

**OPTIMIZING THE LEARNING ENVIRONMENT FOR
CREATIVE WORK BY STUDENT TEACHERS IN
TECHNOLOGY**

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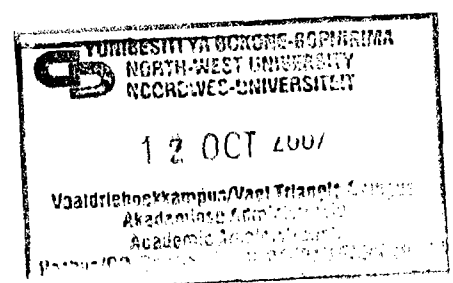
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DEDICATION

I dedicate this work to all the people who provided me with a challenging, inspiring, encouraging and supportive context: especially my parents, Andries and Ria Louw, my uncle, Gerrit Louw and my mentor, S.C.A. Toerien.

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SUMMARY

This study focuses on creativity in pre-service teachers and how it can be improved by using what Technology Education can offer.

Chapter one focuses on the orientation and statement of the problem and it concludes that it would be worthwhile, in the light of the demands for creative work that is expected of teachers in the current educational paradigm, to investigate the *status quo* regarding creativity in students who opt for education as a career and to implement enriched teaching and learning programmes to address their needs in this regard.

Chapter two gives an overview of the available literature about creativity and provides the theoretical framework of this study. It focuses on the concept of creativity, the creative person, the creative process, the context that enhances or inhibits creative work and the creative product.

Chapter three delves into the theories about learning and stimulation of creativity in order to provide a theoretical framework for developing the enriched teaching and learning programme. Objectivist theories including Behaviourism, Connectionism and Neuroscience, cognitive theories like Constructivism, Gestalt and Experientialism, social cognitive theories that focus on the ideas of mediation, scaffolding, modelling and lastly integrative theories are explored in order to explain the importance and the requirements for learning creativity.

Chapter four explains the empirical research design of this study. It describes the composition of the tests and questionnaires used and their reliability and validity. It further focuses on the statistical methods that were used to analyse the data.

Chapter five describes the Technology Education programmes that were aimed at enhancing creativity. The differences and similarities between the basic and enriched teaching and learning programmes are discussed. The effects of these two programmes on the creativity of the participants were tested in this

study.

Chapter six concentrates on the results of the *ex post facto* study (to determine the *status quo* regarding creativity in pre-service teachers and possible reasons for differences) and the results of the quasi-experimental study (to determine the effects of the basic and enriched teaching and learning programmes on the creativity of the participants). The data handling prior to and during analysis and matters like measures to ensure construct validity, handling data from non-equivalent groups and significance testing are discussed as applicable to the data matrix for this study. Selected data are given in tables, illustrated with graphs and path models. Decisions regarding the rejection or acceptance of the null hypotheses and alternative hypotheses are given and discussed.

Chapter seven concludes this study with a summary, as well as recommendations for future research.

OPSOMMING

Die studie fokus op kreatiwiteit in voor-diens onderwysers en hoe dit verbeter kan word deur wat Tegnologie Opvoeding kan bied.

Hoofstuk een fokus op die oriëntasie en die probleemstelling. Daar word tot die gevolgtrekking gekom dat dit die moeite werd sal wees om, in die lig van die eise vir kreatiewe werk wat van onderwysers verwag word in die huidige opvoedkundige denkraamwerk, die *status quo* aangaande die studente wat onderwys as loopbaan kies vas te stel en 'n verrykte onderrig-leer program in plek te stel om hul behoeftes aangaande kreatiwiteit aan te spreek.

Hoofstuk twee gee 'n oorsig van die beskikbare literatuur oor kreatiwiteit en voorsien die teoretiese raamwerk van die studie. Dit fokus op die konsep kreatiwiteit, die kreatiewe persoon, die kreatiewe proses, die konteks wat kreatiewe werk stimuleer of inhibeer en die kreatiewe produk.

Hoofstuk drie delf in die teorieë oor leer en die stimulasie van kreatiwiteit met die doel om 'n teoretiese raamwerk vir die ontwikkeling van die verrykte onderrig-leerprogram te bied. Objektivistiese teorieë waaronder Behaviourisme, Konneksionisme en Neuro-wetenskaplike teorieë, kognitiewe teorieë soos Konstruktivisme, Gestalt en Eksperiënsialisme, sosiaal kognitiewe teorieë wat fokus op die idees van mediasie, steiering, modelering sowel as geïntegreerde teorieë word verken om die belangrikheid en die vereistes vir die aanleer van kreatiwiteit te verduidelik.

Hoofstuk vier verduidelik die empiriese navorsingsontwerp van die studie. Dit beskryf die samestelling, betroubaarheid en geldigheid van die toetse en vraelyste wat in die studie gebruik is. Dit fokus verder op die statistiese metodes wat gebruik is om die data te ontleed.

Hoofstuk vyf beskryf die Tegnologie Opvoedingsprogramme wat gebruik is om kreatiwiteit te verbeter. Die verskille en ooreenkomste tussen die basiese en verrykte onderrig-leerprogramme word bespreek. Die effek van die twee programme op die kreatiwiteit van die deelnemers is in die studie getoets.

Hoofstuk ses konsentreer op die resultate van die *ex post facto* studie (om die *status quo* aangaande die kreatiwiteit van die voor-diens onderwysers te ondersoek en moontlike redes vir verskille te verklaar) en die resultate van die quasi-ekperimentele studie (om die effek van die verskillende programme vas te stel). Die hantering van data voor en tydens die analise en toetsing vir betekenisvolheid van effekte word beskryf. Sake soos maatreëls om konstruk geldigheid en betroubaarheid te verseker en hoe om die data van nie-ekwiwalente groepe te hanteer, soos van toepassing op die data in die data-matriks in die studie, word bespreek. Geselekteerde data word in tabelle gegee en toegelig met grafieke en padmodelle. Besluite rakende die aanvaarding of verwerping van die nul hipoteses en alternatiewe hipoteses word gegee en bespreek.

Hoofstuk sewe sluit die studie af met 'n opsomming, asook aanbevelings.

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CHAPTER ONE

ORIENTATION AND STATEMENT OF THE PROBLEM

1.1 INTRODUCTION

The demand for creativity in the teaching profession increases as the emphasis shifts to more individualized and contextualized education. Teachers are expected to be architects of learning environments: designing and constructing relevant learning experiences and assessment tools to suit the needs of their particular learners. Furthermore, they have to nurture the same creative skills in the learners entrusted to them.

Csikszentmihalyi (1988:325-339) explains that creativity and innovation do not exist in isolation in an individual. They are brought about by a dynamic interaction between an individual and the society in which he/she finds himself/ herself. The existing cultural values, attitudes, knowledge and skills of the society shape the individual. The creative individual builds on these values, attitudes, skills and knowledge. He/she changes them by processes such as adding on, removal of parts, adaptation, combination and reshaping. The changes are inspired, observed, encouraged, evaluated and accepted or rejected by the society.

Teachers are responsible for improving access to knowledge and skills from the past by teaching learners to be literate. They optimize transfer of culture from one generation to the next, enabling the younger generation to build on the experience of the previous one. Simultaneously, they are also instrumental in creating a social environment in which the new generation will operate. This environment can be judgmental, rejecting all changes or it can be accepting, encouraging creative exploration.

For teachers operating in an African cultural background, the situation is even more complex. They must ideally root the learner in traditional African culture and knowledge systems and simultaneously also provide a bridge for them to global culture. The learner must operate and compete in a global world and must therefore be exposed to the knowledge, skills, values and rules of global culture.

Technology Education, aiming to enhance the technological literacy of a population, provides excellent opportunities for nurturing creativity and innovation in students. It

encourages students to recognize problems, to solve these problems in innovative ways and to communicate the solutions. All these abilities require creativity.

Technology Education teachers are, due to the integrative and problem-solving nature of the learning area, in an optimal position to develop a culture that values creativity and innovation within a community. This should lead to a situation where creativity and innovation in individuals are viewed as relevant, useful and acceptable in the society within which the individuals find themselves. It is therefore of the utmost importance to grasp the opportunities for developing the creativity of specifically Technology Education teachers.

It is not only Technology Education teachers who need to be developed in this respect. Globally there is a growing demand for creative people, teachers as well. This demand for creative teachers was brought about by change in the perception of the respective roles of the teacher and the learner that resulted from psychological research. In reality, however, an inability to grasp the opportunities for creative work is observed in many South African teachers, especially those coming from communalistic backgrounds where the individual is of less importance than the group and where individualism is often viewed with suspicion.

1.2 PROBLEM STATEMENT

The new education curriculum in South Africa places huge demands on teachers to be able to think creatively. The Norms and Standards for Teacher Education stipulate that the teacher must be able to:

“consider a range of possibilities for action, use key strategies such as problem based learning and projects, create a learning environment in which critical and creative thinking is encouraged, design original learning programmes, adapting learning programmes so that they are appropriate for the context in which teaching will occur, and adapt to change and unforeseen circumstances” (Department of Education, 2000:15,16).

The school curriculum also places emphasis on creativity. This is illustrated in the Critical Outcome: *“Identify and solve problems using critical and creative thinking”* (Department of Education, 2002:1.)

The notion of creativity is further highlighted by the Policy document for the Learning area Technology in the National Curriculum Statement. The Learning area

Technology uses the design process that is a *“creative and interactive approach for developing solutions for identified problems. It gives the learners opportunities to learn to solve problems in creative ways, use technological skills e.g. design...,use life skills e.g. creative thinking, generate a variety of possible alternative solutions, generate a set of criteria”* (Department of Education, 2002:5-7,39).

The above-mentioned implies that teachers must not only teach learners to think creatively, but must themselves fulfil the creative role of becoming an **interpreter** and a **designer** of relevant learning programmes and learning opportunities for local needs and conditions.

The introduction of the new education curriculum in South Africa assumed that it would be easy for teachers to use their creativity to develop relevant learning programmes if they were given the necessary information on the requirements for such a programme. This is not true. Own observations of pre- and in-service teachers led to the belief that the ability to be creative and design learning programmes cannot be assumed. Knowledge about the processes and products such as design steps, the typical composition of learning programmes, exposure to examples and guided activities too often result in work where examples from textbooks or previous work are copied. Despite the willingness of teachers to design learning programmes, and time, money and effort spent on teacher training, most teachers remain unable to develop quality learning-programmes (Taylor & Vinjevold, 1999:105-130). Some teachers depend heavily on others to develop their programmes for them, or buy programmes developed by various institutions. Often these programmes are applied as is and are not made relevant to the learners following it. RAUTECH, OBE-plus and TO-group are a few examples. Some schools can afford bought programmes and others not.

The problem, however, could be deeper than just knowledge and willingness. It could be rooted in contextual factors like lack of creative role models, culture, habit, history, isolation, intellectual inability, illiteracy, lack of explicit attention to productive thinking at school and tertiary level or even inhibition of creativity in teacher training facilities and schools.

Regarding teacher training, school atmosphere and role models, the remark of the National Professional Teachers' Organisation's (NAPTOSA) submission to the Chisholm committee reviewing Curriculum 2005 may be an indication of how teacher training is often conducted: *“that in training teachers they ...need to be invited to be*

critical of what is being done rather than being discouraged from asking questions” (Chisholm, 2000).

Instead of being encouraged to be critical and creative, educators are often discouraged: A top-down approach of policy makers and the autocratic management style still in place in many schools are given as reasons why teachers resist change (Molete, 2004). Some research, such as the study by Kirsten and Viljoen (2004:9), indicates that some schools in South Africa are indeed “*toxic workplaces*”. The atmosphere and situation inhibit the individual teacher’s opportunities for independence and expression. Doctors report that an unusual number of teachers come to them with stress-related illnesses like burn-out and depression. These might be symptoms of an atmosphere that inhibits creativity, since it may be argued that opportunities for creativity help individuals to maintain mental balance and health and that the conditions that are described above correlate with the picture painted by Parnes (in Wenger & Poe, 1996:12) in his book “*Visionizing: Innovating your opportunities*” as the disastrous path to problems and despair. Bronfenbrenner (1979: 6), Bandura (1986:48-50) and Amabile (1996: 179-202) emphasize the role of role models in modelling creative behaviour. A creative teacher may therefore model creative behaviour and provide an atmosphere encouraging learners to be creative. Characteristics of this kind of atmosphere are: idea time, freedom, idea support, openness, trust, payfulness, risk-taking and debate (Ekvall, 1996:162-163). If the teacher is therefore discouraged from being creative as described in the previous paragraph, the same discouraging attitude may be passed on to the learners.

Culture may be another factor that influences teachers. Tshikuku (2001) explains that it is the cardinal values or worldview of a society that determines the creations. If an attitude of individuality is a high priority in the cardinal values of a society, then it will be encouraged (*cf.* 2.4.3.10). If solidarity (collectivism) is seen as more important than individuality, individuality will be seen as revolutionary and will be discouraged. Creativity, innovation and entrepreneurship are seen as individualistic. Based on a cross cultural study about the values of IBM employees in different cultures, Hofstede (1991:54 &123) classifies cultures on the basis of five different aspects. The relevant aspects in this case are **Uncertainty Avoiders** and **Individualism**. Sub-Saharan African cultures are generally characterized by a low individualism combined with an average uncertainty avoidance index. Several other authors such as Mbiti (in Lassiter (1999:4); Mwamwenda (1995:421-431); Van der Walt (1996: 29-51); Tshikuku, (2001: 7-24) and Van der Walt (2003:70-71 & 136-158) also describe African culture

as collective or communalistic. The individual is important through being part of a group. It offers support, but comes at a price. Individual initiative is discouraged, resulting in a large degree of uniformity. These conditions generally tend to discourage creativity. The global culture, in contrast, is strongly influenced by Western individualistic views that encourage creativity in the individual. Rudowicz (2003:4) explains that it is not merely the African attitude towards creativity that is different, but also the perception of creativity. The African cultures emphasize adaptation where Western cultures emphasize novelty.

