There are no set rules to solve insight problems. Novel and 'out of the box' solutions are needed (cf 2.4.3.4). Initially, an insight problem may seem difficult to solve, yet after taking a break from the problem and then returning to it, the problem is able to be solved. This concept known as *incubation* was identified by

Wallas (1926) in his 4-stage process model, a model which is recognized as one of the earliest descriptions of the creative process (cf 2.3.1.2). Non-insight problems, on the other hand, require gradual step-by-step mental processing, and are dependent upon a combination of memory, reasoning and a routine set of strategies. Problems that require insight require bottom-up processing. Problems that do not require insight use top-down processing, and are useful when attempting to solve problems that are similar to previous problems solved (cf 2.4.3.4).

Creativity as an area of problem-solving involves moving from an initial state to a goal state. Unlike problem-solving, it is more controversial as it has no set definition. Research in creativity has also lagged behind researched topics in the field of Cognitive Psychology. Two contrasting views of creativity are divergent production, identified by Guilford (1967) cited in Smith and Smith (2010:252), and the Investment Theory of Creativity developed by Lubart and Sternberg (1995) cited in Sternberg and Kaufman: 2010:477). Both theorists are well known for their contributions to creativity research in Psychology. An analysis of their investment theory of creativity highlights several essential attributes of creative investors, namely intelligence, knowledge, motivation, encouraging environment and appropriate thinking style (cf 2.4.4.1).

Amabile's research in the field of the social psychology highlights the positive influence of intrinsic motivation on creativity (2006:107-110). The ability to work on a task due to interest, appeal and challenge is seen to be an enhancer of creativity. Extrinsic motivation which is based on the promise of a reward or chance of winning a competition is seen to be a decreaser of creativity. It is mentioned, however, that both intrinsic and extrinsic motivation can, at times, be used to energize the creative person (cf 2.4.4.1).

6.2.3 A CREATIVITY ASSESSMENT MODEL FOR TECHNOLOGY

Selecting the domain relevant knowledge and skills that are reflected in the design process of technology and drawing on the core aspects of Matlin's problem-solving and creativity theory (2009:355-391), as well as aspects of creativity research conducted by scholars in the field, a creativity assessment model for technology was developed to analyze collected data. Citing four categories, namely domain-relevant knowledge and skills, thinking patterns, environmental influences and learner attributes, collected data was analyzed according the five stages of the design process (IDMEC) (Table 5.1).

6.2.4 THE RESEARCH DESIGN

The literature review carried out in Chapters Two and Three, respectively, presented an overview of the nature of creativity and creativity research with a particular focus on Matlin's theory of problem-solving and creativity, and the nature of technology as a school subject in the South African curriculum and in other countries. The literature review therefore provided a solid foundation for the researcher to embark on a qualitative research study that would investigate learners' engagement during the design process of technology, with a view to identifying learners' creative thinking patterns in a problem-solving context (cf 1.2).

A small sample of six Grade 3 Foundation Phase learners at an independent school was selected for the investigation. The school was chosen due to the researcher's involvement in teaching technology to Foundation Phase and Intermediate Phase learners at the school. Access to the school, was gained by the managing director of the group of schools to which the school was affiliated (cf 4.3.4). Participant observations and small group interviews were conducted with the respondents. Data gathered during observations, and interviews using transcribed video-taped and audio-taped recordings, have been analyzed according to the development of a creativity assessment model. The model, presented as a conceptual framework, was developed to include four main categories that are believed to encapsulate and highlight creative conceptualizations during the design process; thinking patterns of learners as they engage in the design process; their personal attributes and influence of the environment on their creative input (cf 4.5.2 & Figure 4.1)

6.3 SYNTHESIS OF FINDINGS AND RECOMMENDATIONS FOR FURTHER RESEARCH

6.3.1 The Design Process: Investigating Problems and Solutions to Problems

The investigative stage of the design process reflects the capturing of transcribed information of individuals in the research group as they collaboratively engaged in identifying problems and offering solutions to problems identified in the conservancy. The findings reported in this stage of the design process reflect a collective effort of the investigation.

6.3.1.1 Findings

a) Knowledge and Skills (KS)

The conservancy walkabout required the research group to identify problems in the natural environment and to offer solutions to these problems. Two research participants in particular, namely R1 and L2, displayed a high level of knowledge and skills during the investigation. Their knowledge of the natural environment enabled them to quickly identify and clearly verbalize solutions to problems. Contributions from these two participants reflect a high level of conceptual knowledge during the investigative stage. Overall findings indicate the research groups' ability to identify and conceptualize solutions to problems based on prior knowledge and skills.

Matlin's theory of problem-solving, states that people with expertise demonstrate consistently good performance on certain tasks within a particular domain due to their knowledge base, memory and problem-solving skills. These people usually employ the analogy approach where previous experience in problem-solving influences how problems will be solved in a current situation, and the mean-end heuristic approach where the end is identified and the means or steps to get to the end will be used to reach those ends (cf 2.4.2). The interactive dialogue between the researcher, the research group and the school principal reflected a combination of both these problem-solving approaches being adopted by the research group.

b) Thinking Patterns (TP)

The investigation required active involvement and paying attention to important information. Problem identification and problem-solving were rooted in a real-life context, using the natural environment as a springboard for problem-solving and engaging the research group in spontaneous conversation with the researcher, the school principal and each other.

The investigation directly corresponds to Matlin's theory of understanding the problem as well as the importance of situated cognition and the importance of context (cf 2.4.1). Matlin's theory of the analogy approach to problem-solving, where the same strategies used to solve a previous problem are used to solve a current problem, was used by individual participants during the investigation (cf 2.4.2).

Both top down and bottoms up processing skills were used by the research group to suggest solutions to problems. The sensory experience of the walkabout in the study strongly influenced the research groups' bottom-up processing skills, whereas their top down processing skills relied on their cognitive process skills such as memory and expectations from past experiences (cf 2.4.3).

Free-flowing thought was clearly evident during the investigation and dominated the thinking patterns category. A high level of fluent thinking was reflected in the responses of respondents R1 and L2. Transcribed information indicates that they provided a scaffold for interactive discussion during the investigation (cf Table 5.2).

The overall high frequency count for this sub-category could possibly be attributed to the nature of the investigation which was contextually-based, activity-based and verbal. Reflective and original thought were also evident as learners pondered on solutions to problems and offered original ideas during the interactive discussion during the walkabout. Flexible thinking scored the least number of frequency counts, and may be attributed to the fact that this sub-category relates more closely to the making and evaluating stages of the design process (cf Table 5.2).

c) Environmental Influence (EI)

The collaborative input of the research group during the investigative stage of the design process underscores the importance of a contextually-based, supportive and interactive environment which provided the research group with the freedom and flexibility to identify problems and suggest possible solutions. This underscores Matlin's principle of problem-solving, which states that people learn skills within the context of a specific situation. This principle highlights the importance of the environmental and social contexts for problem-solving activities (cf 2.4.).

d) Learner Attributes (LA)

Using the outdoor environment, namely the school conservancy, to identify problems and offer solutions to problems revealed a high level of intrinsic motivation from all participants. There was also a perceptible level of openness to experience, as learners engaged in conversation with the researcher, the school principal and each other. Risk-taking was not noted at this stage of the design process, whilst an element of independence was noted as respondents gave their own viewpoints.

Matlin's theory of problem-solving and creativity highlights task motivation and creativity as an area that underscores the importance of intrinsic motivation as an enhancer of creativity (cf 2.4.4).

6.3.1.2 Recommendations

The influence of the natural outdoor environment provided learners with the opportunity to investigate and identify needs and solve problems rooted in real-life contexts. It motivated and stimulated learners' knowledge of the natural and man-made environment, and provided them with the opportunity to think creatively and suggest original solutions to problems through interacting with one another and the researcher. Based on the findings of this project, the active-based nature of the investigative stage of the design process is highly conducive to conceptual and contextual learning.

Schools need to consider the value of active-based investigations of the environment by young learners and plan their Foundation Phase timetable accordingly. The Curriculum and Assessment Policy for the Foundation Phase: Grades R-3 for the

Life Skills subject allocates an hour per week for Beginning Knowledge which incorporates and integrates the Social Sciences and the Natural Sciences and technology. Whilst an hour per week is allocated to Beginning Knowledge for learners in Grades R, 1 and 2 and two hours for learners in Grade 3, the investigative nature of both the natural sciences and technology can be effectively used to identify problems in the natural world, and to suggest solutions that involve man-made products/artefacts. Whilst the whole of the design process may not be worked through due to time constraints, valuable investigations that involve interactive and free-flowing thought could prove to be most valuable in developing young learners' problem-solving skills.

6.3.2 The Design Process: Designing and Planning Solutions to Problems

The designing and planning stage of the design process reflects the capturing of transcribed information of individuals in the research group as they worked on their own to design and plan a solution to the problem they had identified during the investigation of problems identified in the conservancy.

6.3.2.1 Findings

a) Knowledge and Skills (KS)

Conceptualizing solutions to problems during the design process required learners to represent graphically their ideas on paper in the form of annotated sketches, and to verbalize their ideas to the researcher. The category descriptors for technical and constructional knowledge and skills, developed by the researcher in the creativity assessment model, describe the physical skills of manipulating tools and materials and the construction of an actual product. No technical or constructional skills were therefore assessed during the designing and planning stage, although evidence of technical and constructional 'know-how' were noted in the research group's designs and sketches. No evidence of aesthetics was noted in the research groups' designs. The focus was on designing a functional, rather than a 'pretty', product.

b) Thinking Patterns (TP)

Matlin's theory of problem-solving and creativity makes reference to methods of presenting the problem such as symbols, diagrams, matrices or other visual images (cf 2.4.1). In this stage of the design process, the research group was required to represent graphically their ideas as annotated sketches. Free-flowing, flexible and reflective thought was characterized by interactive discussion between the researcher and the individual participants. Assessment of originality was based on viewing each design as a product of the participants' own inventions.

c) Environmental Influence (EI)

The influence of the environment placed an important role in the design process. A supportive and contextually-based environment that provided the opportunity to exercise freedom and flexibility in selecting materials and designing alternative solutions to problems provided an opportunity for quality interaction between the researcher and the research group, and between the participants themselves.

d) Learner Attributes (LA)

All participants were intrinsically-motivated and focussed. They worked independently as they engaged in the designing and planning stage.

6.3.2.2 Recommendations

Designing solutions to problems need not always be graphically represented in the Foundation Phase, although it is preferred in an independent school timetable, where specialist teaching occurs for a set period, once in a six-day cycle. Recording ideas on paper, enables learners to incubate and reflect on previously recorded ideas before entering the making stage of the design process.

Schools need to encourage Foundation Phase learners to plan before they embark on projects where they are required to make an artefact/product. Planning encourages learners to record their ideas on paper and to use these ideas to revise and rework solutions to problems. Whether planning is verbal or graphical, learners are able to communicate their ideas to others. This enables the teacher to assess learners' cognitive thought processes and to scaffold learners' learning accordingly. Graphical representation of ideas enables the teacher to assess the less verbal learners' thinking on paper and provide encouraging feedback.

Both the investigative and designing and planning stages of the design process can be used to assess learners' thinking skills without necessarily requiring learners to make a product/artefact for evaluative and communicative purposes. It should be noted, however, that Grade 1 learners who participate in technological tasks for the first time, do not enjoy graphically representing their thoughts on paper. They prefer to verbalize solutions to problems and engage in the making stage immediately afterwards. The reason for this is that Grade 1 learners may not have the skills to accurately represent their thoughts on paper.

6.3.3 The Design Process: Making the Artefact/Product to Solve the Problem

The making stage of the design process reflects the capturing of transcribed information of individuals in the research group as they engaged in the task of making their artefact which they had designed and planned on paper.