Lassiter (1999) concludes, after a review of the work of a number of African scholars, that he believes that *"there are categories and processes of thought that are unique to Africa"* and that *"the African way of organizing and cognitively engaging the world derives from a strongly restrictive indigenous socio-cultural milieu, and that this approach to social life and the broader world has been negatively effected by Western cultural influences"*.

Lassiter (1999:4) quotes Makgabo who asserts that these unique values that are fundamental features of *"African identity and culture include hospitality, friendliness, the consensus and common framework-seeking principle, ubuntu, and the emphasis on community rather than on the individual"*.

Lassiter (1999:4) further quotes Nyasani who describes the African mind as *"caught in a social pyramid characterized by a one-way vertical authority structure and a two-way horizontal family and communal support system, beset with superstition and destabilized by Western acculturation"*.

Thinking is therefore described as *"relatively uni-linear, uncritical, lacking in initiative and therefore 'encapsulated'". This, Nyasani says, has been "extremely negative for Africa, especially in terms of the African individual's creativity and ability to innovate"*.

The definition of creativity differs according to culture (Rudowicz, 2003). The emphasis placed on novelty, newness or originality in the definition of creativity in most Western cultures, is of less or no importance in some African cultures. In these cultures, modification, improvements, adaptation and variation are seen as more important. The threat of the idea to existing tradition determines in some cultures the scope of the modifications allowed.

Illiteracy or low literacy levels may be factors inhibiting creativity (Mwamwenda, 1995:109,112,116) since it limits access to the domain (field of expertise)

(Csikszentmihalyi, 1994:131-136). According to Tillman and Tilman (in Hale-Benson, 152-153 and Memmi (1991:90-141), historical factors (*cf.* 2.4.3.10) may also be implicated, especially if they lead to colonial mentality.

On the one hand all teachers are therefore expected to be creative and act as creative role models and mediators of creativity. On the other hand many teachers in South Africa come from cultures that may view creativity differently from how it is described and expected in the policy documents. They may also, through an upbringing that taught them to conform, perceive creative behaviour as wrong. They may also have a history of first- or second-generation literacy and a lingering colonial mentality. The openness of Technology Education and the many possible answers may be a bewildering experience for students who are imprinted to give one correct answer.

Based on the aforementioned, the problem this research wishes to address seems to be vested in the following question:

To what extent are pre-service teachers capable of eliciting creative thinking abilities?

The following problem questions arise within this central question:

- What are the creativity indexes and abilities of pre-service teachers in Technology Education?
- What factors impact on the creativity indexes and abilities of pre-service teachers in Technology Education?
- How can the creative thinking abilities of pre-service teachers in Technology Education in Technology Education be improved?
- Can a programme that enhances the creative thinking abilities of pre-service teachers in Technology Education be designed and implemented?

1.3 AIMS OF THE STUDY

The main aim of the study is to optimize the learning environment for creative work by pre-service teachers in Technology Education at the NWU-Vaal triangle.

The overall aim will be operationalized as follows:

1. The creativity indexes and creative abilities of the pre-service teachers in Technology Education will be determined.
2. The factors that impact on the creativity indexes and creative abilities of pre-service teachers in Technology Education will be investigated.
3. Ways of how the creativity of pre-service teachers in Technology Education could be improved will be explored.
4. A programme for enhancing the creative thinking abilities of pre-service teachers in Technology Education will be designed and implemented.

1.4 HYPOTHESES

The literature highlights the importance of personal factors, process related factors and contextual factors, perceptions of contexts, role models and exposure to creative processes as fundamental in the development of creative thinking activities. Based on this, the following assumptions and subsequent hypotheses were formulated:

Assumption 1: **Personal factors** (such as age, position in family, academic achievement and gender), **process-related factors** (such as ability to generate many ideas (fluency), new ideas (originality), different ideas (flexibility) and add detail to ideas (elaboration), **contextual factors** (such as culture, socio-economic factors and acculturation of parents, family factors, role models and school model attended) and **perceptions of whether contexts** (such as culture, family and school) **model creative behaviour as desirable behaviour** might be responsible for the inability of students to seize opportunities for creative work.

Null hypotheses

- H_0^1 Personal factors have no significant influence on the creativity index of participants in this study.
- H_0^2 There are no differences in the strength of the relationships between creativity index and the different creative abilities used in the creative process in the participants in this study.

Person	Process	Context	Perception	Creativity index
X				X
	X			X

- H_0^3 There are no relationships (direct or indirect) between contextual factors and creativity index in the participants in this study.
- H_0^4 There are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity in the participants in this study.
- H_0^5 There are no relationships (direct or indirect) between perceptions about the context and the creativity in the participants in this study.

		X		X
		X	X	
			X	X

The researcher also poses the following alternative hypotheses:

Alternative Hypotheses:

- H_a^1 Personal factors have a significant influence on the creativity index of participants in this study.
- H_a^2 Some creative abilities, influencing the creative processes, are more of a problem for the participants in this study than others.
- H_a^3 There are direct and/or indirect relationships between the contextual factors and creativity indexes.
- H_a^4 There are direct and/or indirect relationships between contextual factors and the perception that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres).
- H_a^5 There are direct and/or indirect relationships between the perceptions that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres) and their creativity.
- H_a^6 There are direct relationships between the personal, process and contextual factors, whether creativity is modelled as

	Person	Process	Context	Perception	Creativity index
H_a^1	X				X
H_a^2		X			X
H_a^3			X		X
H_a^4			X	X	
H_a^5				X	X
H_a^6	X	X	X	X	X

acceptable behaviour by the specific contexts (life spheres) and direct and indirect relationships between the contextual factors and the creativity of participants.

Assumption 2: A Technology Education programme including exposure to creative-role models, modelling creative behaviour as acceptable, combined with exposure to creative processes (enriched programme), should have a more positive effect on creativity levels of participants than a programme focusing just on exposure to creative processes (basic programme).

The following null hypotheses are posed:

- H_0^6 : The difference in Technology Education programmes followed will have no significant effect on participants' **creativity indexes**.
- H_0^7 : The difference in Technology Education programmes followed will have no significant different effect on participants' **creative process skills** (creative abilities).

The researcher also poses the following alternative hypotheses:

- H_a^7 : Hypothesis: Explicit training of pre-service teachers to view creative behaviour positively might have an effect on participants' creative indexes.
- H_a^8 : Hypothesis: Explicit training of pre-service teachers to view creative behaviour positively will have a **definite effect** on participants' creative indexes.
- H_a^9 : Hypothesis: Exposure to the different Technology Education programmes will have **different effects** on participants' creative indexes.

Assumption 3 states that the context from which a student comes and the perceptions about these contexts regarding modelling creativity as desirable behaviour will determine the effect that a programme aimed at enhancing creativity may have on his/her creativity.

The following null hypotheses were posed:

- H_0^8 : The possible effects of the different Technology Education programmes on the **creativity indexes** of the participants will not be influenced by contextual factors and/or perceptual factors.

- H_0^9 : The possible effects of the different programmes on the **creative abilities** of the participants will not be influenced by contextual factors and /or perceptual factors.
- H_0^{10} : Cultural factors have no effect on the “modifiability” of participants regarding creativity

The following alternative hypotheses were formulated:

- H_a^{10} : The possible effects of the different Technology Education programmes on the **creativity indexes** of the participants will be influenced significantly by contextual factors and/or perceptual factors.
- H_a^{11} : The possible effects of the different programmes on the **creative abilities** of the participants will be influenced by contextual factors and perceptual factors.
- H_a^{12} : Cultural factors have an effect on the “modifiability” of participants regarding creativity

1.5 METHOD OF RESEARCH

A quantitative method was utilized to collect numerical data regarding the contextual factors, perceptions, creativity levels and creative abilities of the research participants. A quantitative research design was chosen as it was the intention of the researcher to establish and /or confirm relationships (Leedy & Ormrod, 2004:95).

1.5.1 Literature study

Relevant literature was obtained from the EBSCO host (PsycInfo, Eric), JSTOR, NEXUS databases as well as Lawrence Erlbaum Associates and Google, using combinations of among others the following key words:

Creativity	Creativity, creative, Ingenuity, Innovation or Innovate, Inhibiting creativity Enhancing creativity, Creative role or style, Creative process, Testing,
Person	Motivation, Brain dominance, Behave or Behaviour, Learning style, Personality, Thinking style

Learning	Learning or Learn, Role model or Role model, Connectivity, Cognition or cognitive, Constructivism, Mental Modelling, Mentoring or mentor, Mediate or mediation or mediator Cognitive apprenticeship, Gestalt, Construct, Memory or memorize, Working memory, Long-term memory, Hebbian connection, Neural network, Prefrontal cortex, Neural networks, Neuroscience
Context	Social Modelling, Culture, Cultural evolution, Systems theory, Evolutionary system, Socio-cultural factors or Socio-cultural context, Chaos theory, Society, Social systems, Support network or De Solla Price network, Vygotsky, Bandura
Statistics	General linear model (GLM), Analysis of Variation (ANOVA), Analysis of Co-variation (ANCOVA), Multiple linear regression analysis, Structural equation Modelling (SEM), Analysis of Moment Structures (AMOS), Partial Least Squares (PLS), Maximum Likelihood Estimation (MLE), Covariance-based SEM, Component-based SEM, Latent variables, Measurement model, Structural model, t-test, PLS- Path-modelling, Soft-modelling, Smart-PLS, PLS-graph, Visual-PLS, t-value tables, p-values, Wrong signs, Significance, Cronbach Alpha, Cohen's d, Resampling, Bootstrapping, Jackknifing, Reliability, Validity, Discriminant validity, Convergent validity, Construct validity, Handling missing data, Non-equivalent group data handling, Negative t-values, Negative Cronbach alphas, Valid floating points

Primary and secondary sources as well as journals were consulted.

1.6 THE EMPIRICAL STUDY

1.6.1 Experimental design

An *ex post facto* design was utilized. This part of the study involved no direct manipulation of the independent variables (Leedy & Ormrod, 2004:232). The aim of this study was to identify conditions that were already present, collect data and then investigate possible relationships among these factors and possible relationships between these factors and the dependent variable.

A quasi-experimental design was also utilized for this research. Trochim (2006b) explains that this design, also known as the "Non-Equivalent Groups Design (NEGD)", is probably the design used most frequently in social research. This design was chosen, as randomness was not possible in the practical arrangement of the courses at the university. The researcher could therefore not control for all confounding variables and so could not completely rule out some alternative

explanations for the results obtained (Leedy & Ormrod, 2004:227). Without random assignment, the researcher had no guarantees that, prior to the intervention, the groups were similar in every respect except for the following: year of study, approximate age and level of education. The non-randomness is a threat to internal validity since any prior differences may affect the results of the outcome of the study, resulting in a selection- maturation difference (that could create a pseudo- effect of a programme where none exists). A phenomenon named selection-regression also threatens the internal validity in this kind of study since a programme group may regress towards the mean, especially if they were below the population mean to begin with. Although this is therefore not an ideal design for research, precautions were taken in the data handling, analysis and interpretations to minimize the threats to validity posed by this design.

1.6.2 Population and sample

The population and the sample were the same. All first year pre-service teachers enrolled for a B.Ed-degree at the North-West University in 2004, 2005 and in 2006, preparing to teach in the Intermediate and Senior phase of the GET and FET education band, took part in the study (N= 207). The same lecturer, who is also the researcher, taught all these participants- so it was a convenient arrangement.

Based on the language of instruction, the population was divided into two groups, namely an Afrikaans and an English group. On average, there were between 35 and 70 participants per group. The study was conducted over a three-year period. The B.Ed groups received 1 ¼ hours instruction per week over a period of 6 months. The exposure of the groups to the two different programmes, namely the basic and enriched technology programmes, is given in table 1.1. Unequal numbers (1, 3 and 5) indicated the Afrikaans-medium-of-instruction (AMI) groups. English-medium-of-instruction (EMI) groups were similarly indicated with equal numbers (2, 4 and 6).

Table 1.1: Groups used in quasi-experimental study

Course	Year	Basic Technology Education Programme	Group	Enriched Technology Education Programme	Group
B.Ed I	2004	Afrikaans-Medium-of-Instruction (AMI)	1	English-Medium-of-Instruction (EMI)	2

	2005	AMI	3	EMI	4
	2006	EMI	6	AMI	5

1.6.3 Variables

The variables given below were considered during the study:

1.6.3.1 Independent (exogenous, upstream) variables

Measured variables or indicators may reflect latent variables or form (cause) emergent variables (both unobserved) (Chin, 2000:36). The following represents a list of measured independent variables. Most of them are reflective rather than formative (*cf.* 4.7.3.1) and could be measured with little error.

- Personal variables: Age, position in family, gender, academic achievement
- Contextual variables: Family factors such as family trauma, family status and number of children in family.
- Domain variables: Culture.

Exogenous latent variables are not influenced by any other variables and are indicated by the symbol ξ (Ksi) (Gefen, Straub & Bourdreau, 2000:22). Covariance may, however, exist among the exogenous latent variables.

1.6.3.2 Intermediate (endogenous, downstream) variables

Intermediate variables are endogenous variables dependent on the exogenous variables or other endogenous variables and affect dependent variables. Endogenous latent variables are influenced by any other variables and are indicated by the symbol η (Eta) (Gefen, Straub & Bourdreau, 2000:22).

- Contextual variables: parental education, socio-economic factors, school model attended, people chosen as role models
- The perceptions of students about their culture, family, school and the university as factors that promote or inhibit the development of creativity
- Personal views such as that about ideal education, locus of control, the nature of technology and problem-solving also fall in this group.

- People chosen as role models are assumed to depend on contextual and personal factors.

1.6.3.3 Experimental variables

- Exposure versus non-exposure to an enriched learning environment
- Exposure to different types of enrichment in the learning environment

1.6.3.4 The dependent (endogenous, downstream) variables

These variables are influenced directly or indirectly by exogenous variables and also by the other endogenous variables.

- Creative indexes, level of creativity and creative abilities such as fluency, originality, flexibility and elaboration
- Field variables: academic achievement (possibly co-varying with the levels of creativity)
- Perceptions of ideal education

1.6.4 Data collection instruments

Tests: The ATTA (Abbreviated Torrance Test for Adults)(Goff & Torrance, 2002), used world-wide as a valid and reliable unbiased instrument, was utilized as a pre- and post-test to determine the creativity indexes and creative abilities of the participants involved in the research.

Self-constructed questionnaires: Based on information in the literature study, as well as information gathered from explorative preliminary discussions with participants, informal questionnaires and observations of other pre-service teachers taught by the researcher, two formal questionnaires were developed (*cf.* 4.6.2). Both questionnaires aimed to gather biographical data about the participants, such as personal (such as age, gender) and contextual data (such as parental education, socio-economic status of family, trauma in family, status of family, school model attended). The second questionnaire aimed at gathering data about whether participants perceived their different life spheres (contexts) as stimulating creativity or not. The participants involved in the research completed the questionnaires as shown in table 1.2.

Table 1.2: Questionnaires administered to different groups

Questionnaire	2004 Gr 1 & 2	2005 Gr 3 & 4	2006 Gr 5 & 6
1. Biographical data, role models, socio-economic status, family trauma and values	X		
2. Biographical data, role models, socio-economic status, family trauma, perceptions about culture, family, school, university- enhancing or inhibiting creativity, perceptions of ideal outcomes for education		X	X

The data regarding values that were gathered with questionnaire one, were exploratory. This data were used to compile questionnaire two, but were not used in other ways in this study.

A teaching and learning programme for Technology Education: The basic course material for Technology Education was enriched with activities that could support creativity by representing creative behaviour as acceptable and desirable. The focus was therefore on disinhibition of some cultural imprints that could inhibit creative behaviour. Participants in the experimental groups received training by means of the adapted enriched material, whereas the control group made use of the basic material with no added focus on enriching the instruction to support creative behaviour. In both the basic and the enriched material, however, emphasis was placed on creative process skills (as is inherent in the intentions of Technology Education). All the participants therefore covered the same content, and process skills, and wrote the same examination papers so that no student was at a disadvantage.

1.6.5 Statistical techniques

The Statistical Consultancy Services of the North-West University, Vaal Triangle Campus was approached for the analysis and interpretation of the data collected. A combination of SEM programmes (Visual-PLS) and descriptive and inferential statistics were used to process the data by computer. Path analysis was used to determine the relative effects of different exogenous contextual factors and endogenous perception factors on the levels of creativity. Frequencies and means

were calculated for the various test results of the experimental and control groups, and t-tests were utilized to determine whether differences that might have existed between the groups before and after the research programme were of significance.

1.6.6 Ethical aspects

Participants were asked for written permission before filling in any questionnaires or tests. It was made clear to them that they were under no obligation to take part in the research and that the data would be handled confidentially. The data were further handled with care and were not made available to anybody that was not directly involved in the study. The statisticians received only a data matrix without any names that could lead to identification of the participants without having access to the original lists.

1.6.7 Data collection procedure

All participants involved in this research were asked to complete an ATTA test to determine their creativity indexes and creative abilities. These results were compared to the results of the self-constructed questionnaire. After six months of exposure to the basic programme or different enriched programmes, the ATTA test was repeated to detect possible changes in the creativity indexes. The results for the various test sessions for both the experimental groups and control group were analysed and compared. T-tests were administered to determine the significance of any differences.

1.7 CONCEPTS CENTRAL TO THIS STUDY

Certain concepts are central to this study. These concepts will be explained in more detail in later chapters, but a brief explanation will be given here:

Creativity: the ability to provide a new and unexpected yet practical solution to a problem.

ATTA (Abbreviated Torrance Test for Adults): a pen and paper test designed to test for creativity. The ATTA was compiled by Goff and Torrance (2002) and is based on previous tests, dating back to as far as 1974 (*cf.* 4.6.1).

Creative abilities: according to the ATTA, based on Guilford's dimensional structure of the intellect, creative process skills, such as fluency, originality, elaboration and flexibility are known as creative abilities. In this study they are also discussed as

creative process skills (*cf.* 2.2.2.1.2).

Creativity Index (CI): the sum of all the measurements obtained using the ATTA . This includes the creative abilities as well as creativity indicators (verbal and figural).

Adjusted pre-test creativity index: since a non-equivalent group design (NEGD) was used in this study (*cf.* 4.6.1), a pre-test adjustment was made to remove bias and the possibility of a pseudo effect (Trochim, 2006b). These adjusted pre-test scores were used in all analyses. The post-test scores were not adjusted. The adjustment does not affect the mean of the scores, but it affects the data distribution by pushing the low scores slightly up and the high scores slightly down.

Creativity level: Creativity level is sometimes used informally to describe the fact that some people are more creative (on higher creative level) while others are less creative (on a lower creativity level)(*cf.* 2.1.3). According to the design of the ATTA the creativity indexes are converted to creativity levels on a scale from one to seven. A creativity index of between zero and fifty gives one a creativity level of one, fifty-one to fifty nine equals a level two, and so forth. With a CI-score of above eighty-four, the highest level in the ATTA, namely level seven, is reached (*cf.* table 4.5).

1.8 CHAPTER DIVISION

Chapter 1: Orientation and statement of the problem

Chapter 2: Creativity

2.1 Concept clarification

2.2 The creative person

2.3 The creative process

2.4 The creative context

2.5 The creative product

Chapter 3: Theories about learning and the stimulation of creativity

Chapter 4: Empirical research design

Chapter 5: Technology Education programmes aimed at enhancing creativity

Chapter 6: Data analysis and interpretation

Chapter 7: Findings, conclusions and recommendation

1.9 CONCLUSION

Table 1.3 provides an overview of the study.

1.10 SUMMARY

This chapter focused on the problem investigated in this study, the aims and hypotheses of the study, the methods used in the research and the empirical study.

The next chapter will give an overview of literature on creativity. It will look at the concept of creativity, the creative person, the creative process, context and products.

Table 1.3: Overview of the study

	PRE	POST	Control Basic Programme	Experiment Enriched Programme	Curriculum
2004	ATTA QUESTIONNAIRE 1 Biographical and value, attitude	ATTA	Group1 Afrikaans- Medium- of - Instruction (AMI) 1 st year technology Basic curriculum: Sequential exposure to content. Exposure to technological process with emphasis on creative problem- solving	Group2 English-Medium-of- Instruction (EMI) 1 st year technology	Basic curriculum: Sequential exposure to content. Exposure to technological process with emphasis on creative problem- solving. Creative role models, Brain storming. Two individual projects –One integrating group project. Situation with wide range of possible solutions given- own brief must be written
2005	ATTA QUESTIONNAIRE 2 Biographical data, role models, socio economic status, family trauma, perceptions about culture, family, school, university- enhancing or inhibiting creativity	ATTA	Group 3 Afrikaans-Medium- of - Instruction (AMI) 1 st year technology	Group 4 English-Medium-of- Instruction (EMI) 1 st year technology	
2006	ATTA QUESTIONNAIRE 2 Biographical data, role models, socio economic status, family trauma, perceptions about culture, family, school, university- enhancing or inhibiting creativity	ATTA	Group 6 English-Medium-of-Instruction (EMI) 1 st year technology	Group 5 Afrikaans-Medium- of - Instruction (AMI) 1 st year technology	Enriched curriculum: Basic curriculum plus exposure to creative role -models

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about learning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER TWO

CREATIVITY

2.1 CONCEPT CLARIFICATION

2.1.1 Introduction

Creative thinking is about generating or creating ideas or objects. One may think of creativity in an elitist way and only consider geniuses as creative or in a democratic way when one acknowledges that creativity is an ability that all humans possess.

Creativity may be seen as a phenomenon occurring in human societies leading to change, renewal and adaptation. Different components such as an individual, his/her environment, a process that the individual follows when creating, as well as the product that is produced, are involved in creativity. The product is instrumental in changing the natural and societal environments so that the individual and society are constantly subjected to new challenges (Csikszentmihalyi (1988:325-339); Simonton (1988:412); Vygotsky (1997: 207-209); Mansfield & Busse (in Feist, 1999:288) and Shi (2004)).

Creativity may also be seen as a characteristic of an individual that may or may not lead to innovation or invention. To lead to creative achievement, the individual needs a confluence of factors such as imagination, knowledge, motivation, intelligence, personality, thinking styles and certain environmental conditions (Sternberg & Lubart, 2004).

2.1.2 Creativity and related concepts

Paul Torrance sees creativity as a uniquely human characteristic when he says: *"Creativity is a distinguishing characteristic of human excellence in every area of behaviour."* (in Isaksen, Dorval and Treffinger, 2000:2)

Gryskiewicz (in Isaksen *et al.*, 2000:2) defines creativity as *"novel associations that are useful"* and Welsch (1980) as quoted by Isaksen *et al.*, (2000: 2) describes creativity as *"the process of generating unique products by transformation of existing products. These products must be unique only to the creator and must meet the criteria of purpose and value established by the creator"*.

Noller, (in Isaksen *et al.*, 2000:2), uses an equation to describe creativity as the function of Knowledge, Imagination and Evaluation reflecting an interpersonal attitude toward the beneficial and positive use of creativity and the factors impacting on it:

$$C = fa (K.I.E)$$

where K= knowledge, I = Imagination and E = Evaluation.

Noller goes on to explain that children often have abundant imagination, but lack knowledge and evaluation skills. Practising professionals, in contrast, often have lots of knowledge and evaluation skills, but lack imagination.

Creativity occurs within a certain context or domain of knowledge and involves a dynamic balance between Imagination and Evaluation. Csikszentmihalyi (1996:28) defines creativity as: *"any act, idea or product that changes an existing domain or that transforms a domain into a new one"*.

Creativity is linked to abilities such as imagination, innovation, invention, originality and inspiration. The following explanations were compiled from information from online and printed dictionaries:

- **Imagination** is a complex cognitive process. During this process, aspects of memories are combined and a mental image is constructed. The ability to imagine enables humans to understand one another by forming images of what others communicate to them. It also enables humans to imagine unseen worlds, possible future realities and non-existent situations and objects. Rationalists and empiricists see imagination as "necessary for perception" and as "a response to experiences". Imagination is generally regarded as one of the "higher mental functions," and it is thought to be absent in animals.
- The online dictionary describes **originality** as the quality of being novel and the ability to think and act independently, unexpectedly, fresh, unusual and new.
- **Invention** is the ability to make a discovery or a finding, the act or process of inventing a new device, method or process developed from study and experimentation. It may also be a mental fabrication, especially a falsehood.
- **Innovation** is seen as ingenuity or applied ideas, the act of starting something for the first time or introducing something new. Synonyms are initiation, founding,

foundation, institution, origination and creation.

- **Inspiration** is characterized by mental exhilaration that is linked to the brain's reward system and the release of neuro-transmitters such as dopamine. Inspiration is defined as "*Stimulation of the mind or emotions to a high level of feeling or activity*". Creativity is often the product of inspiration. Synonyms are animation, elatedness, elation, euphoria, exaltation, exhilaration, lift, uplift. Inspiration is linked to liveliness and vivacity of imagination: brilliance, brilliancy, fire, genius, something that encourages: motivation, stimulation or something, such as a sudden exciting creative act or idea, that is inspired. It is also described as a brainstorm or *informal* brain wave. Often it is seen as "*Divine guidance or influence exerted directly on the mind and soul of humankind.*"

From the abovementioned discussion, one can gather that creativity may be seen as:

- A potential that can be realized in processes such as invention and innovation when knowledge and skills are used in imaginative ways to create a new, unique, original, unexpected and simultaneously also appropriate and useful product, system or association
- A unique human characteristic that relates to a person and the context in which he/she finds him/herself
- Reflecting an attitude in an individual as well as the context
- Occurring within a domain or establishing new domains
- Linked to the brain's reward system so that it may make the creator self-driven

2.1.3 Different levels of creativity

Boden (1995) distinguishes different levels of creativity in a hierarchical order from low to high:

- 1 Novel combinations of old ideas or products that combine elements of the conceptual space.
- 2 Novel ideas: "first-time" newness: an idea which can be described and/or produced by the same (specified) set of generative rules as other familiar ideas resulting from exploring the conceptual space - to "*explore a space and locate*

within it a substantial sub-space”.

- 3 Radical originality: an idea that cannot be described and/or produced by the same (specified) set of generative rules as other, familiar ideas. This means transforming a conceptual space. Dropping a constraint negates a constraint.

Exploring a conceptual space is one thing, but transforming it is another. *“In general, novel ideas gained by exploring an unknown niche in a pre-existing conceptual space are regarded as less creative than ideas formed by transforming that space in radical ways.”* (Boden, 1995)

Guilford (1958), Csikszentmihalyi (1996) and Runco (2003) explain the concept of different levels of creativity and express the idea that everyone is and needs to be creative. Csikszentmihalyi distinguishes between personal creativity as *“creativity with a small c”* and *“Creativity with a big C”*. The former is seen in people who experience life in novel and original ways, with fresh perceptions and making important discoveries of which only they know. The latter is seen as individuals with public achievements and changing culture in important ways (Csikszentmihalyi, 1996:25-26).