6.3.3.1 Findings

a) Knowledge and Skills (KS)

The research group demonstrated a high level of knowledge and skills when making their products/artefacts. There was a clear interaction between mind and hand as researched by Kimbell, Stables, Wheeler Wozniak and Kelly (cf Figure 3.2), when learners applied their technical and constructional knowledge and skills to make their products/artefacts. Aesthetic criteria such as incorporating the creative use of shape, form and texture, did not feature prominently.

b) Thinking Patterns (TP)

The making stage is an active-based exercise involving hands-on learning, which reflects a high level of interaction between mind and hand as researched by Kimbell, Stables, Wheeler Wozniak and Kelly (cf Figure 3.2). The making stage in the research study was characterized by fairly evenly distributed levels of free-flowing, flexible, reflective and original thought (cf Table 5.4).

c) Environmental Influence (EI)

The influence of the environment on children's learning helps them construct meaning as they learn. Through the process of assimilation and accommodation, new information is absorbed and accepted by revising existing knowledge to fit in with the new assimilated knowledge. For this to occur there needs to be a challenge or problem to commence the creative process. Piaget's theory of cognitive development is well known in this regard (cf 2.3.1.5).

A supportive and interactive environment that was contextually-based and provided learners with the opportunity and flexibility to exercise choices characterised the learning environment during the making stage of the design process. Deep involvement was noted and individuals were encouraged to exercise independence in making decisions. Of note, is the importance of a supportive and interactive environment which enabled the research group to immerse themselves in making their products/artefacts.

d) Learner Attributes (LA)

Amabile's social psychology theory of creativity cited by Matlin (2009:388) underscores the importance of intrinsic motivation in working on a task for its own sake due to the interest, appeal and challenge it holds for the individual (cf 2.4.4).

Frequency counts scored in this category indicate that intrinsic motivation is the most frequently observed characteristic of the research group during the making stage of the design process. This is closely followed by being open to experience, taking risks and being independent.

6.3.3.2 Recommendations

The making stage of the design process represents a high level of interaction between the mind and the hand. Learners are task-focused, intrinsically motivated and open to experience as they rework their ideas in order to make a functional product/artefact. This making stage is therefore important as learners are required to transfer conceptualized ideas into tangible products that are functional and original.

For learning to be meaningful in the Foundation Phase, learners need to be actively involved in their learning. Learning through doing reinforces the interaction between mind and the hand (cf 3.4.1). Piaget's theory of cognitive development stresses the importance of children's active engagement with the environment in order to construct meaning of their world. The active-based nature of technology combined with the natural sciences as part of the focus of Beginning Knowledge, needs to be consistently implemented in the Foundation Phase.

6.3.4 The Design Process: Evaluating and Communicating Findings

The evaluating and communicating of findings stage of the design process reflects the capturing of transcribed information of individuals in the research group as they engaged in sharing the problems they encountered during the making and evaluating of their artefacts.

6.3.4.1 Findings

a) Knowledge and Skills (KS)

Conceptual, technical and constructional knowledge and skills featured prominently in the last stage of the design process. The evaluation and communication of findings, a verbal exercise, required the individual participants of the research group to share with others, their findings of what they had designed and made. Conceptual, technical and constructional knowledge and skills scored relatively similar frequency counts. Aesthetic descriptors such as shape, form and texture were observed closely, and noted and linked to the research groups' making of products/artefacts.

b) Thinking Patterns (TP)

A high level of free-flowing, reflective, flexible and original thought characterized the evaluation and communication of the findings in this study. Those participants whose products/artefacts required minimal modifications elicited concise evaluation and communication of findings. Those participants whose products/artefacts required major modifications engaged in far more dialogue with the researcher and other research participants. Respondent C1 encountered a problem with her birdfeeder, and required additional time to modify her product/artefact. Frequency levels are therefore perceivably higher for this respondent than for the other respondents of the research group.

c) Environmental Influence (EI)

The influence of a supportive and interactive environment was crucial in assisting the research participants in evaluating and communicating their findings to the researcher and in eliciting help, where necessary, from their peers. Those participants whose products/artefacts did not require modification, volunteered their support to help others whose products/artefacts required substantial modification. An interactive and supportive environment was perceived to be the key during the final stages of the design process.

d) Learner Attributes (LA)

Learner attributes such as intrinsic motivation, openness to experience and a sense of independence featured prominently in the research groups' attributes during the final stage of the design process. Taking risks were considered, but high risk modifications of the made product/artefact were not put into effect, possibly due to the interactive influence of the research participants who offered their help to those in need.

6.3.4.2 Recommendations

Evaluation and communication are important stages in the design process. Learners are given the opportunity to reflect on and verbalize their thoughts and actions. A high level of interaction with others, in a supportive environment, encourages free-flowing, reflective and original thought which is freely communicated.

Technology is not the only subject that engages in problem-solving and finding solutions to problems, yet the distinctive nature of the design process requires learners to evaluate their solutions to problems and communicate their findings to others. This shared process of communication is important in Foundation Phase teaching and learning, as it encourages learners to share their ideas with others. Communication and collaboration are important ingredients in engaging learners in learning, and the results of the final stage of the design process serve as an example of a process of learning that catalyzes creative thought.

6.3.5 The Design Process – Analysis of Findings of the Different Stages

6.3.5.1 Investigating the Problem

A comparative analysis of the different stages of the design process reveals the high level of importance of the investigative process in influencing learners' thinking patterns such free-flowing, flexible, reflective and original thought. The influence of the environment features prominently in its role to provide support to learners, and to give them the freedom and flexibility to exercise choices and interact with the teacher and each other. Knowledge and skills required by the learners depend on their previous experience with similar problems encountered, in order to conceptualize new solutions to problems. A high level of intrinsic motivation and sense of independence in identifying and solving solutions to problems, characterizes important attributes during the investigative process.

6.3.5.2 Designing and Planning Solutions to Problems

Designing and planning solutions to problems generate a high level of conversation and interest in a supportive and interactive environment in Foundation Phase learners. Thought processes dominate, yet results reveal importance for learners in the Foundation Phase. As already mentioned, learners of this age prefer not to engage in the designing process for extended periods, preferring, rather, to engage in the making stage of the design process which requires active and hands-on engagement between mind and hand (Kimbell 1997:29-31).

6.3.5.3 Making Solutions to Problems

Technical and constructional skill feature prominently in the making stage of the design process, and are dependent on domain-relevant knowledge and skills to assemble and construct products/artefacts. All thinking patterns feature prominently during this stage, particularly free-flowing and original thought. The influence of the environment supports learners as they engage in the making process with much interactive discussion between the teacher and learners, and between the learners themselves. Within a supportive and interactive environment learners are motivated, open to experience, independent and prepared to take risks.

6.3.5.4 Evaluating Solutions to Problems and Communicating Findings

Learners' thinking patterns feature prominently in the evaluative and communicating stage of the design process. Thinking is enhanced by a supportive and interactive learning environment characterized by the freedom and flexibility to exercise choices with a contextually-based environment that focuses on solving real-life problems. Given the opportunity to openly share their ideas with others in a supportive environment, learners demonstrate a clear flow of thought and originality without fear of failure.

6.4 ANALYSIS OF FINDINGS: ANSWERING THE RESEARCH QUESTIONS

"What is the nature of creativity in technology? Analysis of findings as indicated in Figure 5.5 indicate that the nature of creativity in technology is reflected in young learners' thinking patterns as they engage in technological pursuits that require fluency and flexibility of thought and the generation of original ideas. Guilford (1950) referred to these measures of creativity as *divergent thinking* (cf 2.3.1.1). The constructivist theories of Piaget and Vygotsky (cf 2.3.1.5) support the findings of a high level of creative output observed in the participants as they engaged in individual, and collaborative tasks where they supported each other. Matlin's problem-solving and creativity theory based on the four aspects of problem-solving further supports the notion that technology catalyses creativity in young learners (cf 2.4)

The answer to the research question: "Can certain thinking patterns be observed in the design process and, if so, what features of the design process contribute to, or influence, creative thinking in Foundation Phase learners?" The answer is in the affirmative. Stages of the design process such as the investigation of problems and finding solutions to problems, making, and evaluating and communicating findings of solutions to problems, catalyze creative thinking in Foundation Phase learners. Domain-relevant knowledge and skills incorporating a conceptual understanding of the problem and requiring a certain degree technical and constructional proficiency and thinking patterns which are free-flowing, flexible, reflective and original, feature fairly prominently in the design process. The importance of an environment which is supportive, contextual, free, flexible and interactive stimulates learners' intrinsic motivation; encourages an openness to experience; the willingness to take risks and a sense of independence.

The answer to the research question: "Can creativity be assessed in technology?" The answer is in the affirmative. The creativity assessment model for technology based on creativity research of prominent scholars in the field of psychology and Matlin's theory of problem-solving and creativity, supports the hypothesis that creativity can be assessed in technology. The design process in technology, particularly the investigative, making, evaluative and communicative stages, act as a catalyst in developing Foundation Phase learners' creative thinking skills.

A creativity assessment model was developed to answer the question "What aspects of creativity will be assessed, what criteria will be used for assessment and how will creativity be assessed?" The model encapsulates key aspects of creativity, namely the process, the product, the person and the *press* (place), i.e. the *4 P's of Creativity* discussed in 2.3.1.2, as well as the key features of the design process, i.e. investigating, designing, making, evaluating and communicating, discussed in 3.5.1.1

6.5 RECOMMENDATIONS FOR FURTHER RESEARCH

This study has investigated the nature of creativity and the nature of technology. Using Matlin's theory of problem-solving and creativity as a springboard for developing a creativity assessment model for technology, the value of technology as a catalyst in developing Foundation Phase learners' creative thinking skills has been explored. Domain-relevant knowledge and skills, learner attributes, learner thinking patterns and the influence of the environment on learners' learning, have been explored within the parameters of Matlin's theory.

Findings of this study highlight learners' creativity during the design process, especially when they are actively involved during the investigation, making and evaluating and communicating stages of the design process. The influence of the natural environment in drawing learners' attention to identifying problems in nature reflects a close link between the natural sciences and technology. Technology as an aspect of Beginning Knowledge, one of the four content areas in the Life Skills Subject in the Foundation Phase, needs to be reinvestigated and fully unpacked in the Foundation Phase Life Skills curriculum. Pre-service and in-service training of students and teachers, respectively, will provide the opportunity for this subject to be accorded its real value in providing learners with the opportunity to develop their creative thinking skills through hands-on problem-solving activities during technological activities that affords integrated learning and an awareness of the natural and man-made environment from a young age.

6.6. LIMITATIONS OF THE STUDY

According to Creswell 2012:209) the number of people and cites sampled vary from one qualitative study to the next. It is typical in qualitative research to study only a few individuals or a few cases, in order to afford the researcher the opportunity to provide an in-depth account of the topic under investigation. Large numbers of cases can become difficult to manage and yield superficial results. In the light of this research, a possible limitation of the study is that only a small sample of learners was selected for the investigation using a specific site. However, it is believed that the selection of a small sample of learners enabled the researcher to conduct an in-depth investigation during the design process of technology and probe learner's thinking as they engaged in technological activities inside and outside the classroom. It is believed that another researcher with the same experience and training in the teaching of technology would yield the same findings generated by this study.

6.7 VALIDITY AND RELIABILITY OF THE STUDY

Data collection and analysis in this study have required that the researcher to ensure that findings and interpretations are accurate. Realising that qualitative research is interpretive and the that the researcher should be self-reflective about his/her role in research and how he/she interprets findings based on his/her personal history, the accuracy or credibility of findings is of the utmost importance (Creswell 2012:259). In the light of this research the method of triangulation of data using different methods of data collection has been used to compile a credible and accurate report

More recent research acknowledges validity in qualitative research as being addressed through the honest, depth, richness and scope of data collection and analysis. Also include in the notion of validity is how the participants are approached, the extent of triangulation and the objectivity of the researcher (Cohen, Manion & Morrison 2011: 179) In the context of this research, the natural setting has been the principal source of data collection. The natural setting selected for the study, context- boundedness and rich description of transcribed information, the inductive analysis of data and the role of the researcher as a key instrument of the research project, embrace key criteria of qualitative research stated by Lincoln and Guba (1995) as cited in Cohen, Manion and Morrison (2011:181), namely credibility, transferability, dependability and conformability. The researcher therefore believes that this study is valid.

Reliability is regarded as “a synonym for dependability, consistency and replicability over time.” (Cohen, Manion & Morrison 2011:201). For research to be reliable, it needs to demonstrate that, if it were to be carried out with a similar sample group or respondents, in a similar context, similar results would be found. (Cohen, Manion & Morrison 2011:201; Flick 2011:360; Lankshear & Knobel 2004:362). In the context of this study, reliability is regarded as a “fit” between what the researcher has recorded as data, and what has actually occurred in the natural setting that has been researched which, according to Bogdan and Biklen (1992), cited in Cohen, Manion and Morrison (2011:202), indicates a degree of accuracy and comprehensiveness of coverage. This does not include striving for uniformity, as two different researchers may come up with different findings, both of which are reliable.

Qualitative enquiry is not a neutral activity and the researcher acknowledges that there may be elements of bias in her analysis of data due to her being well known to the respondents which may have had an influence on her role in the research project. Cooley (1902) cited in Cohen, Manion and Morrison (2011:225) refers to reflexivity in research as the “looking glass self”. As a reflexive researcher, there is an acknowledged awareness of my selectivity, perception, background and inductive processes and paradigms that have shaped this naturalistic research project.

6.8 CONCLUSION

Technology as a school subject has the potential to develop learners’ ability to meet the demands of a changing environment for the 21st century. Learning and innovation skills for the 21st century require people who are creative and innovative, problem-solvers, critical thinkers and people who are good communicators and collaborative workers (Jacobs 2012:211-212).

The unique features and scope of technology as a school subject provides learners with the opportunity to solve problems in creative ways; use authentic contexts which are rooted in real life situations outside the classroom; combine thinking and doing; engage with knowledge in a purposeful way; work collaboratively with others. It encourages them to use a variety of life skills such as creative thinking, problem-solving, identifying needs and developing technological skills through practice projects where learners engage in the design process (Department of Basic Education 2011d:9-10).

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APPENDIX ONE

LETTER TO PARENTS

Dear …………………

RESEARCHING CHILDREN'S CREATIVE THINKING IN TECHNOLOGY

Last year, I forwarded letters to all G2 parents outlining my PhD research that focuses on investigating the value of technology as a vehicle that develops young children's creative thinking skills and requested permission to carry out this research with your child.

This year, my research continues with a reduced sample of six Grade 2 children who have now progressed to Grade 3. These children have been carefully selected using a statistical formula, in order to ensure a balanced and accurate representation of Grade 3 children at the School.

Using the case study method of research to track all six individual children's thinking skills, as a non-teaching researcher, my aim is to spend time observing and interacting with your child as he/she engages in the various technological tasks of investigating, designing, making and evaluating.

I am hoping that the findings of this research, namely that technology does influence and develop young children's creative thinking skills, will assist other teachers in education, both nationally and internationally, as they pursue the teaching of this valuable subject. Please be assured that at, all times, the strictest ethical principles will be adhered to, i.e. the name of your child will remain confidential and his/her participation will be voluntary.

Kind regards,

C.B THATCHER (MRS.)

APPENDIX TWO

DATA COLLECTION: TRANSCRIBED VIDEO-TAPED AND AUDIO-TAPED RECORDINGS OF CONVERSATIONS WITH THE RESEARCH GROUP

Code: V-Video-taped data; A-Audio-taped data

Name Codes:

- R1: Participant 1
- L2: Participant 2
- C3: Participant 3
- E4: Participant 4
- K5: Participant 5
- K6: Participant 6
- R: Researcher
- P: School Principal

<u>VIDEO-TAPED TRANSCRIPTS</u>

INVESTIGATING

Conservancy Walkabout

Viewing the conservancy from the primary school campus

R: Let's just think about this area – Let's put on our thinking caps (walking towards the catchment area of the conservancy)
Looking at the grass ….
Let's just look at this area here – what could we do here? Let's just put on our thinking caps – Pointing to hollowed area (catchment basin).
Could we create some water for the birds?

R1: If we had to then we could.
We need to think about where a good place for a dam would be.

E4: Maybe over there – pointing.

P: Why?
Why do you think so, E? Why do you think it would be a good place?
C3: I think it could be by those 2 bushes.
Do you think this is hollow enough for a dam?

R1: Yes because when the floods came, it took in the water naturally (gesturing)
Yes, we had floods years ago, you were little.

R1: I was in G00.

R: Yes, you were in Grade … 00 …. 000 & the natural water from the sky fell here & there was a kind of dam here (gesturing). Mr. T will now tell us where they think they will create a dam. Mr. T where have you decided that a possible dam will be.

P: Shall we go a bit lower down. Then you'll be able to see the whole area.
What we can do is we can see what everybody else thinks about it & get their ideas, because we've got the video camera & we've got pictures & we can record your ideas.

P: Let's just stop here & look up that Valley. R, you will remember quite well because you came onto the campus as a baby boy, many, many times. Now tell the group again, why you think this area here would be a good place for a dam. There are obvious reasons, children as to why a dam should be put right here where you are looking. R1 you start, and C3 you can add on.

R1: Because it is like a hollowed place & you could probably put a lot of water here …..

P: C what do you think?

C3: I just found this plastic (litter).

P: Hold onto that. We've already found litter.

P: R's absolutely right. This area here (turning camera) right in front of us here. Do you see how it forms a very big saucer?

ALL: Nodding.

P: Like the saucer of a cup or a soup plate. Why do you think a saucer or a soup plate is shaped the way it is?

L2: So it can hold water.

P: So it can hold water. So that if there's a spilling of the coffee or the tea, it won't spill out onto the table, it'll be held in the saucer & it's shaped that way to hold the liquid. This is exactly the same shape. Referring to the conservancy basin – Boys & girls this is exactly the same shape. We've really got 2 of them because if you look beyond that ridge there. Can you see the ridge up there?

ALL: Nodding

P: Way before the car's that there (parked on descent in road), up onto the next ridge, where it's (the grasses) growing so beautifully up there, near to the College circle. Those are the 2 areas – This big area here & the big area at the top there. That's where they plan to build those dams. Let's think carefully, if you're going to put water in here – referring to immediate area. If we don't construct it or build it in a special way, won't the water eventually just seep away?

ALL: Yes.

P: So what do we do?

L2: You put like cement at the bottom to keep the water in.

P: In a similar way that we would do to a swimming pool?

L2: Ya.

P: If we didn't want to use concrete because it was very expensive or gunite that we use in a swimming pool. How else could we do it?

L2: Like plastic – put plastic underneath.

P: That's a special kind of plastic with rock as well, that we're looking at, at the moment. Who of you have been to Ushaka?

ALL: All raise hands.

P: All the G 3's went to UShaka a while ago – Have you seen the waterways?

ALL: Nodding.

P:The company that built that in Ushaka, is the same company or group that is going to build this dam. Now try to picture in your minds in 4 or 5 months' time that we've got water in these 2 valleys, the smaller one at the top & the bigger 1 down here.

R: Are we going to have 2 dams?

P: 2 dams. Mrs. T wants you to do is think about how we can work with that water & the area around the water, to protect our fauna & flora. What could you do in technology to protect that. What are the things you could do or make.

K6: You could put up some signs.

R: You could put up some signs & what would those signs do K?

K6: They would tell the students what to do at the dam.

P: Excellent. What else did we say this morning about the mongooses – they were frightened of noise. What signs could we put up for that ?

R1: We could put up a sign that said "Please be quiet".

P: Yes, what else?

C3: We could make bird feeders.

R: What would the bird feeders do?

C3: They'd make the birds come more & more.

R: Yes, they'd make the birds come more & more & attract the birds. And we would need to think about what sort of feeders we would need. Would they be hanging or standing from the ground?

C3: I think they'd be hanging.

R: We could make them hang & maybe hang them over the dams so that the birds could feed & then drop down to the dam for water. I think we need to go into the valley now & see where the mongoose family is, so that can get some idea of where the other dam is going to be as well. Any other ideas about what we could do?

L2: We could put grass around the pool.

R:And what would that do?

L2: And it would attract more animals to making the … what's it called … the environment so that they won't know it's a pool there. So like if they come down, & people who don't really know about the environment & don't care, they won't even see the pool .. (suggestion of camouflage).

R: They won't even see the pool. K you started to say something there.

K6: If you make grass grow around the dam, you might get some nests.

R: You might get some nests. How do birds make their own nests?

K6: Twigs & mud.

R: Good for you.

L2: We had a dried nest in our trees from the Hadedas and it was made out of big thick, thick, sticks.

R : Did you? Have you still got part of that nest left?

L2: Yes, a little bit.
R: Perhaps you could bring it to school & give it to Mr. T. We could look at it & analyses it to see how the birds made that.

L2: It might be a bit hard, because it's 80 yrs. old. It's very old & it's in the tree which is very, very high.

R: Oh is it still in the tree?

ALL: Nodding.

L2: It would've broken if it had've dropped because it's too high. If it fell to the ground it would've just broken into pieces.

R: Tell us about the litter bin – To R.

R1: I think we should take a closed bin so that the mongoose don't climb up and eat out of the rubbish bin.

R: So you close it up so that the mongoose can't get in & they don't eat it (the food) up?

R1: So they don't eat the plastic & that sort of thing. And, ya, so they don't die or anything.

R: I think it's a good idea. Also what would the wind do if the bin didn't have a lid?

R1: It will blow it (the litter) away into the bush

R: And it would spread the litter, wouldn't it?

R1:Yes.

Walking in the Conservancy Area

R: Let's take a little walk. Let's take a look here (indicating to "Nature Trail" sign), everybody. Just feel this – referring to the plastic sign –(All feel). It's made from recycled plastic. It's waterproof & weatherproof. Is it a stable structure?

ALL: No! (All have one hand on top of sign & move it backwards & forwards.

R: What could we do to stabilise it?

L2: Put a stick at the back.

R1: Sticks in between.

E4: Rocks at the bottom.

R: So, maybe that's another problem we need to solve before we start building our other things – To take a look at the stability – it's wavy at the bottom

K6: Look at what I've found – from top of sign –It looks like a cocoon.

R: What normally happens inside a cocoon?

R1: A butterfly or something is busy changing & when it comes out the cocoon it eats it for protein or something.

P: (Reminds the group to stay on the path). Look its rather sandy – Up on that ridge there, it's almost entirely sand. Is that dangerous?

ALL: Yes.

P: Why?

R1: Because it could wash away done here – indicating towards the proposed dam site

P:Correct. Remember what I said about soil erosion?

R1: The bank & the road can come down – indicating.

P:Correct. You're absolutely right

L2: Mrs. T the geese tried to take over the hadida's nest.

Walking towards the area where the water came cascading through in a flood some years back. Focussing on the wire & stone that has been placed in the 'wash away' area.

P: Why do you think that all this stone & wire has been put there?

ALL: For the water.

R1: For the water so that it doesn't flood up again.

R: What do you think would happen if there was a heavy rain?

L2 & R1: It would go through the rocks & into the soil.

P: It'll also hold up the bank, won't it?

ALL: Yes. (nodding).

P: It would keep the bank together. It would give it some support – Let's make our way carefully – to the mongoose home – Let's part the grass here – (All whispering & being very quiet) – Make a pathway to there.

R1: Do you think we could take these seeds – indicating to pods on long grass and plant them somewhere else?

P: They'll fall & they'll re-establish themselves somewhere else.

R1: Which is great that's what nature does.

P: Look here these are droppings.

R: What do you think those could be?

R1: Mongoose or duiker.