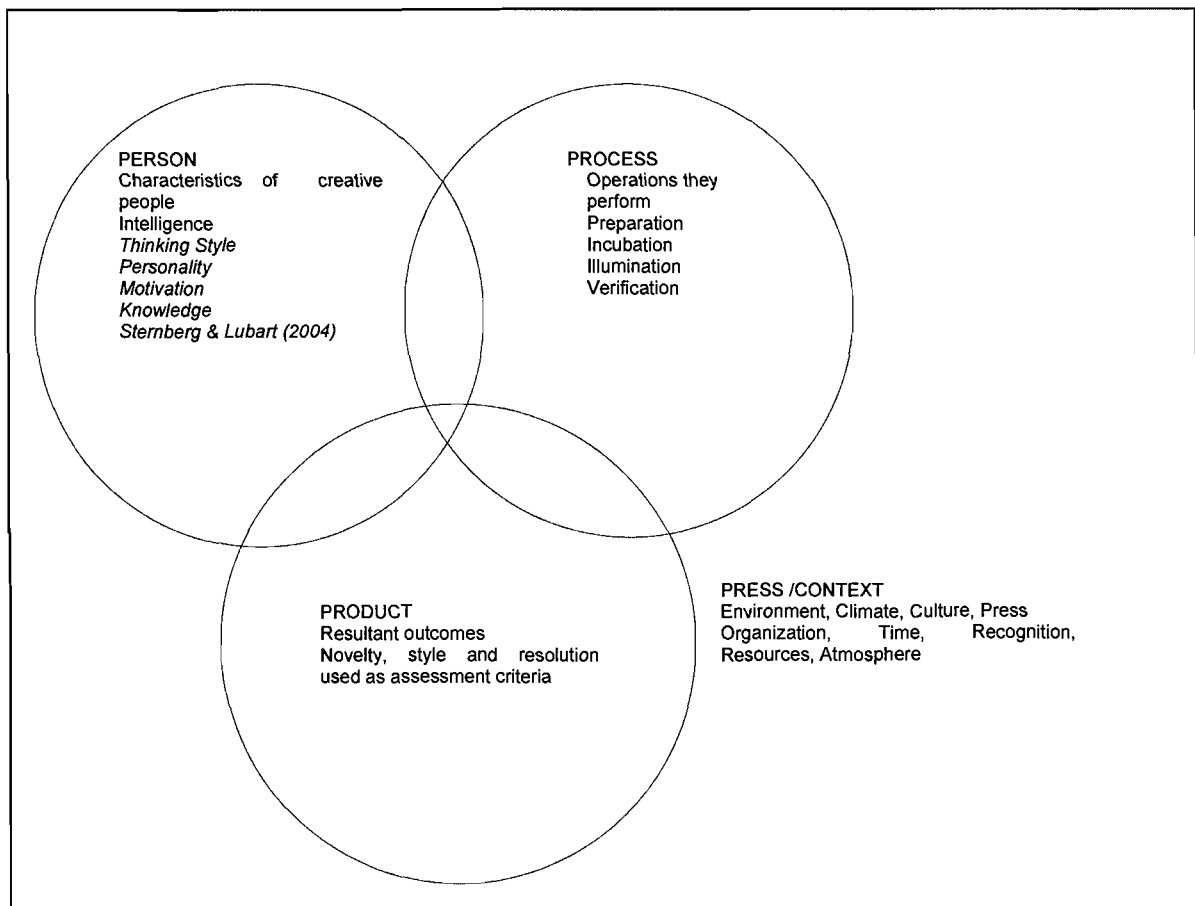
2.1.4 Enhancing creativity

Creativity does to culture what mutation does to the gene pool: it brings variations that may or may not be selected. Creativity can therefore be seen as the source of cultural variation (Gabora, 2000:6-9). Without this variation, adaptation to changing environmental circumstances, as seen in humans, would have been impossible. Creativity enables the human species to adapt to a wide variety of environments and constraints. Why the enhancement of creativity may be desirable, as well as how creativity may be enhanced, are discussed further in section 2.4.4 and chapter 5.

2.1.5 The components involved in creativity

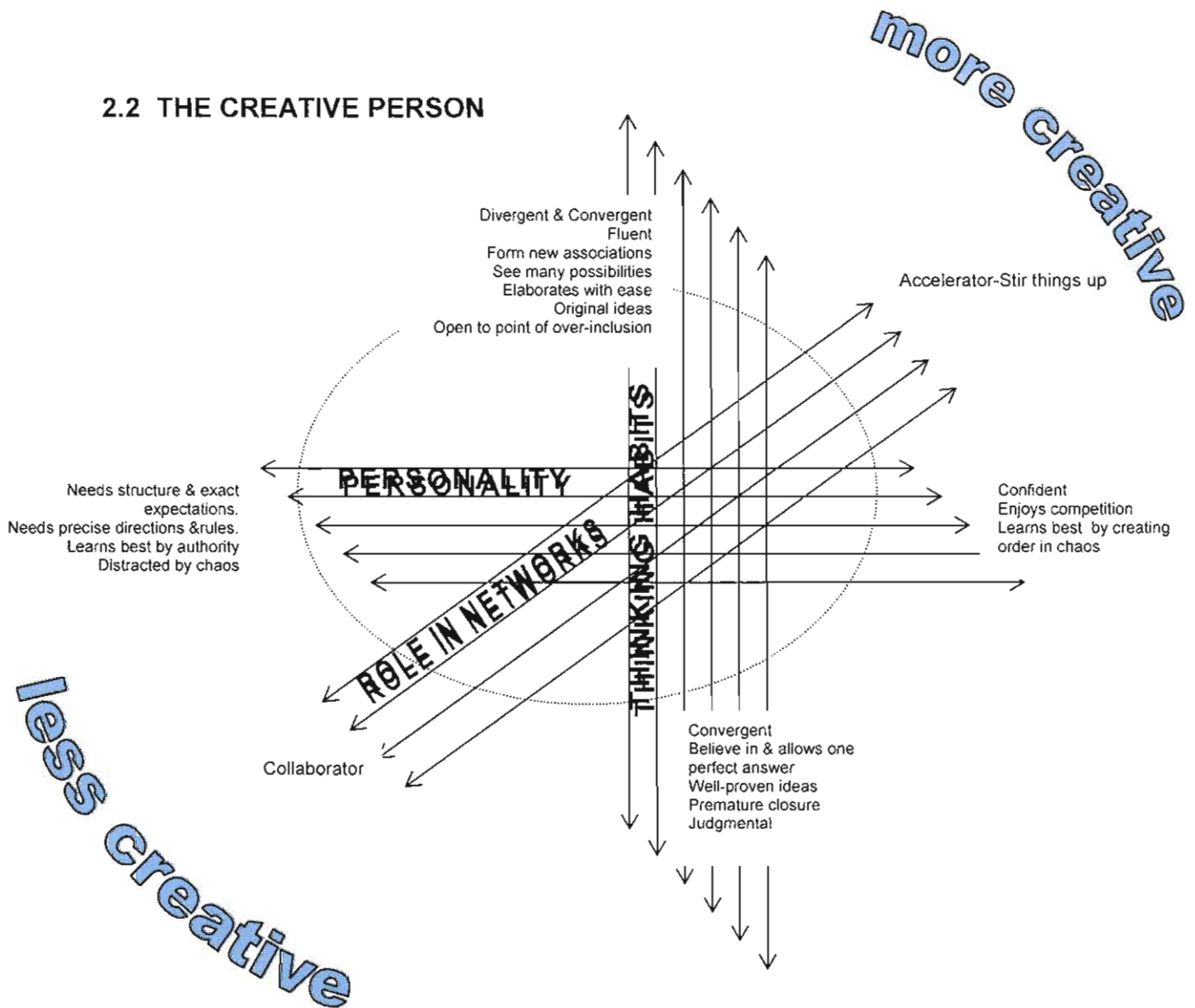
Isaksen and Rhodes (in Isaksen *et al.*, 2000) developed the Venn diagram in figure 2.1 to explain the components involved in creativity.

Figure 2.1: The Components of Creativity (Rhodes in Isaksen *et al.*, 2001)



In this research these components are used to organize the literature study: Section 2.2 deals with the creative person, Section 2.3 with the creative process, Section 2.4 with the creative context and Section 2.5 with the creative product. Chapter 3 deals with knowledge acquisition and retention by addressing "Theories about learning and the stimulation of creativity". Application of the knowledge gained from the literature study in enhancing creativity is discussed in Chapter 5, using the same basic organizing concepts, namely person, process, context and product.

2.2 THE CREATIVE PERSON



2.2.1 Introduction

Runco (2003) explains that everyone has creative potential. It is however obvious that people are creative on different levels and in different ways. Michalko (1998:2) describes the difference between creative people and less creative people in terms of how they are thinking: more creative people think productively (a term introduced by Wertheimer, 1945) and less-creative people reproductively (what they have learnt). More creative people are able to look at a problem from different perspectives. They may therefore have a mechanism to resist the formation of "hard boundaries" leading to placing certain information in one category only. Guilford (in Amabile, 1996:99) is of opinion that *"creative abilities determine whether the individual has the power to exhibit creative behaviour to a noteworthy degree"*.

Whether or not the individual who has the requisite abilities will actually produce

results of a creative nature will depend upon his motivational and temperamental traits. Sternberg and Lubart (1999:11) therefore conclude that an adequate confluence of the following six resources in an individual is needed to be creative: intelligence, knowledge, thinking styles, personality, motivation and environment. In this chapter, creativity's relationships with intelligence, personality type, thinking and learning styles, the predominant use of certain parts of the brain and motivation will be discussed. The chapter will be concluded with descriptions of different kinds and styles of creativity and personal factors that can inhibit creativity will be pointed out.

2.2.2 Creativity and cognitive factors

The most conventional view of the relationship between intelligence and creativity is that they overlap in some respects but not in others. Looking at the different proposed models of intelligence might give one a clearer picture of this relationship.

2.2.2.1 Intelligence

2.2.2.1.1 Two-factor intelligence

Spearman sees intelligence as consisting of two factors: a general mental ability and a specific one. The concept of a general mental ability refers to the existence of systematic individual differences in the performance of tasks that involve the manipulation, retrieval, evaluation or processing of information (the type of ability that all intelligence tests test for). The **general ability scores** of an individual usually correlate positively on any two cognitively demanding tasks. **Specific mental abilities** are performance in a specific type of task (the type of ability that differs from intelligence test to intelligence test). Vernon (in Murphy & Davidshofer, 1994: 205 - 206) also uses the terminology general and specific intelligence in his hierarchical model of intelligence.

Horn and Cattell's Gf-Gc theory (in Mwamwenda, 1995: 275; Cattell & Horn, 1978; Murphy & Davidshofer, 1994:207-208) is based on Spearman's theory and distinguishes two components of intelligence namely **fluid (Gf)** and **crystallized (Gc)**. Fluid intelligence refers to innate intelligence comprising of a person's ability to reason, discriminate and engage in abstract thinking, independent of education and acculturation. Crystallized intelligence refers to acquired knowledge and experience, accumulated during a lifetime and increasing as the person's vocabulary and experience increases. It therefore stems from learning and acculturation.

If creativity is considered as totally dependent on intelligence that fits into the general mental ability or fluid intelligence categories of these two models, it could be seen as something that is genetically determined and that cannot really be developed. If it relates directly or partly to the specific or crystallized categories, it can change and programmes for its development should bear fruit. Rossman and Horn (1972: 283) conclude that intelligence and creativity are two independent constructs and are outgrowths of two distinct but overlapping sets of influences.

2.2.2.1.2 Dimensional intelligence

Guilford (1968:618) proposes three dimensions of intelligence in his Structure of the Intellect (SI) model, namely:

Five Cognitive Operations: cognition, memory, divergent and convergent production and evaluation.

Four Contents: figural, symbolic, semantic and behavioural.

Six Products: units, classes, relations, systems, transformations and implications.

For creativity, the most relevant of the five cognitive operations in this three-dimensional model is that of divergent production which can be within any of the content areas and results in any of the products.

Guilford (1958:5-18) maintains that creativity (divergent-productive ability) should be studied and encouraged in all people (not only in geniuses). Guilford (1958:14 & 1966:186-188) identifies a number of factors that are relevant in creativity. He states that these factors are meaningful and that factor analysis demonstrated their uniqueness. The factors are:

1. Fluency (number of ideas)
 - 1.1 Ideational fluency
 - 1.2 Expressional fluency
 - 1.3 Associational fluency
2. Flexibility (shifts in approaches, fluidity of information, lack of rigidity)
 - 2.1 Spontaneous flexibility (to be flexible even without need)
 - 2.2 Adaptive flexibility (to be flexible when necessary)

3. Elaboration (adding a variety of details to information that has already been produced)
4. Originality (unusualness)

Torrance (1974) based the Torrance Tests of Creative Thinking on Guilford's ideas. The Torrance tests consist of several simple verbal and figural tasks that involve divergent thinking plus other problem-solving skills. The tests can be scored for **fluency** (the number of relevant responses), **flexibility** (number of different categories of relevant responses), **originality** (statistical rarity of the responses) and **elaboration** (amount of detail in responses). In the context of this study the researcher will focus on factors identified by Guilford and Torrance to determine the creativity indexes and abilities (*cf.* 4.6.1) of the participants involved in the research.

2.2.2.1.3 Multiple intelligences

Thurstone (1946:106-109) and Thurstone (in Murphy & Davidshofer, 1994:206) identify seven primary mental abilities given as verbal comprehension, word factors, number, space, associative memory, perceptual speed (detecting differences and similarities between objects) and reasoning (finding a solution to a logical problem).

Gardner (in Gardner & Hatch, 1989:6) theorizes that there are multiple intelligences, and that we all use one or two for the most effective learning. He explains that although they are not necessarily dependent on one another, these intelligences seldom operate in isolation. Every normal individual possesses varying degrees of each of these intelligences, but the ways in which intelligences combine and blend are as varied as the faces and the personalities of individuals. Table 2.1 gives a summary of Gardner and Thurstone's theories.

Table 2.1: The theories of Gardner and Thurstone regarding intelligence

Intelligence	Strength	Pathway for optimum learning	Thurstone's mental abilities that correspond
1. Linguistic	Writing poems/ stories	Words	Verbal comprehension (V)
			Word factors (W)
2. Logical-Mathematical	Solving a logical/ mathematical problem	Numbers	Number (N)
			Reasoning
3. Spatial	Getting lay of land in new city	Pictures	Space (S)
4. Body-kinesthetic	Athletics/ dancing	Physical experience	
5. Musical	Composing sonata	Music	

6. Intra-personal	High level of understanding of self	Self-reflection	
7. Inter-personal	Finding effective ways to understand others and the relationships between people	Social experience	
8. Naturalist	Seeing complex patterns in the natural environment	Experience in the natural world	

Creativity, (novelty, originality and appropriateness) can be exhibited when an individual makes contributions in one or more of these areas or through one or more of these modes.

2.2.2.1.4 Triarchic theory of human intelligence

Sternberg's Triarchic theory of human intelligence (1985) tries to bridge the research between cognitive psychologists and measurement specialists. He describes intelligence as consisting of three types of intelligence namely **Componential Intelligence, Experiential Intelligence** and **Contextual Intelligence**. Creative work involves the application of all three of these intelligences.

1. **Componential intelligence** refers to the following aspects related to the internal world:
 - Meta-components: (High-level planning and decision-making processes are used to define problems and select and utilize lower order components to arrive at the solution.)
 - Performance components: Planning has been done, using meta-components. Performance components are used to process the necessary data through e.g. combining different elements.
 - Knowledge acquisition components: Process involved in learning or acquiring new behaviour-selective encoding, selective combination and selective comparison.
 - Retention components: Processes that bring to memory what has previously been experienced.
 - Transfer components: Used to relate newly acquired information to a new situation.

This intelligence has an analytic nature. Its purpose is to develop effective cognitive routines to use when confronted by challenges. This includes the ability to think convergently and requires critical thinking and appraisal in the process of analysing

and evaluating thoughts, ideas, and possible solutions because not all of them are worthy of pursuit. Creative people use critical thinking to make judgments, consider implications and project possible responses, problems and outcomes. In the Creative Problem-solving (CPS) model of the Creative Education Foundation (*cf.* 2.3.4.2), this would be linked to the stage of *getting to know the challenge as well as the convergent phases of every step*.

2. **Experiential intelligence** refers to mediating between the internal and external world.

This intelligence relates to the ability to cope with novelty, as it relates to componential intelligence such as an old problem being seen in a new way or a new problem being solved in an old way. It has to do with **synthesis**. It includes divergent thinking –the generation of new, novel and interesting ideas. It is also the ability to make connections between ideas or groups of things spontaneously – some which may be obvious afterwards but unnoticed up to that moment. In the CPS model of the Creative Education Foundation, this would be linked to the stage of *idea generation as well as the diverging phases of every step*.

3. **Contextual intelligence** refers to the external world:

This intelligence relates to environmental adaptation, selection of alternatives and shaping the environment if adaptation is impossible. The latter gives most scope for creativity. This is **practical** intelligence and is used to anticipate the motives, intentions and behaviour of others (Sax, 1997:375). Contextual intelligence involves the ability to translate abstractions and theories into realistic applications and to find an audience, to recognize and to see the creative work as valuable, different, useful, innovative, unusual or worthy of consideration. In the CPS model of the Creative Education Foundation, this would be linked to the stage of acceptance finding.

Sternberg explains that all these intelligences play a part in creativity (Sternberg, 1988:132-138). Experiential intelligence is most often associated with creativity.

In conclusion, to summarize what has been said about intelligence and creativity: Intelligence is not equal to creativity. Michalko (1998:1-2) points out that intelligence is not enough – an individual can be far more creative than he/she is intelligent, or far more intelligent than creative. A high degree of fluency without a reasonable degree of intelligence, however, seems to put one at risk of psychotic behaviour (Peterson, Carson & Higgins, 2003).

Creativity can be seen as a process or behaviour that draws on a variety of mental abilities described as intelligences (Hamacheck, 1998:147) such as:

1. **Abstract thinking abilities:** (Thurstone's inductive reasoning, Guilford's cognition, Gardner's logical/ mathematical reasoning, Sternberg's componential intelligence and Thorndike's abstract thinking.)
2. **Seeing new possibilities where none existed:** (Guilford's divergent thinking abilities, Thurstone's inductive reasoning, Thorndike's abstract thinking ability and Sternberg's experiential intelligence.
3. **Intelligent behaviour:** (Spearman's specific intelligence, Thorndike's concrete thinking, Thurstone's space, memory and number intelligence, Gardner's spatial and Kinesthetic intelligence, Guilford's convergent thinking ability and Sternberg's contextual intelligence.)
4. **Social abilities:** (Thorndike's social thinking, Gardner's interpersonal intelligence and Sternberg's contextual intelligence.)

2.2.2.2 Creativity and learning styles and cognitive styles

Learning styles or cognitive styles are orientations for approaching learning tasks (input) and ways in which information is processed (processing). The basic assumption is that learners learn differently and at different paces. From this, one can assume that a learner learns better and performs better when the environmental input (from teacher, peers and support material) corresponds with the learner's own input, processing and personality (processor) styles. Paying attention to learning styles is popularized as one of the advantages of Outcomes-based Education (OBE). It is proposed that OBE is learner-centred (Botha, 2002) and allows teachers to make provision for the different learning styles of their learners (Killen, 2000:7; Killen, 2006:74-75, 105).

Is there a link between learning styles and creativity? Different authors propose different models. Some of these models, classified as based on input, processing and on the processor as well as integrated models, will be discussed below.

2.2.2.2.1 Learning styles concentrating on input

These styles refer to the human sense organs and the primary way humans take in information, such as the smell, visual, auditory, kinesthetic and tactile senses. Per

implication, it also refers to parts of the brain that are primarily involved in the processing of the impulses as they enter the brain. The most well-known of these input styles is the VAK (visual, auditory and kinesthetic) styles:

- **Visual:** prefer sight-based: writing, drawing, neatness, demonstrations
- **Auditory:** prefer voice-based learning: talking, reading aloud, singing, listening
- **Kinesthetic:** prefer movement-based activities: gestures and touching, sports and drama.

2.2.2.2.2 Learning styles concentrating on processing modes

Processing modes describe the way the brain processes information, the ways humans think, solve problems, and remember information. The models proposed by Hagberg and Leider (1988) and Felder and Silverman (1988) fit into this category.

Hagberg and Leider (1988) identify four learning styles according to the **actions** that provide the optimum learning opportunity for individuals, namely:

- **Feeling:** These people use body movement and speech to learn and communicate, prefer to learn through real experiences and use their emotions or feelings to guide them in deciding how to proceed in a given situation.
- **Observing:** People who learn through watching, use visuals and analogies to think through ideas and prefer to observe and use their imagination to digest new material or ideas, seeing them in new ways or drawing mind pictures. They might find it difficult to verbalize their ideas. They react to the ideas of others.
- **Thinking:** Analysers by nature, these people primarily scrutinize or analyse information, pulling it apart and putting it back together logically. They design models and symbols, taking as much information into account as possible.
- **Acting:** Some people learn through action because they process information primarily by doing. Action helps them solve a problem. They use words and acts to promote a project or a solution. They like to learn during the process. They make things happen.

Felder and Silverman (1988) classify learners as follows:

- **Sensing learners** (concrete, practical, oriented towards facts and procedures) or

intuitive learners (conceptual, innovative, oriented towards theories and meanings);

- **Visual learners** (prefer visual representations of presented material-pictures, diagrams, flow charts) or **verbal learners** (prefer written and spoken explanations);
- **Inductive learners** (prefer presentations that proceed from the specific to the general) or **deductive learners** (prefer presentations that go from the general to the specific);
- **Active learners** (learn by trying things out, working with others) or **reflective learners** (learn by thinking things through, working alone);
- **Sequential learners** (linear, orderly, learn in small incremental steps) or **global learners** (holistic, systems thinkers, learn in large leaps).

Based on creativity theories like that of Dietrich (2004) and Sternberg and Lubart (1999:10-11), one may suggest that a combination of processing modes mentioned in the models of Hagman and Felder might be needed for a person to be truly creative. Certain of the processing styles in Felder and Silverman's model may tend to make it easier for a person with that style to be creative, such as an intuitive, visual/ verbal, deductive, active/reflective or global learner. Other combinations of learning styles may not be excluded.

2.2.2.2.3 Styles concentrating on the processor

Processor style models concentrate on the processor: the person involved and how he/she interacts with his/her surroundings. People tend to have certain typical preferences, consistent behaviour and distinct ways of perceiving, organizing and retaining information. This may also be seen as linked to a certain personality type that may be the result of both environmental and hereditary factors. The theories of Rosenberg, Myers-Brigg Type Indicator (MBTI) and Armstrong will be discussed.

Rosenberg's model of learning styles (in Hamacheck, 1998:260-262) is based on certain types of processors and makes specific provision for a creative style:

- **Rigid-Inhibited:** Needs precise directions and rules. Learns best by authority.
- **Acceptance-Anxious:** Worried about pleasing others. Needs warm accepting

educators who emphasize self-evaluation and reassure learners that it is acceptable to make mistakes.

- **Undisciplined:** Needs structure and exact expectations. Learns best by authority.
- **Creative:** Confident, divergent, enjoys competition, learns best by exploring.

The Myers-Briggs Type Indicator (MBTI) (2004)

This model classifies humans according to their preferences on scales derived from psychologist Carl Jung's theory of psychological types (The Myers-Briggs Foundation). Learners may be:

- **Extraverts** (try things out, focus on the outer world of people) or *Introverts* (think things through, focus on the inner world of ideas);
- **Sensors** (practical, detail-oriented, focus on facts and procedures) or *Intuitors* (imaginative, concept-oriented, focus on meanings and possibilities);
- **Thinkers** (skeptical, tend to make decisions based on logic and rules) or *Feelers* (appreciative, tend to make decisions based on personal and humanistic considerations); and
- **Judgers** (set and follow agendas, seek closure even with incomplete data) or **Perceivers** (adapt to changing circumstances, resist closure to obtain more data).

Lubart and Getz (1997:296) point out that the intuitive style is most often associated with creativity, since people with this style tend to rely on hunches, feelings and internal sources of knowledge and may be seen as an emotion-centred information processing. They further indicate that research has shown no such differentiation for creative subjects between Thinkers and Feelers.

Armstrong (2000) bases his model of learning styles on Gardner's Intelligences and describes eight learning- styles namely: **Linguistic, Logical-Mathematical, Spatial, Musical, Bodily-Kinesthetic, Intrapersonal, Inter-personal and Naturalist.**

When the characteristics of creative people, as identified by researchers, are compared with the styles above, it seems as if creativity cannot be confined

exclusively to individuals with any specific input and processing learning styles. The research of Boyle, Geiger and Pinto (1991) confirms this statement, showing no significant relationship between **creativity** and **learning style**. Certain styles, however, may tend to favour creativity more than others (such as intuitive, global and deductive learners). One can imagine that a combination of processing styles, for example that of the “intuitive” and “perceivers” of MBTI, might tend to make creative thought easier for people with that tendency and that “sensors” and “judgers” might find it more difficult. Armstrong’s learning styles refer to specific strengths or “input portals”– creative people may learn more easily when the input corresponds with their optimum “input portal”. A person may also be considered as creative within that specific field or when the output generated from the input and processing styles is considered to be new and appropriate.

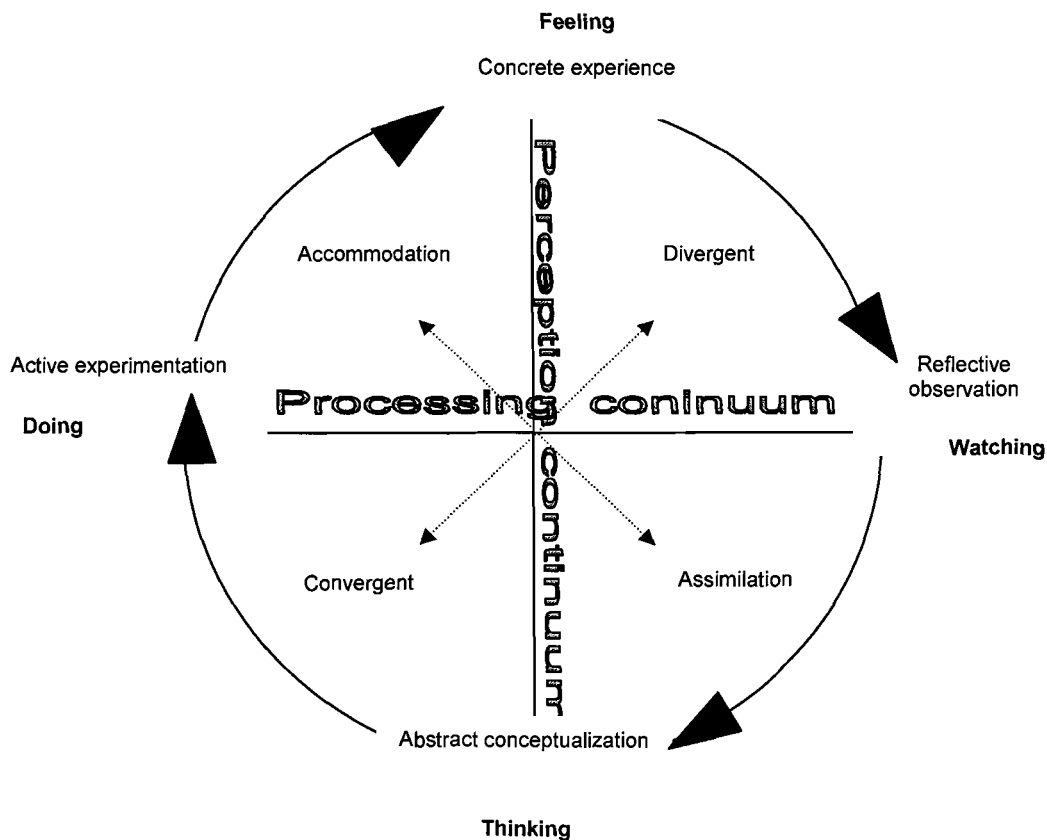
2.2.2.3 Learning styles using an integrated approach

Field-dependent /independent theories (Werner and Witgen in Noppe, 1996:369) and Kolb’s integrated model (1983) use both processing and processor in their style descriptions

2.2.2.3.1 Kolb’s integrated model

Kolb proposes four learning styles arranged in opposing pairs as seen in figure 2.2 and summarized in table 2.2 below:

Figure 2.2: Kolb's learning styles and its association with Lewin's cycle of experiential learning



Accommodator is placed opposite **Assimilator** (corresponding with Piaget's terminology). Assimilation includes fitting particular instances into general categories, and accommodation is about working from the general principle to the particular application. **Divergent** is placed opposite **Convergent**. People with divergent styles view concrete situations from many different points of view, whereas convergent learning styles describe people who are best at finding practical uses for ideas and theories to solve problems and make decisions.