P: I would say mongoose. Looks like mongoose … (evidence that there are mongoose – All looking)

L2: I think that they are there … indicating to under rock.

K6: Look up there, I can see butterflies.

R:See all this dryness …….. ?

L2: They haven't had much water.

P: Why is it different to January & December, L?

L2: It's winter.

P: What season is it?

L2: Winter.

R1: We have dry winters & wet summers.

P: We have dry winters & wet summers.

R: Guys we're full of blackjacks – sticking to us ……. All look at their clothes.

P: Boys & girls I want you to look around & see what life you can see
Let's close our eyes & listen. Can you hear birds?

C3: Look there's a beautiful butterfly – It looks like a flower. Finds more litter.

P: Look at that bird. Look at the rock & fencing has been built in a particular.

ALL: Standing on the structure.

R1: This is also a danger to wildlife .. the water goes thru & feeds the sand

ALL: Walking in the catchment area up towards the ridge

K5: Look at those orange flowers

C3: Collecting pods & shaking them.

DISCUSSING THE INVESTIGATION
Back in the classroom

R: What we going to do is look at the activity here. After taking a walk thru conservancy, draw a map of the trail. To group: Anything interesting you think we should focus on?

ALL: Hands up …….

K6: I think what was interesting was the mongoose's hole.

R: Do you think they are in any danger here …. Any problems they might have?

K6: Yes, they need water.

R: Now R1: Can you add to that ….. Why do you think mongooses would need water?

R1: To survive.

R: Can you think of any other plants & things would need water here?

K6: The birds.

R1: The duiker.

R: Why would they and the plants need water?

R1: To survive.

R: Do we need water to survive?

ALL: Yes.

R1: It's an important part of our life.

R to C3: You picked up a few things along the trails – What did you find that was stuck to pieces of grass & the plants.

C3: I found quite a few seeds & a lot of blackjacks.

R: Just to add to that – Those were things in the natural environment & we know that those seeds might have been dispersed or blown by the wind & they would start growing in other parts of the conservancy. What other things did we find that you think shouldn't have been there?

L2: Litter stuck in the trees & on the floor.

R: What kind of litter?

L2: Chip packets & sweet packets & foxy nuts.

R: Now if we left those things there, why do you think it would harm the environment?

L2: Because they'll eat it & it'll block their pipes.

R: Now what happens to the litter, if we did have water?

L2: It would pollute the water.

R to K5: Can you add anything there?. Do you think that we've got a litter problem in the conservancy or do you think it could become a problem?

K5: It could become a problem.

R: If we take from what K5 & the others have said, what were some of the problems that you think we've got in the conservancy?

E4: There's too much litter that L2 said can destroy the habitat of the birds.

R: What do you think we could do?

E4: Put up dustbins or signs that said don't litter.

R: Now, I'm just going to let you focus on your own maps & do a trail on your paper. Starting in the one corner where the school building is & draw a trail of where we walked & from there mark carefully the different things that we saw.

INVESTIGATION FOLLOW-UP: DRAWING THE TRAIL AND IDENTIFYING PROBLEM AREAS

R to E4: Have you identified any problem areas on your trail?

E4: No, not yet.

R: Perhaps you could mark the areas with a X where you thinks something needs to be done.

R to K6: When you spoke about the litter, think about where you think the litter bins could be put.

L2: Mrs. T, this morning when I ran cross country (through the conservancy), they cut the bushes down in the pathway & there was so much litter, you know when you drive up to come to school, there were bins that had fallen down the bank.

R: What do you think we should do?

L2: They should be moved …… they should be moved across the road or something

R: When you speak about bins, are those the bins with the wheels (general, green plastic bins with lids).

L2: There was one on wheels & one which was like tar & then it fell down.

R: We need to have a look at it. Maybe we could take a look.

L2: But it's going to be quite far, it's at the bottom school (pre-primary school). Maybe we could go the easy way.

R to K6: You were going to say something K6 …?

K6: Maybe, you know where the bushes are, where the pre-school is, maybe we could put a dam there.

R: We could. But we need to maybe focus on the area at the prep school.

R: L2 let's just talk about the litter bins & the problems we've got there & what we could possibly do about them.

L2: The litter bins have fallen down the bank by the cane & all the rubbish has fallen out of them .. like black bags & all stuff. So we need litter bins that can go in the ground or ….

R: So L2, tell me what do you think we could do to stop the litter from falling out of the bin, even if the bin did fall to the ground?

L2: You might put like a clip & the top clips down & you gotta pull the thing away & then lift it up.

R: So that if it did fall to the ground, the litter wouldn't spill out … Mmmm, so you battle to run cross country ?

L2: Sometimes … & you can twist your ankle so that means like it's like a slope and it gathers water.

R: And so you could slip.

L2: Mmmm.

R: And so tell me how could we keep the water in the dam & stop it from seeping into the ground?

L2: You could put plastic underneath & sand on top of the plastic so like if there's those ducks that live in the dam & they dive down to get fish

R: Show me on your plan so we can see the trail …

L2: There it is there …. .

R: Is that the dam there?

L2: Mmmm. It'll gather there, so if there's plastic on the side the animals won't eat the plastic on the side.

R to C3: You've done a detailed trail. Can you hold it up so that we can see what you've done?.

C3: Holds up.

R: Oh that's perfect. Where have you put your dam?

C3: I've put my dam here – indicating

R: What makes you decide that that would be the best place?

C3: I think one of them should be near the trees because at least they'd have a bit of shade

R: What happens to the water in the sun?

C3: There'd be trees there so it wouldn't dry out

R: Trees there . That's a jolly good idea. We might need to plant a few more trees, what do you think?

C3: Yes, I think we should plant a few more trees around in the place where there's going to be the dam.

R: Now R's been busy there ………. Anything you'd like to propose about the dam?

R1: I'm just starting one here … indicating.

R: And the reason for that dam .. any ideas?

R1: Not really, but I was thinking that if we put a dam by the nature trail down … on the top nature trail, then we can put some fish there & stuff…..

R:Yes we could & who do you think the fish would attract ?

K6: Fish eagles.

R: Yes we might be able to get one here

R1: So if the fish eagles get the fish they (the fish) may lay eggs & those fish will lay eggs & so we'll get more fish.

R:That's a good idea.

K6: I think I should put the dam where there's lots of trees & flowers & the 2nd dam where the mongooses' hole is (holding up plan), so that they can have water

R: That's a jolly good idea .

R to K5: Anything else to add?

K5: Shaking her head.

E4 to R: Here you can see my plan – I thought of dam1 here close to the mongoose home because they also really need water & I put the trees around there (indicating) & I'd put some more trees there because it's quite hollow.

R to K5: Tell me about the problem which you identified.

K5: When we were walking we saw a bank & it doesn't basically have any grass on it because it's on a slope..

R: And you feel that's a problem there?

K6: Nodding.

R: Can you give me a solution to that?

K6: You can build it up..

R to L2: You said something now about building up that bank …..

L2: You could like … those bricks which are outside .. on my right .. you can build the bank up a little bit by putting those bricks, but there're plants in between. So maybe the grass can go in between so as it falls it will pass it on .. the water.

R: Yes, and you also got your grass & the bank won't wash away in the rain.
That's a jolly good idea.

R to ALL: Any other ideas …..?

C3: I think we should put birdfeeders.

R: Would they stand or would they hang?

C3: I think they'd hang because sometimes some animals like eating birds to it needs to be high up.

R:That's right so that by hanging them you'd protect those birds.

C3: Nodding.

R to R1: Any other problems which you've identified there (on plan)?

R1: Well, there isn't enough water.

R:What would you like to propose as a solution?

R1: A dam … ya…. A dam . Can I just say something about the litter because I've got a solution about that.

R: Yes

R1: We can take a raid of people & say to them go through the bush & pick up all the litter you can find & that would be the solution.

K5: A litter walk.

R: If we're walking through the conservancy & we've got lots of litter do you think we could carry all that litter on the litter walk.

R1: We could carry plastic bags & stuff.

R: Do you think we could make a special bag or use any plastic bags?

R1: Well, we could use a garbage bag or we could make a very big bag out of newspaper & staple it all together.

R: Well, we could try & do that so maybe that could be your solution & you could design something there.

R to K6: You spoke about something …..?

K6: We could make our own bag from paper.

R: Paper. Now if it's a rainy day & you're going on a conservancy walk, what would happen in the rain?

K6:You could use a plastic bag & we could put a jacket on.

R:You would also protect yourself.

K6: And we could see who collects the most & get a prize.

R:Yes, we could have a prize for that. Any other problems?

K6: We need water.

R:Yes, we said we'd need water.

K6: And a bird's house.

R:Any more suggestions?

E4: Yes. I think we should also send people out to cut the alien invaders.

R: Yes, we can get people to do that. I don't think we'd really be able to do that but I think they (the school) have got something in place.

E4: Because the aliens are taking over all the plants.

R: They are. Thank you everybody.

L2: We need a house also for the birds so if it starts raining, the birds won't fly away, they'll stay here. I'm not saying they won't come back but they can stay here & we can be sure that they're safe. Because we need a house so that the birds can stay in. Because my Grandpa made a house & when it's raining we can see out of the window that there's birds inside the house.

R: Good idea.

DESIGNING AND PLANNING

R to C3: C3 was going to talk to me about the plan for her feeder. Would you like to show me on your plan what you're going to do.

R: Is that a water bath? Would you like to tell me what you've done there?

C3: It's quite simple to make one of these. It's not really for water, but sometimes you can use it for a tree.

R: I see you've got a bird feeder there. Can you tell me how you're going to put it together.

C3: I'm going to put it on one of the trees that are quite low down

R: To attract the birds?

C3: Nodding.

R: When the bird flies to the feeder how will it stay on the feeder? Are you going to put anything there for it to rest on?

C3: Like L2 said, when he went somewhere he saw one like that ….. That was one of my ideas. I'm going to put sticks

R: Just show me (on the plan) where they can rest their feet & what you're going to use. What could we use for that … pointing …. real sticks or could you use…. .?

C3: Real sticks that sometimes you buy marshmallows with.

R: Oh yes, like a skewer.

R to K5: Let's see what you've done there. You've got an original idea there. What are you going to make?

K5: Like a basket so when you go you can pick up the rubbish & put it in
A basket so you can put the rubbish in when you go on a trail.

R:Any ideas on what you're going to make your basket from?

K5: Cardboard & string & buttons

R: And if you use material do you think that would work?

K5: Not really.

R: And when you say cardboard … Are you going to use a ready-made box?

K5: No, I'll make my own box.

R to E4: Can you just tell us something about your design there?

E4: Well, I'm going to be using a coke bottle & few sticks.

R: And what will you be making, tell us?

E4: I'll be making a birdfeeder

R: A birdfeeder. Where will you place it?

E4: Maybe I'll place it in a high tree.

R:Good. What made you decide to use plastic

E4: Plastic – It won't really let water in unless it's got holes.

R: Do you think it will last?

E4: Yes.

R: Well, I look forward to seeing that.

R to R1: What have you decided to do?

R1: I've decided to build a packet kind of thing. Except for the hot days .. You can see what I've written here … (indicating) I've used newspaper, and for the rainy days, I've done plastic.

R: Would that be a carry bag?

R1: Yes, you grip it on the top so that you could carry it around (gesturing).

R: So you’ve got a newspaper one that you’ll make & a plastic one. What made you decide to use newspaper & plastic?

R1: Because I thought that in the rain, newspaper won’t last because of the rain. It’ll soak into the paper.

R: And the plastic?.

R1: The plastic is waterproof so that water won’t get into the litter & it won’t stink as much.

R: Good.

R to K5: What are your plans K5?

K5: I’ll think I’ll also make a litter bag with plastic.

R: Tell me something about yours.

K5: You can put a handle on it so that you can carry it around & put the litter inside.

R: Any idea on the size of the bag?

K5: Um…… 3 or 4 metres … .

MAKING

K5: Using a ready-made box (originally decided to make a litter box).

R1: Carefully stapling newspaper.

E4: Looking for the craft knife in JP room. Decided to use scissors

R: Talking to R1 ….

R1: I’ve taken one of these bags (Ronnie Bin paper waste plastic type- sacking bag) & put newspaper around to basically protect it.

R: Is that going to be outside or inside?

R1: Outside.

R: What made you use that part of the bag for the inside (referring to waste bag)?

R1: Well, I wanted the newspaper to protect it.

R to E4: How did you make that hole?

E4: With scissors.

R: Jolly good.

R to L2: If you are going to use tiles, can I make a suggestion. I don't know how we will cut them. We don't have tile cutters.

L2: We don't need to cut them

R to K6: Are you putting things together? Are they heavy or light?

K6: Light.

R: Have you thought about how you're going to join those tiles.

K6: I think the glue gun glue will glue it.

R: You think it'll work?

K6: Yes (battled with trying to join the tiles but persisted).

R to L2: Carefully joining wood – off cuts all the same size except for base.

L2: I don't know if it's going to be stabilized enough.

R: If it's not strong enough what can you use?

L2: We'll find a way (careful use of glue by).

R:To K5: Do you need help there? Talk to me about what you're doing .

R to R1: You should've thought about what you're going to do in the rain.

R1: Well, I'll put plastic over it.

R: Do you think you'll go out in the rain or will you wait for a dry day?

R1: I'll wait for it (the day) to dry.

R: Explain to me how you're going to make that & then I can try & help you.

R1: I want to make this flat here (referring to inside flaps of box) She has a piece of cardboard to place over.

R to K5: You don't want to tape it from the bottom … flip it on the other side & use some duct tape (she flips it over to take a look).

R: So you just want to make it firm at the bottom. Let's look for something to seal that with. What could you use to seal it with?

K5: The glue gun. (she waits for E4 to finish using the glue gun).

R to E4: What are you trying to do with the gun?

E4: Seal the stick so that it's firm in there.

R: Have you thought how you'll fill it up with seed?

E4: Um, through the top (indicating the screw lid on the top).

R: Will you keep the label on or take it off?

E4: I'll definitely take it off.

R to K6: When L2's finished you can start sealing your box.

R to L2: Can let that set.

R to L2: Talk to me about the materials you've used there.

L2: I'm using tiles, cause I'm positive they'll stay cause they really are quite strong (carries on sealing tiles).

R: Hanging or standing?

L2: Clipped.

R: You need to think about how you'll clip that & think about that while you're waiting for it to dry.

L2: (meticulous about glueing & sealing the joins) I might hang it but I'll see how strong it is first.

R to R1: You're looking very busy. How's your litter bag going? Pretty bad (battling with the stapling). Pretty bad at the moment.

R to K6: Just talk to be about how you're placing those tiles together (trying to place them so they'll stand up to form 4 walls on a temporary base).

K6: I'm trying to make a house but every time I put them together they come apart

R: Have you given some thought about how you'll join those tiles together

K6: I'm going to use the glue gun.

R:Are you just placing them together.

K6: Nodded. To get the pattern.

R to E4: Have you thought about using a hammer & nail to make a hole in the bottle That's a good idea. Goes to find one in the senior technology room.

K5: Trying to glue & press the flaps.

E4: Trying to make a hole in bottle.

R to K5: Let's turn the box the right way round & then press down from the inside. K5 does this & lets it set.

R to R1: (busy with plastic container) I can see that you changed your mind. What are you doing there?

R1: Busy with dome shaped roof. Placing it over walls of bird house.

R: How are you going to join it together? That transparent dish there. How is it going to be used?

R1: I'm going to put food in the one, water in the one.

R to K5: I can see you're using a bag. What are you going to use that for?

K5: So that when it rains the inside won't get wet. Has used to round containers which she's spaced apart on the top of the box to make a kind of controlled opening to hold flaps together

R to C3: Talk to be about what you're doing. Has placed her feeder on a large plastic catering plate. Has collected small coloured yoghurt containers & is busy unpacking these to place on her feeder.

C3: I'm putting small feeders here so that if they don't want, are too many birds on the sticks they can come here (referring to the small containers which she is busy placing on the base).

R:Is it going to stand or hang?

C3:It's going to hang. Busy glueing with glue gun

R to R1: Are you helping K5?.

R1: Yes.

R: Are you completely finished?

K5: Yes.

R: Let's take a look at your bag.

K5: What I've done here is taken the bag – opening the top & put it inside. I've put another layer of the newspaper around it, so it can protect it & when I want to throw it (the litter) in, I open up the bag, open up the rope & throw the litter in & close up the back with the rope.

R: That's quite a big bag there. What made you decide to use the newspaper?

K5: Just for protection.

R: Now obviously if you were going to collect litter in the conservancy, you wouldn't go on a rainy day, would you?

K5: No I wouldn't do that.

R: Is it waterproof inside?
K5: Um. Feels inside with hand. Yes, kind of.

R: That means if you get cans with water in, the inside of the bag is waterproof and won't make it soft on the outside. How did you join the sides together?

K5: I stapled them.

R: Is it quite secure there do you think?

K5: Looking & feeling ….. Yes. Busy covering box with black opened out plastic bag

L2:Busy glueing sides of feeder/house again.

K6: Using a box (has decided against using the tiles) which he's busy covering with opened out plastic shopping bags – R1's helping him smooth the bags over the box which is tilted to reveal the opening from the front (bird home). Using wood glue to glue the bags over the box

R to K6: Tell about what you've made.

K6: Turns box so I can see inside. Has placed ice-cream containers in side.

R: That's jolly clever.

K6: I took the glue gun & stuck this (ice cream container) down for the water & maybe for the other I'll make a nest.

R: Oh, so you're making a ……..

K6: I'm making a bird feeder.

R: It looks like a little home in there. How are you going to suspend or hang that? How are you going to put that in the conservancy?

K6: Feels top of box …… I'll just make holes here.

R: What will you use to hang it?

K6: String.

R: We'll need to take string & other things with us when we go to the conservancy in case we need to change things

E4: Trying to get bottle onto base.

R:You said you had a problem there. What are you trying to do?

E4: I'm trying to cut holes for the birds to eat (put heads through into feeder)

R: Perhaps use a marker first. Once you've made hole you can use the scissors

R1 helping L2 who's cutting a long piece of wood with a handsaw.

E4: Comes to help.

R1: Intervenes & helps stabilize wood being cut. Holding saw with both hands.

R to K5: Any thought about what you going to put on your hands?

K5: Not yet (She had suggested that she wanted to put gloves on her hands when she collected her waste. Later comes up with the idea of latex gloves from the first aid box)

R to L2: Once cut – How do you think you'll secure it?

L2: I'm just going to use the glue gun to do it (to balance house on stick) Has plastic flaps over roof. It's dry now – referring to glue on top of pole. Then L2 realizes it may not work. – I'm not going to use the glue gun, I'm going to take this off (inside dish) & screw it on (put screw through inside of house & into pole). He removes plastic dish & tries to balance house on top of wooden pole

R to E4: Trying to put wire to hang it. How can we make a hole?

E4: A punch maybe

In the background – K6 shouts: "Success!"

R: Success! That's great!

R to E4: How are you going a make a hole in the base (referring to suspending the feeder)?

E4: A punch maybe.

R: That's a good idea.

R to K5: Tell me about your success K5. Lift your handle – She does. Lift it right up. As the bin gets heavier, do you think that's (the string handle attached to the box with tape). Is it going to be strong enough?

K5: Mmmmm.

R: How have you secured that to the box

K5: With sticky tape.

R: How else could you make it stronger?

K5: Thinking …… Glue gun.

R: …Or what else could you do?

K5: Um ….. I don't know.

R: Well, let's try it out & see. The heavier your bin becomes, what might happen?

K5: It might break.

R to K6: Explain what you & R1 have been doing. I heard you mentioned *success* there?

K6: I've put a plastic bag in case it rains for waterproof & these things for water.

R: I like that …… let's get a closer look. Is that going to be a hanging feeder or standing?

K6: Hanging.

R: Now what you need to work on is how you're going to hang it.

R to C3: Now completed feeder with string ready to hang – very attractive.
Talk to me about your feeder here.

C3: I've put some sponge inside – indicating to small yoghurt containers.

R: Where are you going to put the seed?

C3: Indicates showing how – I'll put the seed in here.

R: Shall we put some in now?

C3: We better ask E4. It's her seed.

R to E4: May we put some seed in just to test it out?

C3: Gets a funnel & places in neck of bottle & prepares to open the bird seed packet

R: Why have you placed the funnel there.

C3: It's just going to make it easier. It's hard to take little handfuls & put it in.

R: Why don't you get a scoop to take the seed out of the packet?

C3: That's a good idea – She has found a margarine container to scoop out seed.

R: That's a nice little margarine container.

K5: Comes across to show how she's reinforced her handle attachment to the box. Has used a double layer of string.

R: That looks fine.

R to K6: Has made holes in the side of the box & has threaded string through. See the birds can fly straight in.

R: The moment you lift the string there you don't think they might use it to sit on.
Lifts string & the one side comes away from the box. You'll have to make that stronger & attach that with a proper knot.

K6: I can't tie a knot. K6 to R1: Mrs. T's going to tie the knot.

R to L2: Has balanced the feeder on top of the wooden pole.R1 is helping him balance the feeder by holding onto the pole.

L2: I can't find a long enough nail. Fetches a glue gun & proceeds to glue the base to the pole

R: Calls R1 to come & help hold again.

R1: I think we'll need to find a screw. There're no screws so we'll use a nail. Let's get some bricks to support the bottom of the stand

R to C3: Let's test the strength of that feeder.

C3: Holds it up ……… I've got some sponge in there so when the seed drops it can start growing again when it gets wet.

R: Good C3.

R to L2: Has got feeder upside down – Adding finishing touches of glue before joining again to base. C3's holding one side. L2 more glue from glue gun.

R to K6: Are you done? K6 holds it (the birdfeeder) up after re-knotting & attaching string.

R to R1: Please come & hold this pole. L2 busy putting glue around the join between house & pole.

R: One will have to hold & one will have to bang.

R to L2: R1 holds the pole – It's not straight he says.

R: Let’s use the other side.

L2: With help from R1, re-attaches the pole to the feeder.

R1: It’s not straight – Still upside down.

R to C3: Are you happy with that? Has put seed in bottle.

C3: Yes.

R: What you need to do is to test the strength of that feeder.

C3: She lifts it up. It’s quite heavy.

R: Do you think that it’s going to be fine?

C3: Ya. I had an idea of putting this toothbrush thing (part of the box) in here so the seed won’t fall out. So it’ll stay in there & support it – take a closer look at pic of feeder. I put some sponge so maybe if it rains there’ll be little grass shoots coming out.

R: Oh yes, then they could feed off that – Keep growing in there. Good. We need to place that & see what happens. Good C3.

R: Observes C3 putting more seed into her feeder.

R: Observes L2 putting more glue on the underside of his birdhouse.

R1: Helping L2 to chip off excess dried glue to even out & level the pole

C3 also helping to hold & K6 also assisting L2.

L2: It’s not straight. Adds more glue.

R to E4: Talk to me? E4 has poured seed into her feeder – All spilling out.
I’ve just realized that everything going to come out (coming out through holes in feeder originally meant for the birds heads). K5 helping E4.

R to E4: What do you think the problem is?

E4: The holes – pointing to the holes in the bottle (for birds to put head thru – She’s filled it up too much. I need a tub or something (to catch the seed).

R: We need to think to about it …. How you you’re going to solve that problem. That’s what technology is all about - Things don’t always work out so you’ve got to think – Why. So it’s better to test it out now. K5 still helping E4.

R: What do you think you might need to do?

E4: I need a yoghurt tub or a box to put it underneath.

R: Try it out now while we’ve got time.

E4: Ya. Okay. (Pulls bottle away from the base).