Kolb uses Lewin's cycle of adult learning, the so-called **experiential** learning process. Kolb and Fry (in Smith, 2001:2-3) argue that the learning cycle can begin at any one of the four points and it should really be approached as a continuous spiral. Each of Kolb's styles combines two of the learning steps of Lewin's experiential learning cycle. Lewin discovered that learning is best facilitated when there is a conflict between immediate concrete experience and detached analysis within the

individual. The **perception continuum** represents the grasping experience and the emotional responses of how one feels about or thinks about a task. The **processing continuum** represents the transforming experience and gives the way in which the task is approached (through doing or watching).

Table 2.2: Kolb's integrated model

Learning style			
Processing		Processor	Description of individual
Action	Concrete experience	DIVERGENT	strong in imaginative ability good at generating ideas and seeing things from different perspectives interested in people and broad cultural issues
Reflection	Reflective observation		
Generalization	Abstract conceptualization	ASSIMILATOR	strong ability to create theoretical models excels in inductive reasoning best at understanding wide range of information and putting it in a concise logical form concerned with abstract concepts rather than people
Testing	Active experimentation	CONVERGENT	strong in practical application of ideas can focus on hypo-deductive reasoning on specific problems unemotional has narrow interests
Action (Tennant in Smith,2001).	Concrete experience	ACCOMMODATOR	greatest strength is doing things more of a risk-taker performs well when required to react to immediate circumstances solves problems intuitively

According to Kolb's description of the type of people who learn best using each of his styles, people like artists tend to have divergent learning styles. A person like Edison who found applications for ideas and theories would fit the description of a **converger**. Scientists fit the description of an **assimilator** the best, namely "*Best at understanding a wide range of information and putting it in a concise logical form.*" Teachers are seen as *accommodators* and are described as follows: "*Best at learning from hands-on experience acting out gut feelings- carrying out plans and involvement in challenging experiences.*"

Every one of Kolb's styles therefore describes a type of processing and processor that can be found in creative people. Perhaps the ability to combine the opposing

styles of diverging and converging and/or assimilation and accommodation successfully in resolving conflicts arising within the individual and in his/her interaction with his external world, can be a key to what makes certain people more creative than others. This concept of conciliation of opposites is connected to Obiols's (1996:33-47) observation: *"There must be an interaction between two elemental dimensions of the psychological world: the processes of control and spontaneity, of inhibition and release, and of adherence to a standard and its violation."*

2.2.2.3.2 Field-dependent and field-independent cognitive styles

Field-dependent and field-independent cognitive style-theory stems from research done by Werner and Witgen (in Noppe, 1996). The tendency of an individual to adhere to existing externally imposed frameworks is linked to a field-dependent cognitive style. A field-independent cognitive style according to McGee (in Hansen, 1995) represents the tendency to restructure perceived information into a different framework. Since field-dependent individuals make use of externally developed frameworks, they tend to be more socially oriented, are better at learning material with human content and are influenced by the opinion of others. Field-independent individuals tend to restructure knowledge and develop their own internal frameworks. They learn impersonal abstract materials more easily, tend to exhibit more individualistic behaviours and are not easily influenced by others or affected by the opinion of superiors (Hansen, 1995:20).

The aspects of mobility and fixity are added to these two concepts. Fixity means that a person is restricted to be either field-dependent or -independent. Mobility implies that a person can move between field-dependence and-independence (Noppe, 1996: 370).

The more mobile and more field-independent styles lend themselves better to being more creative.

2.2.2.4 Creativity and thinking processes

According to some researchers, creative people seem to possess certain common thinking processes that enable them to be creative. Some of these processes are discussed below:

2.2.2.4.1 Ability to alternate well between primary process and secondary thought processes

Kris (in Martindale, 1999:138) argues that creative people are better able to alternate between primary process modes found in dreaming, reverie, hypnosis, intoxication and psychosis and secondary thought processes as found in abstract, analytical, logical and reality oriented thought of waking consciousness than uncreative people. Kris maintains that creative inspiration involves a "regression" to a primary process state of consciousness. This would mean that the creative person has conscious and/or unconscious means to retrieve unrelated pieces of information more effectively from where they are stored so that connections can be made between them.

2.2.2.4.2 Low latent inhibition

Latent inhibition is defined as an animal's unconscious capacity to ignore stimuli that experience has shown to be irrelevant to its needs. Peterson, Carson and Higgins (2003) of the University of Toronto and Harvard University used psychological testing to test for latent inhibition. They agree with the idea that openness is a strong characteristic of creative people. They concluded that the *"brains of creative people appear to be more open to incoming stimuli from the surrounding environment, while "normal" people's brains might shut out this same information through this process called "latent inhibition. This means that creative individuals remain in contact with the extra information that is constantly streaming in from the environment. The normal person classifies an object, and then forgets about it, even though that object is much more complex and interesting than he or she thinks. The creative person, by contrast, is always open to new possibilities."* Peterson *et al.* (2003) hypothesize that latent inhibition may be positive when combined with high intelligence and good working memory (the capacity to think about many things at once), but negative otherwise. Because few of the many ideas that come into the mind of a person are going to be worthwhile, the person must be able to discriminate between them or otherwise be swamped with incoming ideas. It seems as if a link exists between madness and creativity and that *"the low levels of latent inhibition and exceptional flexibility in thought, might predispose to mental illness under some conditions and to creative accomplishment under others"*.

Peterson *et al.* (2003) further point out: *"....during the early stages of diseases such as schizophrenia, often accompanied by feelings of deep insight, mystical knowledge*

and religious experience, chemical changes take place in which latent inhibition disappears”.

2.2.2.4.3 Large attentional capacity

A **large working memory** and **nimble prefrontal cortex** are mentioned in literature and correspond with Mendelsohn's opinion (in Martindale, 1999:139) that the creative individual has a **large attentional capacity**- making the chances of combinations to form much larger. Eysenck (cited by Feist, 1999:287) proposes a causal theory of creativity linking genetic and neuro-chemical processes. It begins with genetic determinants, hippocampal formation of the neurotransmitters (dopamine and serotonin), cognitive inhibition and psychoticism, which in turn leads to trait creativity (personality) and ultimate creativity. Cortical arousal is a key component in this model. High arousal narrows attention and low arousal widens the attention. Creativity depends on wide attentional focus and an expansion of cognitive searching to a point of over-inclusion. Martindale (in Feist, 1999: 287) used EEG apparatus to test this model experimentally. It was found to be valid.

2.2.2.4.4 Thinking styles

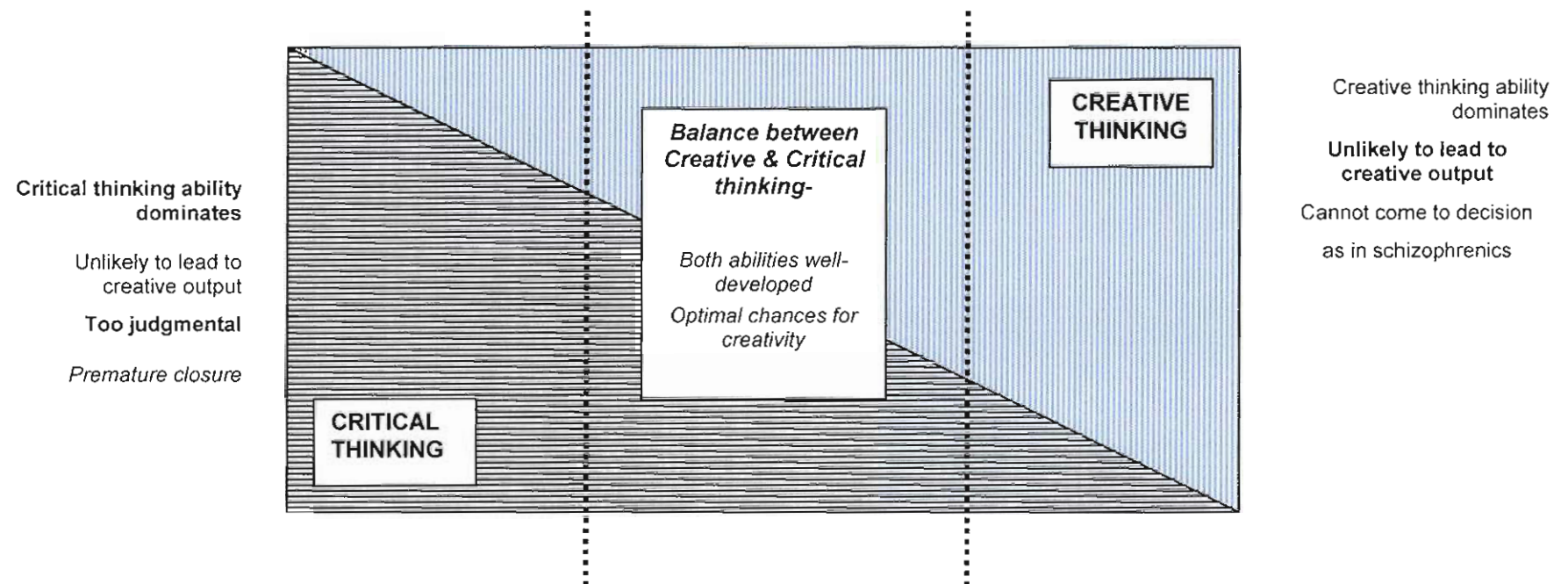
Sternberg (1988:132-146) describes five thinking styles that are most prone to be found in creative people. These learning styles link with the divergent and accommodator styles described by Kolb (*cf.* 2.2.2.3.1). Sternberg describes thinking styles according to:

- I. Functions of self-government: Legislative (rather than executive or judicial). Likes coming up with own ideas, creating own rules and doing things in own way.
- II. Forms of mental self- government: Anarchic (rather than monarchic, hierarchical or oligarchic). Avoids systems for doing tasks.
- III. Orientations of mental self-government: Internal - Likes to work on own.
- IV. Levels of mental self-government: Globalist (rather than localist). Deals with the big picture and general issues.
- V. Ideologies of mental self-government: Liberal (rather than conservative). Likes to do things in own ways.

Creative and critical thinking are often contrasted as will be explained below: Creative thinking (Guilford's divergent thinking) is open and inclusive: daring, uninhibited, fanciful, imaginative, free-spirited, unpredictable, revolutionary, expansive, innovative, inventive, unconstrained, associated with exploration and idea generation. Critical thinking (Guilford's convergent thinking) is about closing and concluding: focused, disciplined, conservative, constrained, logical, down-to-earth, realistic, practical, dependable.

These two modes of thinking are precisely the opposite of one another and can usually not be followed at the same time by the same individual or group. Nickerson (1999:397) and Baker, Rudd and Pomeroy (2001:10) assert that they are independent dimensions and that enhancement of creativity does not mean the diminution of criticalness. Thinking in a given individual could be characterized by both of these styles of thinking to a high degree and they should both be developed for creative output to occur, as is illustrated in figure 2.3.

Figure 2.3: Both divergent and convergent abilities are necessary for creativity



According to Nickerson (1999:397), the person able to produce creative output may be among others, a person who develops the ability to take an uncritical frame of mind temporarily to facilitate idea generation (brainstorming) and alternate to a critical mindset when judgment must be made.

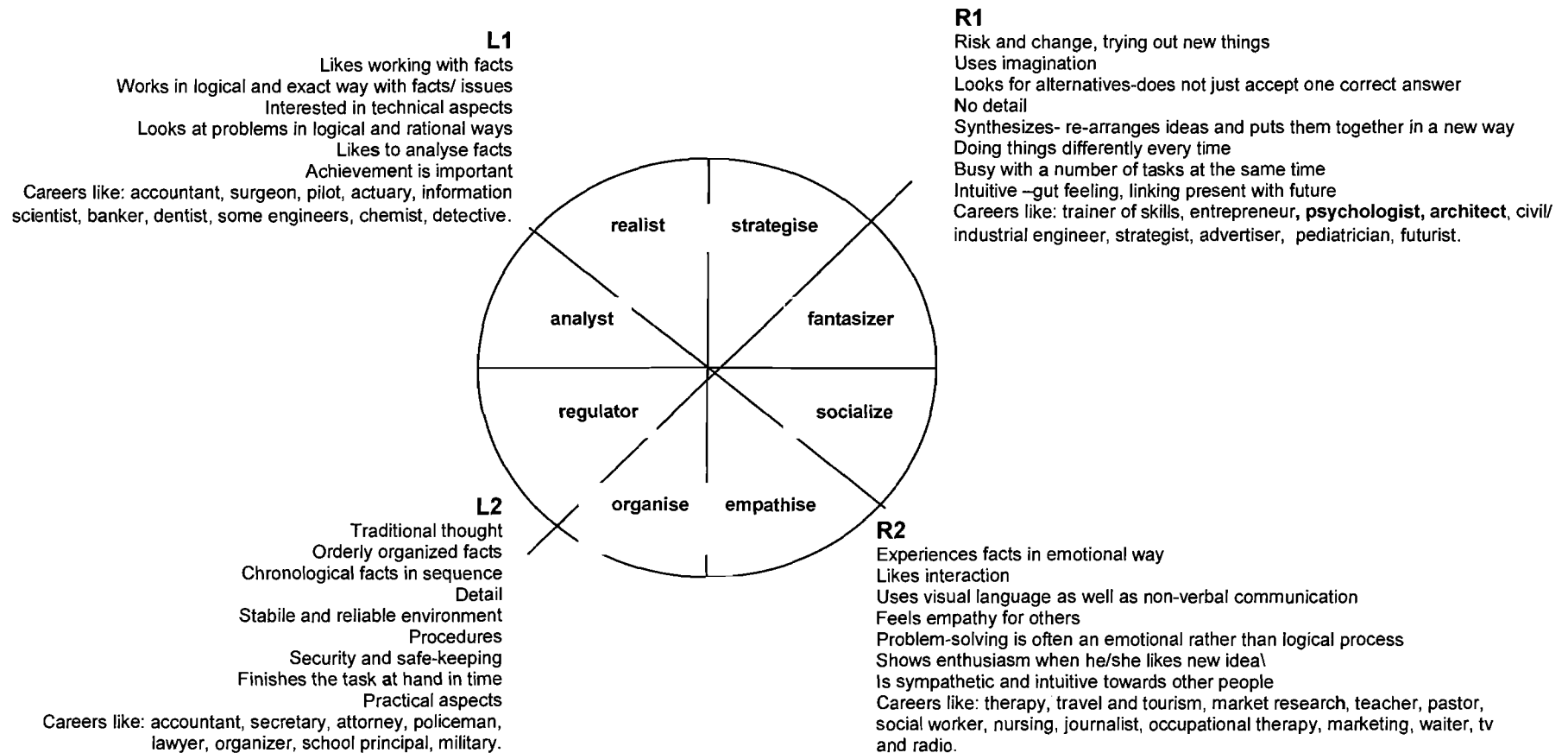
2.2.2.4.5 Creativity linked to predominant use of certain parts of the brain

Galin and Hoppe (in Martindale, 1999:145-146) argue that the right hemisphere of the brain operates in a primary process manner, whereas the left hemisphere operates in a secondary manner. Because of the better access of creative people to their primary processes, they should tend to have higher right hemisphere than left hemisphere activation during periods of creativity. There is also evidence that the right hemisphere is more involved in perception and the production of mental images and can, when stimulated, produce vivid auditory and visual images. Kaltsounis (in Martindale, 1999:146) mentions that there is also evidence that procedures known to increase right hemisphere activation (such as music) can facilitate creativity.

Neethling (1996:87-99) describes people's thought processes according to four quadrants of the brain.

According to this theory, illustrated in figure 2.4, one specific part of the brain, namely Left posterior (L1), Left anterior (L2), Right posterior (R1) or Right anterior (R2), usually dominates the thoughts and actions of people. According to Neethling every quadrant can be subdivided into two: L1: **Realist** (preferring clear and concrete information) and *Analyst* (likes to get to the root of things), L2 : **Regulator** (Traditions and proven ways of doing are very important) and **Organizer** (planning and organization is of utmost importance), R1 : **Strategist** (questions existing order and risks into new terrains) and **Fantasizer** (daydreaming and playing with strange ideas and new insights) and R2: **Empathizer** (people with empathy with preference for intimate relationships) and **Socializer** (social people who prefer groups.) The diagram below gives more information about the preferences of people with each of these specific dominances. Although the R1 brain profile describes the typical creative personality, Neethling explains that creativity is not confined to people with right brain dominance. Again it might be the linking of processes happening in different parts of the brain that might be the answer to being creative. For example, if an individual is able to operate well in both R1 and L1, he/she can be a very creative chemist.

Figure 2.4: Explanation of the characteristics of people with certain brain hemisphere dominances (Neethling, 1996)



2.2.3 Creativity and conative and affective factors

Conative (will and motivation) and affective factors (feelings and emotions) are not easily separated and will be discussed together.

2.2.3.1 Creativity associated with a certain personality type

MacKinnon (in Isaksen *et al.*, 2000:9-10), says that the full and complete picturing of a creative person requires many images. Both positive and negative characteristics are associated with creative people.

2.2.3.1.1 Socially desirable characteristics

A number of characteristics, usually viewed positively by the society, are consistently listed in the literature: fluency, flexibility, originality, elaboration, openness, capacity to make order from chaos, high energy, risk-taking, curiosity, complexity, imagination, independence, tolerance to ambiguity and playfulness. Maslow (in Sternberg & Lubart, 1999:8) states that boldness, courage, freedom, spontaneity and self-acceptance are needed for a person to realize his/her full potential. Tolerance for ambiguity and incompleteness in struggle for synthesis, willingness to surmount obstacles, intrinsic motivation, willingness to grow, desire for recognition and willingness to work for recognition are other personality traits contributing to creativity. Dollinger, Dollinger and Centeno (2005:10) find that people who "*endorse an information-seeking style and a personal identity orientation*" have the greatest potential creativity. Those emphasizing normative or collective identities evidenced fewer accomplishments.

Russ (in Feist, 1999:288) implies that access to affect-laden thoughts (primary process thought and affective fantasy) and openness to affective states lead to the divergent-thinking abilities of free association, breadth of attention and fluidity of thought, as well as to the transformation abilities of shifting sets of cognitive abilities. Taking affective pleasure in challenge and being intrinsically motivated result in an increased sensitivity to problems and problem-finding. Being sensitive, open and flexible in thought are in turn important personality dispositions related to creativity.

Creative people are often described as healthy, happy people leading fulfilled lives (Csikszentmihalyi, 1996:2, 16-20).

2.2.3.1.2 Socially less-desirable characteristics

Studies also paint a picture of an asocial creative person with a need for power, diversity of

experience and high incidence of mental illness. Asocial characteristics of creative people include introversion, independence, hostility and arrogance. Power-seeking personality traits include drive, ambition, self-confidence, openness to experience, flexibility of thought and active imagination. Joy (2004:323) indicates that a strong need to be different (or setting a high value on behavioural variation for its own sake) predisposes the individual toward originality (including creativity).

Longitudinal studies conducted by Helson, Robert and Agronick (in Feist, 1999:284-285) indicate that there are certain personality traits, such as being interesting, driven, rebellious, independent, non-conventional, non-conservative or non-submissive, that can be recognized early in life and that persist in the creative individual. Freud (in Sternberg & Lubart, 1999:6) proposes that creativity arises from the tension between conscious reality and unconscious drives. Authors therefore express their unconscious wishes in a publicly acceptable manner in their creative work. Kubie (in Sternberg & Lubart, 1999:6) emphasizes that the true source of creativity is the pre-conscious thoughts (loose and vague, but interpretable) that fall between the conscious reality and the encrypted unconsciousness. Kubie, in contrast with Freud, sees unconscious conflicts as stumbling blocks (rather than the source) because they lead to repetitive fixated thoughts, interfering with creativity.

Simonton (2005:1 - 5) asks: "*Are genius and madness related?*" He answers this question by saying that creativity and psychopathology share a common set of traits. These traits will cause creators to commonly exhibit symptoms often associated with mental illness. Martindale (1999: 143,145) describes creative people as characterized by a lack of both cognitive and behavioural inhibition and quotes Eysenck that links creativity to psychoticism. Verhaeghen, Joormann and Khan (2005:16) propose a link between "*self-reflective rumination*" and creativity. Self-rumination "*prepares individuals to generate a larger number of ideas. This enhanced fluency in turn allows for the emergence of more creative ideas and for increased elaboration*". They ascribe the reflective tendency that leads to self-rumination to dysfunctions in cognitive inhibition. Because of this dysfunction, the contents of the consciousness is not limited to thoughts that are relevant to a current goal or to a current task, but give access to a large inventory of irrelevant thoughts, making random associations more likely.

The five factor model (FFM), first proposed by Norman (1963) and later widely accepted in psychological circles, proposes that there are five bipolar dimensions to personality (indicated by the anagram OCEAN): Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. Creativity is linked very strongly to openness. Research also indicates relationships between creativity and each of the other four dimensions of this model: neuroticism,

lack of conscientiousness (attention to detail), introversion and lack of agreeableness (Feist, 1999 :288-289). A link between creativity, mood disorders and genetic factors is also indicated by research by Chang, Steiner and Ketter (2005), Carreño and Goodnick (1998), Jamison (1993) and Andreasen and Glick (1988), linking bipolar affective disorder (BAD) in a family to a high prevalence of creativity. Two bipolar tendencies implicated to lead to creativity are the tendency to overly constrict the attentional field and the opposite, extensive scanning of even peripheral information. According to Prentsky (in Noppe, 1996:380), merging these two tendencies brings a creative breakthrough. Ghadirian, Gregoire and Kosmidis (2001:145-148) show that in the case of BAD patients, as well as other psychopathologies, the degree of creativity is inversely proportional to the severity of the illness. Sick people are NOT creative, but the genetic factors that may cause the diseases may help to make a person creative.

Feist (1999:290) lists the characteristics of creative people and distinguishes between artists and scientists. In both art and science they tend to be open to new experience, less conventional and less conscientious, more self confident, self-accepting, driven, ambitious, dominant, hostile and impulsive. Artists tend to be more affective, emotionally unstable, less well socialized and accepting of group norms, while scientists tend to be more conscientious.

2.2.3.1.3 A complex person

The highly creative person is described as a person of contrasting characteristics. Feist (1999:288) quotes Barron saying: "*the creative genius may be at once naïve and knowledgeable, being at home equally to primitive symbolism and to rigorous logic. He is both more primitive and more cultured, more destructive and more constructive, occasionally crazier and yet adamantly saner, than the average person*".

Csikszentmihalyi (1996:57-73) agrees that the creative person is a complex person, showing tendencies of thought and action that are segregated in most other people. These extremes are present simultaneously or at different times, depending on the situation. He gives ten areas of contradictory extremes: more restful and more energetic, more imaginative yet more realistic, more extroverted and more introverted. Females tend to be more dominating and males more sensitive than the norm. Other examples are: simultaneously more knowledgeable and more naïve, more playful and more responsible, more open and more focussed, more passionate and more objective, more humble and more proud, exposing themselves to suffering, but also to enjoyment and lastly more rebellious and independent, but also more of a traditionalist.

2.2.3.2 Creativity and motivation

Intrinsic motivation is one characteristic of creative people that is mentioned throughout the literature (Gruber & Davis, 1988:264-267; Fritz, 1994 & Amabile, 1996:99). In terms of Rotter's social learning theory, one prerequisite for creativity is therefore an "*internal locus of control*".

Kolbe (1990:8-11) explains that to create is: "*to bring into being, to cause to exist, to produce. Since every person has conation, the ability to take action, every individual also has the ability to create. Without conation there is no product, only potential*".

Kolbe further points out that it is not so much IQ or "*I wish*" that matters, but "*I will*." While limited intelligence, education and experience may be seen as factors inhibiting a person's creativity, a strong will may overcome many of these obstacles.

Gruber and Davis (1988:264-267) view the creative person at work as one who is able to invent and pursue sub-goals and work on a rough draft to make the work manageable, to make inconclusive moves fruitful and enriching and help the creator to maintain direction. The person is seen as consisting of three main loosely coupled subsystems, namely knowledge, purpose and affect. These three subsystems interact as they explain, using the following hypothetical case: The creative person at work is baffled and discouraged by a task A and inclined to put it aside without his/her activity level dropping to zero. The process of stopping work on task A, reorganizes motivation and activates another enterprise B. He/she retains the knowledge and skills acquired in task A, his/her mood shifts or a new opening for further progress in the task A arises and work proceeds on a higher level on that task. His /her mind is prepared to see these openings. The individual is actively involved in rich and complex interactions with his/her external milieu –choosing and constructing. The creative person is characterized by seemingly perpetual activity, and intrinsically motivated by "deviation amplifying systems" such as the repetition of interesting acts (cf. 2.3.4.3).

Research by Way (2003:801) suggests that artists employ a "variety of self-regulatory techniques" to motivate themselves. "*These strategies are typically directed towards maintaining the work process, and include motivational strategies (the use of rewards, for example), emotional strategies (e.g. working through a "blue" mood to maintain focus on their work), cognitive strategies (e.g. telling themselves to just "take one small step at a time" when frustrated with the work process), and behavioural strategies (e.g. simply buckling down to the task when necessary)*".

The link between creativity and motivation is discussed further in section 2.4.3.2.

2.2.4 Creative styles and roles

Creative kinds, styles or instincts that are described by the literature seem to fall into two categories, namely those that relate to personal styles of problem-solving (Kolbe, 1990; Goff & Torrance, 2002; Isaksen *et al.*, 2000 & Puccio, 2002) and those relating to a person's role in society (Kirton, 1989). The former relates to how a person tackles a problem and is able to contribute in a group effort. The latter sees creativity from a global perspective and every style or role contributing in a unique way to fulfil the needs of society.

2.2.4.1 Styles that relate to personal styles of problem-solving

These styles or creative types or instincts point out that every person has a unique creative strength. Some of them relate to the different phases of the creative process so that each person can have a strong contribution in one or more of the phases of the creative process. If a problem is solved in a collaborative team, the team would be able to exploit the strengths of each of the members to form a strong unit.

2.2.4.1.1 Goff and Torrance's Collaborator, Contributor and Accelerator

In the Abbreviated Torrance Test for Adults (ATTA), Goff and Torrance (2002:27) distinguish between three creative roles namely that of collaborators, contributors and accelerators. These roles correspond with scores for fluency, originality, elaboration and flexibility. According to this model, a person can therefore have different roles in a group effort, such as an accelerator in fluency (able to come up with many ideas), a contributor in originality (able to contribute a few good new ideas) and a collaborator in elaboration (rather leave it to others to elaborate) depending on his/her strengths.

2.2.4.1.2 Kolbe's Creative Instincts

Kolbe (1990:10-11) identifies four creative instincts and links every instinct to an action mode. The instinct to **Probe** is linked with the action mode of **Fact Finder**, the instinct to **Innovate** with the action mode of **Quick Start**, the instinct to **Pattern** with the action mode of **Follow Thru** and the instinct to **Demonstrate** with the action mode of **Implementer**. Every person uses all four of these instincts and action modes. The relative intensities of these instincts and action modes differ in different people. What matters is to use one's natural creative instincts and to work according to your strengths. Individuals get more fulfilment and employers more success with their employees when allowing people to work following their creative instincts.