EVALUATING AND COMMUNICATING
Off to the Conservancy:

All agree to select the tree in the middle of the hollow.

E4: has selected a tree high up on bank – hangs her feeder.

L2: Has wedged his house in the tree.

C3: Has hung her feeder from the same tree.

K5 has her gloves & is busy adjusting her box on the ground.

R to K5: What’s happened here? String has come away from box. How are you strengthening it?

K5: With sticky tape.

L2: It’s stable – referring to birdhouse

R: Do you think it can stay on its own here?

L2: Maybe, but I want to get it in (referring to wedging the feeder in between two branches).

R to K5: Have you found any litter?

K5: I found a packet of litter.

R1: Is busy putting on gloves too. Slings bag over shoulder.

R: Are you putting that on your shoulder?

R1: Yes, It’s comfortable – Off he goes to look for litter.

R to L2: What you’re doing there?

L2: I’m making sure it doesn’t fall back & it doesn’t fall forwards.

R: Are you tying it with leaves? What are you securing it with there?

L2: Wire (he had anticipated this and had put wire in his pocket). Busy tying wire & knotting it to the tree.

K6: I can see a cricket.

R to E4: E4 has taken her feeder down & is busy finding another spot to place it.

R: What made you decide to move your feeder?

E4: Cause it's an open space there & birds don't like that open space – Is only carrying her base.

R1 helping K6 to place his bird house at the base of a thorn tree up on the bank – wedged at base.

R to K5: What have you collected there?

K5: I've collected a cup, 2 packets, a piece of packet, some polystyrene.

R: So your litter bag was quite big enough?. Where do you think was the weak link was?

K5: The string.

Back in classroom – Modifying artefacts – C3 & E4 only (other respondents quite happy with their artefacts).

R to C3: What are you going to do with the net here? Alongside is a foil dish.

C3: I'm going to make an extra water supply. When the seeds start growing, instead of growing all ways, they'll start growing through this net (points veg netting bag). Can you see them, they'll start growing through the holes?

R: Yes, I can, I collected those veg bags for our project. What do you think that's made from

C3; I think it's made from plastic.

R: Do you think it's quite strong?

C3: Ya.

R: Tell me what you're doing.

C3: (Busy cutting a hole through the lid of a plastic cake container) I'm going to make a nest for my feeder.

R: That looks really interesting.

R to E4: Tell me what you're doing there.

E4: Well, I'm trying to stick this on here – half a yoghurt cup – arc shaped – I'm trying to attach this to side of feeder so the seed will fall into the container & won't all pour out like the last time.

R: What can you use to attach it (she has already applied bostik)?

E4: Sticky tape. Once the glue's dry.

R to C3: (She has placed straw inside the cake container with 3 upright sucker sticks protruding from the base up through the hole in the lid) I see you've got sticks there. Explain to me what you've done & why you've done it.

C3: I'm gonna put sticks there so I can put a roof - indicating. So if it starts raining, none of this will get wet. This is where the bird will be resting on (indicating the opening & pressing down onto the straw).

R: And the straw that you've used. What made you decide to use that?

C3: I just maybe thought that it would be comfortable.

R: And what are you going to call that (indicating to C3's construction)?

C3: It's going to be a bird's home.

R: Are you going to connect it to your feeder or keep it separate?

C3: I think I'll keep it separate & put it next to it.

R: Where are you going to place it?

C3: I'm going to place it on the ground somewhere, next to the island ….. the lowest part of the of the tree (ground not such a good idea).

R to E4: Can I give you a hand to hold it? She has secured the hollow dish onto the stick. Tell me what happened the last time?. I know you've changed things now. What was the problem with your feeder?

E4: Talks as she's working. Last time, it kept on …. I didn't realize I had to have something to keep it here, indicating to dish so all the seed falls into something.

R: Oh yes, I know what you're saying.

E4: So when they eat it just keeps filling up.

R: Are you going to do more than one little feeder (dish) there?

E4: Ya I think I'll do a few of these. Carries on sticky taping

R: Your original plan – Did you stick to it?

E4: I stuck to it.

R: I'm just looking at your plan here – Once we've finished here, it might be an idea to show me in your diagram here, what you've done, so that we can have a look.

R to C3: Are you almost done there? Has taken a cocktail drink umbrella and is debating whether to place it on top of the nest as a roof.

R: Tell me about that umbrella.

C3: Maybe with this umbrella I could see how it's made. Then maybe I could make a bigger umbrella & hook it on like that (indicates showing how).

R: What material do you think would be better for that?

C3: I think soft material . See it's breakable (she has torn the paper umbrella and looks for material). I

R to K5: What happened to your box the last time we went on the walkabout ? Show me your handle (Is busy trying to reattach with masking tape).

K5: I'm just going to stick it back with sticky tape.

R: Do you think that's going to be strong enough? How could we test the weight to see whether that handle's strong enough? What could you do?

K5: Put like rubbish.

R: Have you thought about making a hole in the box & seeing what will happen?
Look at the tape here ……Do you think it's strong enough? I'm going to leave you with that.

Later ……
R to K5: Was that the weakness (pointing to the tape)?

K5: Yes.

R: Open up your box. The space inside was there plenty of space for the rubbish?

K5: Yes.

R: The newspaper. Remind me about that .. (looking inside).

K5: It's just so that the box couldn't get dirty with any of the stuff (like a lining) & you could take it out & put new newspaper in all over again.

R: Let's look at the flaps of the box. What made you decide to keep those?
What can it do ? On a windy day like today, what could it do?

K5: Keep the stuff inside.

R: I like the size of that. So you're just going to work on the handle for now?

R to K6: You're busy there. What are you doing here?

K6: I'm just drawing the design of my bird feeder.

R: Did you change your mind from the original plan? Did you go from one plan to another?

K6: I was going to make a litter bag.

R: What made you decide to change your mind?

K6: I'm not quite sure. For the litter bag I have to go into the conservancy like every day (to pick up litter with the bird house one doesn't).

K6: So what made you decide to change to the feeder?

R: So I don't have to go in every day.

R: But with the feeder what do you have to do?

K6: Make it strong.

R: What about food to put in there.

K6: I did put food in there and some water.

R to K6: Referring to plan ….. We'll take a walk just now & have a look at your feeder

R to K5: I see you've made a hole there (tape didn't work – kept on coming off) Made a hole on lid for string to go through. Tell me about your plan.

K5: I'm trying to put the string inside.

R: And how can we stop the string from pulling through do you think?

K5: Put sticky tape on the back of it.

R: Have you thought about knotting the string?

K6: Could do that. We could do both.

E4: Still busy sealing her holes & joins.

R: Are you going to do something with the base?

E4: Yes, I think I'll stick it on again.

K5: Busy threading string through holes.

R: That looks good. We'll take it out and test it in the wind today.

R to K6: Talk to me about your plan (aerial view indicating materials used and placement of containers inside box). Where did you place your feeder? Remind me.

K6: I placed it in a thorn bush for the night birds.

R to L2: Let's take a look at your original thoughts there. That feeder box package that you kept. Did you use the same design.

L2: I didn't.

R to L2: Let's look at your plan. We've seen your bird home & it seems to have stayed wedged in the branches.

COMMUNICATING FINDINGS
In the Conservancy

R to L2: Looking at his birdhouse. It's pretty strong.

L2:Ya.

R: Has there been any movement of your home?

L2: No.

R: Any improvement necessary, or do you think it's fine?

L2: I think it's fine.

R to L2: We've had quite a lot of wind & rain since we last place your feeder & it's lasted pretty well. Can you tell us why you think you feeder was strong & why it's so successful ?

L2: I think it's because I used the glue gun a lot & put a lot of glue on . The tree, the spot I chose is a pretty good spot.

R to K5: How did you manage to bring your litter box that you modified?. Do you think it's a lot stronger.

L5: Um, yes.

R: Any difficulties in carrying it in the wind?

K5: Kind of because the wind was blowing.

K6 to R: Okay, R: Come and look at my bird home. There're a lot of thorns here. I think I'll move it.

R: Now we're looking at K6's home. What made you decide to move it from the thorn tree?

K6: There's too much thorns & no birds can get in.

R: So where do you think would be the best place to place your feeder & your home. You said there were spiders here. Do you think that would have any effect on the birds? I can see some of them hanging up here

L2: The birds eat them.

R: You reckon they would?

L2: Maybe.

K6: Can we empty my box?. There're spiders in there.

R: Let's make a plan there. We're are you going to place it.

R to C3: Where are you going to put your home?

C3: I'm putting it over here …….. (at foot of tree) It's quite nice & shady here

R: And not too windy.

C3 No.

L2 is helping K6. They're emptying seed on ground.

R: Where do you intend to put your feeder?

K6: I'll place it under tree.

R: Is it safe there? It's pretty windy it might blow away.

L2 to K6: Let's use sticks – Proceeds to pierce base of box with a long stick so that the birdhouse can stand above the ground.

L2: Very involved with K6's feeder. Managed to peg it with sticks & leave under tree.

AUDIO-TAPED TRANSCRIPTS
Recapping the conservancy walk – Designing and Planning (A)

R to L2: Last time we met can you remember what we did

L2: We were finding out why the buck died & we found out now that he had no water so we are going to make a pond like a dam ……… and we are going to make like bird feeders

R: L has just put us back to where we started. We had to look at the problems that we saw when we walked thru the conservancy

E4: When we walked thru the conservancy I saw lots of litter & litter problems for the birds

K5: Any other problem that you saw?

R: Prompt – What did Laurent say

K6: There was no water.

R:So what is that solution to the problem?

K5: Make a dam

R: So how could we attract the birds to the dam?

K6: Could put fish in there

R: You could put fish in there for those big birds that could eat the fish …. Now, if the birds are coming to the dam. Turns to R1 K6 & K5: Any one of you want to answer? What could you do?

R1: The fish eagles & stuff …….or the seed eaters…..?

R: Both. What could we do for the seed eaters?

R1: The seed eaters: We can hang the birdfeeder up in the tree & we can now build a roof over the bird feeder like I've got a home because if it rains the seed will get all soggy & it's not nice for the birds to eat it.

R: That's right. Let's just open our books now & let's look at your solutions to the problem. You had to identify 2 solutions or 2 problems & then you had to choose 1 & then you had to design & make something like a product, it's like an artefact that you could use to solve that particular problem.

R to K5: Would you just like to tell us which 2 problems you identified if you look at your activity sheet. What did you write about?

K5: Litter & the bank.

R: Tell me about the problem about the bank.

K5: No water for the grass to grow there.

R: So when you chose your solution what did you decide? Which problem did you choose?

K5: To build it up (the bank)

R: If I remember correctly did you not choose the litter

K5: Yes I did.

R: What did you decide to make?

R1: I decided to do the litter

R: Right, let's just look at our plans you did. I asked you to do a rough sketch of what you were going to make. Now what I am going to do, is I'm going to ask you to have a look at your plan & just spend some time even if you take it out of your plastic sleeve and look carefully at how you're going to make that. You really need to think about what you're going to make & how you're going to go about that today. And then, what we'll do, I've got the different materials here that I thought you might want to use in order to make whatever you're going to make. So let's just go round the table starting with K, what are you going to design & make.

K6: I'm going to make a plastic bag for litter.

R: If I look at your plan there, I think you need to do some labels there, to show me what kind of bag you're going to make, what you're going to use to make your bag. And you need to think about how you're going to join it & what size it's going to be.

K6: It's going to be 1-2 metres long.

R: I have got newspaper here today. Anybody else who wanted to actually make a bag?

R to K5, K6 & R1: I know your bags are going to be different & on your plan there you just need to write down a few things that you're going to use to make your bag .. I think I do know, so I brought things with me today. And you can think about how you're going to carry your bag. You might want to make a pattern out of paper 1st just to see what it's going to look like before you make the real thing. Okay, so we've got 3 litter bags people are going to make.

R to L2: What have you decided to make?

L2: I think might make a birdfeeder which also has like, so the bird's don't go down to the water's edge like to drink so you don't want to look like something happens to the birds like .. what you call it, their babies want to go & drink & fall into the water & drown, so I was thinking of making a bird feeder & next to that a hole full of water. That sounds wonderful. Now I think you need to look at your plan & put that in your plan or your sketch before your forget.

R to E4: What are you going to be doing?

E4: I might make a birdfeeder.

R: So what we have around the table … We've got 2 birdfeeders & 3 waste bags (1 participant absent). Now you don't have to all sit around this table.

Later …… You can use this whole room. If you want to sit on the carpet & you want to work. I've some of the baskets out (containers with plastic waste, cardboard, etc.), I've got bags there. Just feel free to select the things you want to use to make. I don't know how far we'll get today but before we leave today, we'll have a special bag to put your things inside, so that the next time I come & see you, we can then take everything out.

MAKING

R: Have you given some thought about how you're going to carry your bag?

R1: Yes, I'm thinking that I'm going to tie a rope around here where the litter comes out. Here's some string to try it to test it out. ……….(not really clear)

R:Ki I know that you were sealing the bottom of your basket for your litterbag. Can you tell me what you put inside there & why you've done that?

K5: I've put paper in the bottom to stop the basket from getting dirty.

R: Let's just repeat that …. You've put paper in the bottom. What kind of paper have you chosen?

K5: So, that I can replace it (the paper when it's dirty)

R: Have you given any thought about how you're going to carry your basket?

K6: I'm going to make a handle on & carry it like that.

R: What material are you going to use for your handle?

K5: I'm not sure yet.

R:You're not sure yet, you're still busy.

R to L1: you've done quite a lot today with your birdfeeder. Can you tell me something about the kinds of material you've used for the roof.

L2: Well, for the roof, I'm going to put over the cardboard, some plastic which will block it from getting soggy. *I hope!*

R: Now, what sort of plastic were you thinking of using?

L2: I was thinking of using, I saw in the thing some leathery kind of thing, in one of the boxes.

R: What do you think would happen if you used varnish?

L2: Varnish … I think it would still get soggy. Varnish only really works on wood.

R: And if you use it on the cardboard, what do you think would happen?

L2: I think it would get soggy.

R: Do you think it would dry like it would on wood?

L2: No, I think it might. No I don't think it would stop it.

R: So you think plastic would be a good solution?

L2: Yes.

R to R1: Talk to be about …… I can see that you've attached your handle to your bag. Can you tell me about how you went about making the holes.

R1: I used my scissors & made a hole through the newspaper & this bag (opened out paper waste bag). I have taken the string through here.

R : Looks interesting & I think you'll be able to collect a lot of litter in that bag. It's a very good design.

R to K6 You've got those lids there. What were you thinking of doing with them?

K6: I'm could put 2 on this side & 1 near one side, so that when you open the basket it has strings around these 2 & you can put string around it (indicating – see video or photo).

R:That's a good idea. Let's try it & if it doesn't work you can make another plan.

R to E3: I like that design you've used with your sticks. What made you do them across like that.

E4: I thought that for the birds…. 2 on each.

R:What made you push the stick right through to the other side?

E4: Well, I don't really know.

R: I think it's a good idea because they're both very stable.

E4: Ya, I could stabilize them by just sticking them (on the sides). It's better going through the bottle.

R: Absolutely. Now I know that we've run out of the glue what have you used as a temporary measure to seal the holes & attach the bamboo sticks?

E4: Prestik.

R: Do you think those bamboo sticks are quite strong .. Do you think they'll last?

E4: Ya, they will last.

R:They're quite strong & they're also natural, aren't they.

E4: Ya, because most birds use them.

R: If we look at the height of your bottle, it's a good height or do you think it should be slightly shorter?

E4: I think it's fine.

R: If you have a look at the height there that you've made your sticks, you need to make sure ….. if the birds are going to sit there .. where're they going to get the seed from?

E4: I'm going to make 2 little holes here.

R: So you're still thinking about that?

E4: Ya

R: Will they be able to get their heads through or just their beaks?

E4: No, just their beaks.

R: If you have a look at how much seed you'll need. How seed do you think you'll need.

E4: A lot.

R: Is that going to be a hanging feeder

E4: Nods.

R: How will you actually fill it up each time you need to?

E4: It might just be like a hook. I'll put it onto a branch & I can tape it on.

R to R1: That's a really good bag that you've got there. Have you given any thought to heavy things inside. What will it do to the handle do you think?

R1: I don't know .. maybe stretch it a bit, maybe the handle will break.

R: How could you reinforce & strengthen the hole?

R1: Um, I dunno. Well .. let's see.

R: What sort of litter?

R1: Cans, coke bottles, fanta bottles, chip packets.

R: Do you think they'll be fairly light?

R1: Yes

R: Why do you think they'll be light?

R1: Because they um. What's it …… they um, they're really light because they don't have anything inside them.

R: Good.

R1: And if they do …. You can either pour it out or put it in the same place

R: So, although you've got a big bag there, the things you put inside won't be too heavy?

R1: No.

R: That's great. What I think you need to do now, is put your name on & then fold it up carefully, so the next time I see you we can go & test it out.

R to:K6: I see you've been battling there, trying to get your tiles to stand. Do you think that the tiles are the right things to use or are you still going to try & use them.

K6: Yes, because the cardboard has got holes in them.

R: The cardboard's got holes. Ray said he was going to help you, & give you a hand there. How are you going to attach your tiles to the box?

K6: With the glue gun.

R: Like I said to E you can use something temporary to attach it to the box. What could you use until we get more glue sticks.

K6: Maybe wood glue.

R: L2 talk to me about the flap there & how you've attached it with the tape

L2: If the rain blows, it blows on the flap & it doesn't blow inside & I want it to be like flapping around so if it's like windy, then the birds can fly through it, they'll fly that way.

R: I wanted to ask you one thing. Is there any reason why you chose red?

L2: It's just a thing that I found. There was one yellow. But I didn't think anything.

R to E4: You've done a lot since I last chatted to you. What you've done there really looks so interesting. What have you used as the base?

E4: I done something so that the birds don't just have to sit on here (sticks), they can sit around.

R: What do you plan to put on the various containers there?

E4: I'll put water in them.

R: And what made you put 2 yoghurt containers one on top of the other?

E4: So I can make a height.

R: Make it higher, make the height.

E4: Ya.

R: So that'll be for the water. That's a jolly good idea. If they are sitting on the perch, they can pop their heads into the seed & just turn their heads & dip their beaks into the …
E4: Water.

R: Into the water. What have you still got left to do?

E4: I've still got to make the feeders so that they can dip their beaks & have their seed.

R: Which I think we can do the next time & just complete it.

Another session ……………
R: Now you need to go back to where you left off last week. C3 wasn't here so, C3 will only just be beginning to make what she had planned to make. I do have your planning books here but once we have finished we're going to take what we have made & place it in the conservancy. It would be nice if P was here for that, he could then have the video camera & record the responses as you & I work together to see where we're going to place everything. They haven't built the dam yet, that is going to start happening soon.

E4:….. It's filling up.

R: Yes, it's filling up. We're starting to get rain now, so we're getting natural water that's falling from the sky & I'm sure there would be some puddles. Maybe we could take a look around today & look at the conservancy again. The fact that you might need to seal some of the things that you made, using the glue gun, means that you're going to need to let it set. So if we don't place the things in the conservancy today, means that the next time I see you, you'll be able to do that. That'll be right at the end of the term. Maybe we could spend some time there & have a bit of a picnic with a snack. It's also a special week this week. Does anybody know what it is?

E4: It's Arbor Week.

R: Does anyone know what arbor's to do with?

K6: Planting trees.

R: Planting trees &, apparently, some trees have been planted. They were planted, I think, last week. The whole of last week & this week, is Arbor Week, it's running through to the 7th September. I think it might have been yesterday, or today.

ALL: Yes.

R: So, if we have a chance today, we can go & have a look at those trees & maybe we can think of, perhaps, making signs or seeing what the trees. So I'm going to stop talking now & what I am going to do is hand out all our different things & you'll be able to sit where you need to. Nobody's coming in for a while & we'll be together until break. Let's remember not to hurry. Let's remember to make something that's well made, that's going to last in the conservancy. And thing about what we used last week.

R to E4: Talk to me about what you thought we could do after we'd finished our project.

E4: I think when we've hung up our birdfeeders, we should make a sign that says "Please be quiet when you go on the nature trail."

R: That's a good idea. Would anybody like to comment on that. He was saying that after we've finished we should do a poster ……. Talk to me K5.

K5: People will be quiet & will watch. We'll have stuff there that when people come to look, they'll be able to see more birds.

R: Right, while you're busy making when we talk about the signs, what do you think we could make the signs out of.

K5: We could make them out of cardboard & put plastic around them & we could make special letters.

R: Maybe we could think about materials that wouldn't require us to put plastic over the signs, something that is more durable. I'm going to turn to R1 now who's helping

K6.

R to K6: Just talk to me about what you're doing & why you're doing it.

K6: In case the rain comes through, I've put in some cardboard inside.

R: How you're joining it?

K6: With sellotape.

R: Do you think sellotape's strong enough?

R1: Well, we're going to join it at the top as well.

R: You're going to join it at the top as well.

R to L2: How's your roof looking?

L2: Fine. I think it'll be okay.

R: Are you going to use that flap that you used from the last time. Now tell me about that red piece of plastic that you're using. What is the reason for that.

L2: I'm going to put like at the back of …… I'm going to put one at the top to stop the water getting through the roof & one at the back (bell) just so that it can hang.

R: Say that again. One at the back just to …..

L2: So that it can hang & when like the rain comes it usually, it'll blow the flap & the wind it won't like come in, like from the back …. So when they (the birds) turn around they don't have too many areas, so like they have like an area to hide.

R to C3: You were saying something about putting sticks into that bottle. Just talk to me about that.

C3: If you wanted to test it out to see if the food actually went into it. I put some plastic at the bottom & then, put one in here to see if it would goes in.

R: Okay.

C …& then you push it to the side …….

R: Show me.

C3: … And if they don't go in .. they go into there ….. & then sometimes when it rains, I'll take this out & we can sometimes the water will go in place of grass.

R: Good idea.

E4: It's just come off (feeder pulled away from base).

R: It's just come off . You don't think you need to use something stronger…..?

L2 to E4: …….. Use a glue gun.

E4: I'm going to use bostik.

R: I think you need to let it set for a while as well.

E4: Ya

R: Remember when you've got the seed in there & the birds are sitting on the bottom, it could also pull away. So we're really going to have to secure that. Let it set & don't move it around too much

C3: Do birds like pecking around on things that are like string?

R: Well sometimes they use little bits to make their nest.

C3: Maybe that'll work.

R: Okay. Put it on & see.

R to E4: Just tell me about what you're putting on those yoghurt containers.

E4: I'm putting this sort of plastic ….. C3 gave me the idea. She said that if there're too many birds trying to eat they could also come down & eat from these little containers.

C3 to E4: Why are you putting that plastic over?

E4: So the water won't get in.

C3: Then how are they going to get to their seed?

E4: Well then I don't have those (holes) big enough.

C3 to E4: Well then how are you fill it ……….?

R to C3: You might have a point there, C3,…… but E4 can try it out & see.

E4: You just put seed in the holes.

R: Will they be able to get to the seed? What if they can't reach the seed?.

E4: They're wise birds

R: They're wise birds. ….. I hope so.

R to C3: What are you doing? Tell me.

C3: I'm trying to get a few more things down here .. so sometimes if they're hungry I have food for them.

R: I see you filled up the containers with water.

C3: Ya, I'm just seeing to see if they'll leak. If I put it there & it starts leaking, I don't know what I'm going to do. So I'm going to test it out.

R: And that black fringy stuff that you've got there?

C3: I think I'm going to use it …here .. & then just put a few things on it to attract them.

R: Okay, like what? What could you put on there to attract them?

C3: Maybe I could hook it like that & while it's hanging sometimes, they like swinging on them

R:Oh. That's a good idea. Jolly good. So how will you attach that so that it's strong enough to carry the weight of the bird?

C3: I think I'll have to use the glue gun cause bostik's not as strong as the glue gun glue.

R: And a stapler?

C3: A stapler … Umm, I don't think staple, cause maybe if they find it & they've got strong beaks they could maybe try & open it.

R: I didn't think of that …. The only other alternative would also be to make a hole & knot it through. And try & seal it with the glue. You could try & do that.

R to L2: Tell me about how you're going to place your feeder.

L2: I'm going to use like a stick & stick the stick in the ground & then I'm going to tie the stick & wrap it into a tree like just to keep it stable so it won't fall.

R: Now what we need to do is if you're finished now you need to think about what you want to take with you to the conservancy. So I would say, let's look for the string & let's get a kit bag together so you can/might need to do a few things when you're there.

R to E4: Are we going to test out what you're doing there. Talk to me about what you're doing there?

E4: I'm just taking my bottle off & I'll just use it (the base) as a tray. That's like a modern day, a normal …… (feeder).

R:So you're just going to try it out ………

E4: Yes, I'll just see what the birds do ….

EVALUATING AND COMMUNICATING FINDINGS IN THE CONSERVANCY

R: I've got C3 here & we've evaluated her feeder out in the conservancy. It seems to have held up pretty well & I'm going to chat to her & get her to talk about it. To see whether the feeder has been a strong one or where she could improve. It's a fairly windy day & I see your feeder's hanging quite beautifully from the branch.

C3: It didn't really work quite well because the bottom actually fell off. I don't what we should do to stick it back on. Maybe I shouldn't put a bottom.

R: Why do you think the bottom came off?

C3: Because of the wind, the strong wind. I only put the glue gun on.

R: Mmmmmmm. If you didn't put the bottom onto the main part of the feeder, what could you do to have water containers?

C3: Maybe, just maybe, I could maybe try and thread some string up here with a needle. I'd make it go through then I'd get a few of these. Then I'd put holes through there & I'd make them go & hang.

R: Just think about that bottom if you wedged it in branch somewhere. Do you think you could do that without attaching it to the birdfeeder?

C3: Ja.

R:Would you like to give it a try?

C3: Nods.

R: Okay

Later…….

R to C3: If you look at the size of your tray. Do you think you need to make it smaller or do you think ……. What do you think is the problem here with the wind?

C3: I think it's a bit too windy for ……. maybe if I could…., I could put some sticky tape at the bottom. If it was a windy day it **…**

R: Now you talk about sticky tape, do you think it's waterproof?

C3: Sometimes it is.

R: You think so**.**

C3: Ya

R:So you'd like to keep it like it is there. Well, we can leave it there & what were you intending to do with those little containers?

C3: I'm going to put water in them & a bit of seed so when they like drank from it (hard to hear with the wind) & if any of the bird seed fell it would grow into grass shoots.

R: Let's just look at your feeder here .. if the birds come to feed where would they sit & how would they feed? EI4; EI3

C3: They would sit over there …. & then, while they're feeding, when this is all disappearing & more comes out ….. like that ….

R: Mmm. Do you think the birds have eaten some of your seed**?**

C3: Ya, I can tell, because last time it was up to there (indicating the level of the seed in the container).

R: And so the level's gone down a bit?

C3: Ya.

R: Well, I think it was quite successful. And the top of the feeder? Will it get wet in the rain?

C3: …… No, I don't think it would.
R: Have you got a lid on at the top?

C3: No. Maybe I could …. (puts a leaf on the top of the bottle to act as a lid). R:Now you've put a leaf at the top of the bottle. What do you think the leaf will do? C3: It'll just make the birds feel safe.

R: If you had to make your feeder again. Is there anything you'd change, or would you keep it the same?

C3: I'd change quite a bit of it if I had to**.**

R: Let's talk about it now while we're here so you can show me what you'd change & tell me why.

C3: You know the idea I told you about what I could do.

R: Yes .. Let's talk about that so that I can put it on the tape & I can remember.

C3: For example, it's something round like this, except it has big sides on the edge of it there. Maybe I could put it up over there & cover the bottom. Then I cut holes in it. Then put little sucker sticks, I'd bend them a bit & put plastic around it.

R: Would you like to take your feeder from the tree today & see whether you could modify it or are you happy to leave it there? C3: I think I'll just change it a bit.

R: Okay. Well let's do that then.

Later …….
Back in the classroom after taking a walk through the conservancy.

R: We've brought C3's birdfeeder back & we've now looked at her original plan – They (the research group) had to think of 2 ideas & then select one of them & draw … the feeder (referring to her plan. I've got C3's plan in front of me & I'm going to take a picture of it & then she's going to talk about her plan & whether she actually followed her plan, or whether she changed her mind as she went along (taking a pic).

R to C3: Let's talk about your original design & what you actually made – You've got both in front of you now. Would you like to talk to me about it.

C3: Well, I was going to do the birdfeeder on the floor but you know like the ones we only put water in - I was going to make one like this (referring to drawing. Then I decided why didn't I do one for hanging.

R:Why did you change your mind? Why did you choose one that you're pointing to now?

C3: I chose that one cause it's not like I want to choose … My Mom would spend a fortune just getting the top there & the stone bottom**.**

R: Do you think you would've been able to work with things like stone & join it together? Do you think it might've been too difficult?

C3: It would've have been too heavy to carry.

R: Let's just talk about the kind of material, that you used to make your feeder & why you actually chose that material.

C3: Well, I used plastic. I used sticks. Then I took the sticks out. Then I had bird food. Then I had a leaf on the top.

R: And what do you think is good about plastic? Do you think it's good to use?

C3: Plastic is actually quite nice, especially, coco cola bottles – You use it & if it's going to rain a lot in one place, all the food inside will get wet, but in plastic it'll stay fresh**.**

R to R1: If we look at your feeder now, you've also used a toothpaste box. Now, that seemed to have held up pretty well & it actually hasn't broken up and we've had a lot of rain. And you've used sticky tape and the sticky tape has also held up pretty well. And, usually, it doesn't do that.

C3: Before I put the toothpaste (box) in. I thought why don't I use the toilet roll. But the toilet roll didn't really work. I tested it.

R: And what happened to the toilet roll?

C3: I tested a few bird seeds in it & it just started to break up, so I decided why didn't I get a box. I'll cut up a box like that (pointing to the toothpaste box) and I'll put 2 sides together & sticky tape it.

R: Now we did say that you were going to change things slightly. What are you going to change and tell me why you're going to change it. If you had to make it again, you said you'd do things slightly differently.

C3: Mmmm.

R: What would you do?

C3: I'd get that funny roll that I was talking about

T: Mmmm. Plastic or card?

C3: Cardboard but I'd put plastic around it. You know that plastic for wrapping over?

R: What do you think that would do?

C3: It would just make it a bit waterproof**.**

R: Mmm.

C3: Then I could cut holes in so they could like have a house & I'd put a bit of wood inside before I seal it. Then at the top, maybe I could make a little roof. Then, at the bottom I put in seed.

R: What do you think the roof would do?

C3: The roof would at least protect them & the baby.

R: Like the roof protects us?

R to C3: Now if I just take a look, …. I can see plasters at the top of that bottle. What made you put plasters there.

C3: I don't know, I just put them there.

R: And do you think a hanging feeder is quite successful?

C3: Yes.

R: Why?

C3: Because, for an example, if I had a stone one & it wasn't properly into the ground, it could've fallen and got broken and damaged and I couldn't repair it again.

R:And that one is pretty strong. Mmmm, what are you going to do about the water?

C3: Well….. for the water I don't know what I'm really going to do.

R: Do you think that when it does rain & the birds haven't got water in the dam, they might use that water?

C3: Maybe. Maybe if it rains one day. If we go on a rainy day, we could bring our anoraks.

Just then P walks in.

R: Hello, P. (acknowledging his presence) We thought that maybe we need something stronger to join C3's birdfeeder.

P: ……….Well, with this wind.

R: …….That's why we think it was a pretty stable structure actually.

R to C3: Tell P about your birdfeeder. Where could the birds get water?

C3: Maybe I could make another birdfeeder. Instead of putting cardboard, I could put a special kind of plastic there.

R to C3: Tell P about what we spoke about regarding that opening there (pointing to the top of the bottle) which you do need to have covered. What did you put there?

C3: I put a leaf.

R: Why did you choose that leaf?

C3: Because they're waterproof.

R: Well, thank you very much. That's all for now. Show P your plan there & what you actually decided to do.

P: Can I go back to the question that R asked you just now where you said you'd put a leaf in. My question to you is why is it important to cover that hole?.

C3: Cause, if for example water goes thru all the seed will go into grass ……..
… And it will get wet & it probably won't attract the birds & the fact that the 1st part that would get wet would be the top part and ….. that's going to put the birds off. The funny thing is that the seed is actually dropping into here (pointing) from somewhere else & not the top.

P: Mmmm.   But once these seeds here get wet because this is not covered……What else could you have used in there if you hadn't looked for something natural?

C3: I could've used a lid for a coco cola bottle, or I could've used some .. plastic … do you know that plastic wrapping   .

P: …… or a cork.

R to C3: Tell P …. If that (the seed)got wet ….and it started to grow …. Would the birds still be able to eat from that …….. That could start growing into a little plant. Could the birds still be able to eat that?

C3: The birds could be able to.

P: It would just be the time that that takes to grow.

C3: Yes.

P: That's happened to us at home……… We've got 2 birdfeeders at home and the flat one is similar to this (referring to diagram). P fell knocked over the birdfeeder and it broke.

C3: Burst out laughing.

P: But that one – referring to C3's feeder – When the birds are pecking at it …….it (the seed) falls onto the floor and, after a couple of weeks, you'll find that growing. And the birds will fly down & start to eat that plant.

C3 to P: We can't put feeders at home because we've got cats in our house**.**

R: So you don't want to attract birds at your home?

P: Unless you put them very high.

C3: Our cats can also get on our roof ……….(referring to the fact that cats can climb heights).

P: Oh yes. Well done**!**

R to E4: I'm talking to E4 here. She says that she is going to change her feeder slightly & she's busy selecting new material. E4, just talk to me about your feeder & why you think it didn't work & what you'd like to do.

R to K5: I'm talking to K5 here & we're looking at her original plan, i.e. what she chose to do.

R to K5: What kind of litterbag or box did you decide to do? Talk to me about what your original thoughts were.

K5: I thought maybe I should have a lock to close it but I can't do that. I didn't have any space for it. So I just changed my plan.

R: Was that going to be a bag or a box?

K5: A box.

Later ………..

R:Just to say that we're all outside – the whole group of us are here. It's a really very windy day & I think that whatever we've made, it's a good test of the strength of our structures. I'm just going to turn back to L here.

L2: We've had quite a bit of rain & a lot of wind since we last put your bird feeder in the tree and it's lasted very, very well.

R: Can you tell us why you think your feeder was so strong & what made it so successful.

L2: I think it's because I used strong material & the spot that I chose in the tree was quite safe.

R: You chose a pretty good spot.

R to K5: How did you manage to make your litter box which you now modified? Do you think it's a lot stronger?

K5: Yes.

R: Did you have difficulties in carrying it in the wind?

K5: Kind of.

To the research group ….

R to All: Well, I think it (the project) was very, very successful and I'd like to say "Well done!"

APPENDIX THREE: LANGUAGE EDIT

Prof. M.W. de Witt

27 September 2013

Dear Professor de Witt

On behalf of Mrs Colleen Thatcher I need to confirm that I was responsible for the editing of her dissertation in July this year. If you need to contact me please use my email address: kearney@ukzn.ac.za.

Yours sincerely

John Kearney (Professor)