2.2.4.1.3 Puccio's FourSight style model

FourSight (Puccio, 2002) is based on the Creative Problem-solving Process and is a tool that is used to identify the strengths of members of a creative team. Four creative styles are described. The styles are that of a **Clarifier** (explores challenges and states problems clearly), an **Ideator** (natural divergent thinkers who like working on ill defined problems and are able to produce many ideas), a **Developer** (analytical thinkers who like breaking problems apart and examining them from all angles) and an **Implementer** (likes to implement ideas).

2.2.4.1.4 Treffinger and Selby's three-dimensional model

Treffinger and Selby (2004:2) propose a three-dimensional model for defining and assessing problem-solving style preferences. The model, which builds on the literature from learning styles, cognitive styles, personality type and from theory and research on Creative Problem-solving, includes:

1. Orientation to Change (with the Explorer and Developer styles)
2. Manner of Processing (with External and Internal styles) and
3. Ways of Deciding (with Person and Task styles).

2.2.4.2 Styles based on a person's role in society

2.2.4.2.1 Kirton and Vygotsky

Kirton (1998) and Kirton (in Puccio, 1999:2-4), in his **Adaption-Innovation Theory**, distinguishes between two creative styles, namely innovation and adaption. Innovators are seen as unique, visionary and ingenious, and are challenging the paradigm or structure. They function well in unstructured situations, approach tasks from unexpected angles and are responsible for big radical, revolutionary change. They plan in a broad general way. They may miss or disregard important details and may under-structure or improvise so that others feel confused or lose their focus and direction for the task. They often have problems in getting their ideas accepted. Adaptors are seen as conforming authorities within given structures that rarely challenge the status quo. They function well in structured environments and refine the system in an evolutionary way. They will focus on change that promotes incremental improvements. They may become so focused on details, that they may miss the broader patterns or themes. They are precise, reliable and dependable. People with these different creativity styles can collaborate to compensate for the "weaknesses" of the

other style. Adaptors can provide stability and acceptance of ideas, while innovators can provide task orientation to bring about periodic radical change. Individuals are said to possess varying degrees of both styles, but usually lean over in varying degrees to one side.

Isaksen *et al.* (2000:193-199) mention a third style: people with more moderate preferences. They will generate novelty as the situation demands and offer suggestions that will appeal to many others. They are often well placed as arbiters and leaders and can usually find common ground or reach out to the extremes. Moderators can become very focused on the middle ground and lose the usefulness and novelty found at the extremes.

Vygotsky (1997:205-201) also expresses the viewpoint that different people respond differently to their environment. Similar to Kirton, he distinguishes two styles, namely a “*social dynamic*” and a “*social static*”. He sees the aim of education as adapting the child to the environment in which he will have to function, namely the constantly changing social system. This makes a revolutionary person who is always in conflict with his surroundings and rises up in rebellion against society to be more adapted to the highest tendencies of the environment (the social dynamic), whereas the career seeker is more adapted to the social static. The social dynamic may be related to Kirton’s accelerator style and the social static to the adaptor style. Vygotsky believes that the response of an individual to his surroundings depends on the direction in which his purposefulness is guided.

2.2.4.2.2 Csikszentmihalyi’s creative types

Csikszentmihalyi (1996:25-26) uses case studies to study highly creative people. He distinguishes between three creative types: **brilliant** (interesting, stimulating with quick mind and varied interests), **personally creative** (experience life in novel and original ways, fresh perceptions making important discoveries of which only they know) and thirdly **creative people** (with public achievements changing culture in important ways) (*cf.* 2.1.3).

2.2.4.2.3 Expressive, social, specialist and global styles

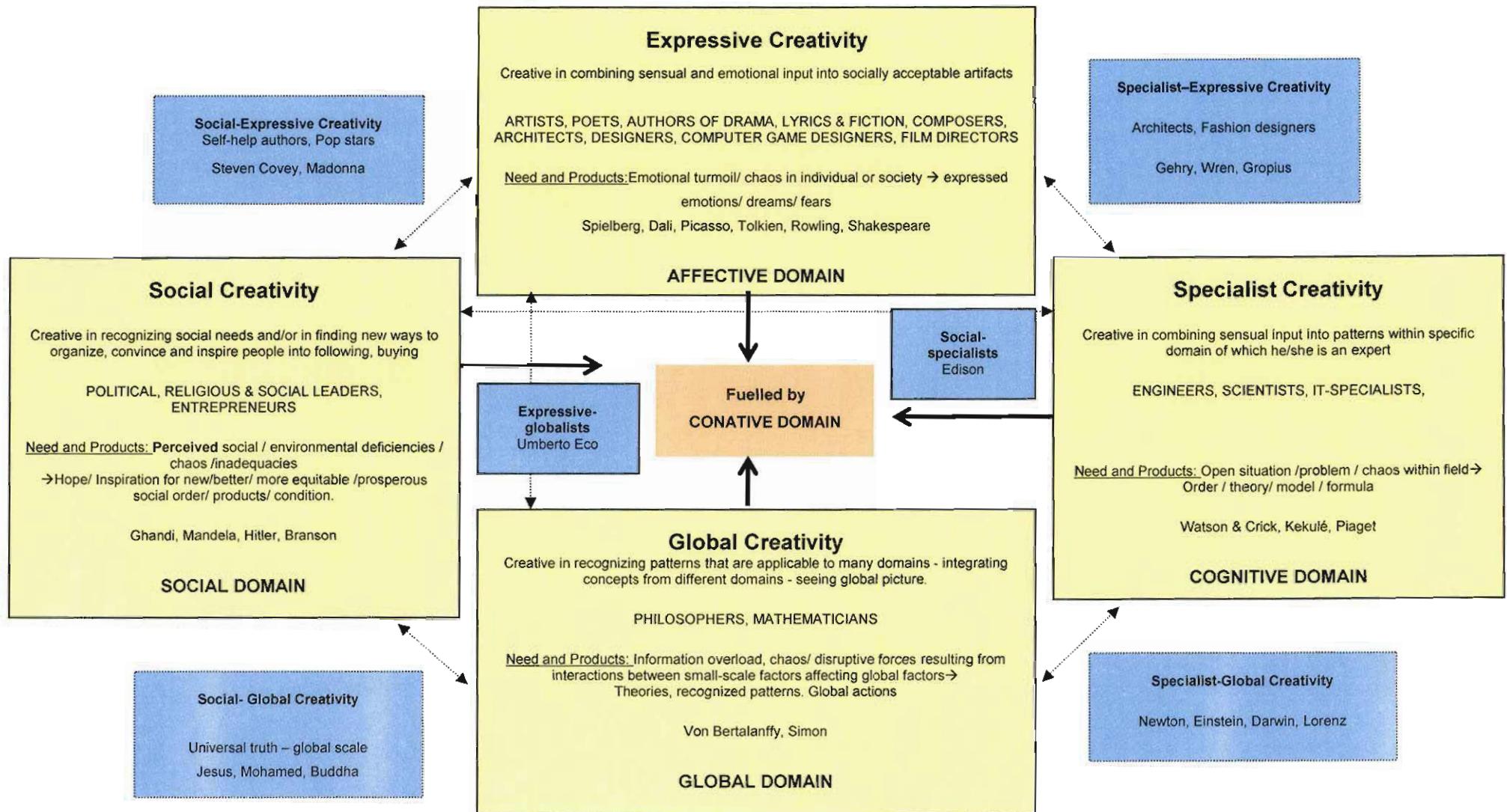
From what was learnt from the literature study, a model giving recognition to the **expressive, social, specialist and global** styles is shown in the scheme proposed in figure 2.5 and is based on the idea of different needs that are to be fulfilled in a society. Some individuals are talented in expressing their own emotions and/ or the emotions of the society as a whole in the form of music, words, paintings and so forth. Others, the globalists, are talented in integrating knowledge from different domains to create order by recognizing patterns and links between areas of knowledge. Specialists fulfil the need to create knowledge and skills within a domain. People with a socially

creative style may tend to be entrepreneurs and leaders on social terrain – they are creative in recognizing and fulfilling social needs. Combinations of these styles give six more styles namely expressive-globalists, expressive-specialists, expressive-socialists, social-specialists, global-socialists and global-specialists. An architect or fashion designer, for example, may be a specialist as well as an expressive creator.

According to the researcher, different societies may encourage different creative styles. Social creative styles may, for example, be more in demand in communalistic cultures whereas specialist creative styles may fit the individualistic culture better. Certain needs and conditions in society may also call for the shift in emphasis on a different style of creativity, such as chaos that calls for clarification by the **globalist**, emotional upheaval (as during hardship or joy) that calls for expression by the **expressivist**.

Isaksen *et al.* (2000:10) explain that from a situation where the emphasis was on creative levels (*"How creative am I?"*) more emphasis is now placed on the variety of styles and kinds of creativity (*"How am I creative?"*). Two directions could be recognized in the research of the concept of the creative person: The first emphasizes the creative individual in isolation (his/ her intelligence, personality, psychological health and so forth). The second looks at the creative roles people play in corporations and in societies and how to manipulate conditions to optimize these creative contributions to the benefit of the corporation or society.

Figure 2.5: Creative styles related to societal needs



2.2.5 Inhibitors of a person's creativity

Jones (in Isaksen *et al.*, 2000:14) and Zich (1996) identify the personal barriers to creativity from literature. They are listed below:

2.2.5.1 Cognitive factors

Jones notes the following as strategic or intellectual inhibiting factors: resistance to using imagination, inability to tolerate uncertainty, saturation, excessive enthusiasm, various value and cultural influences, lack of imaginative control and inability to see variety of possibilities. Zich (1996) adds specialization, inability to fantasize and a lack of humour in problem-solving.

Jones further lists the following perceptual problems that may inhibit creativity: stereotyping, difficulty seeing a problem from different viewpoints, imposing unnecessary constraints and failure to use all the senses. Zich (1996) adds ill-defined problems, boundary-laden thinking, resource myopia, habits, polarized thinking and under-or over-stimulation.

2.2.5.2 Conative factors

Jones lists the following as self image/ value factors that may inhibit creativity: reluctance to exert influence, failure to take advantage of available resources, lack of flexibility in applying personal beliefs, values and attitudes, strong desire to conform to pre-existing patterns, dogmatically negative attitude towards creativity and rigidly custom-bound. Zich (1996) adds: not allowing for play, need for balance, criticizing rather than producing ideas, difficulty using incubation skills.

2.2.5.3 Affective factors

Jones names fear of failure as a factor that may be classified as an emotional factor while Zich (1996) adds fear of the unknown and submissiveness-fear of voicing ideas, avoiding frustration and reluctance to let go.

Although these blocks may be part and parcel of a personality type and thinking styles, they may also be the result of conditioning, social and cultural modelling and mediation into certain ways of thinking about life and problems (*cf.* 2.4.3).

2.2.6 Using Technology Education to enhance the creative person

The type of creativity known as “Creativity with a capital C” (cf. 2.1.3) is unlikely to be achieved by classroom manipulation alone. Certain key ingredients are, however, identifiable from the high level creativity from which one can learn. These key ingredients can be classified as Conative, Affective, Contextual and Cognitive factors (cf. 2.2.5). The first two will be discussed here and contextual and cognitive factors will be discussed in section 2.4 and chapter 3 respectively.

2.2.6.1 Conative factors

Conative factors are the factors relating to motivation, commitment, will power and perseverance (cf. 2.2.5.2).

2.2.6.1.1 Intrinsic motivation

According to Nickerson (1999), Amabile (1996) and Fritz (1994), **intrinsic motivation** is a key ingredient for creativity. This means, a psychological urge to keep a creative process going till satisfactory results are achieved is essential. Eisenberger and Shanock's (2003) explanation of the link between reward and intrinsic motivation is important: rewarding novelty and/or originality explicitly increases intrinsic motivation. Rewarding any attempt inhibits creativity. There must be a development of abilities and strategies to self-regulate motivation. Deci and Ryan (2005) conclude that *“contextual and person factors that tend to promote autonomy show that autonomy support has generally been associated with more intrinsic motivation, greater interest, less pressure and tension, more creativity, more cognitive flexibility, better conceptual learning, a more positive emotional tone, higher self-esteem, more trust, greater persistence of behaviour change, and better physical and psychological health than has control. Also, these results have converged across different assessment procedures, different research methods, and different subject populations”*.

2.2.6.1.2 Commitment

Establishing intention and *“purpose is essential to creative expression”* (Nickerson, 1999:408). Commitment, intrinsic motivation and energy for a specific task may be achieved by creating a potential difference between the current unsolved mystery or problem, unbearable complexity or unresolved emotion and the vision of a resolved mystery or problem, simplicity (in the form of a formula /theory/ pattern) or expressed

emotion (in the form of a poem, sculpture, painting). An enthusiastic facilitator is important in inspiring students, but a challenging task and students that inspire and challenge and expect the best from one another may be even more important. Lastly, but most importantly, the student him/herself needs to buy in.

2.2.6.2 Affective factors

Making use of affective factors would involve stirring the emotions. The individual must feel in control and able to improve the situation. He/she must feel that his /her contribution is valuable and appreciated

2.2.6.2.1 Feeling of being in control

Fritz (1994) describes an oscillation pattern that establishes itself in people. He explains that people who feel that their circumstances control them and that they have to respond to them and/or react against them, will not reach their creative potential. According to Rotter (in Mearns, 2000-2005) they are vulnerable to their circumstances and powerless against them. An internal locus of control is needed. The person /group must believe that luck or being advantaged is not the crucial factor. Sustained own effort is. Believing that solutions and opportunities are plenty and can be achieved by anybody willing to invest time and energy in it, may constitute a major life-changing mind-shift that motivates people. Creative role models who achieved success despite odds may provide useful and motivating temporary emotional “scaffolds” in cases where exposure to creative role models in the students’ personal lives is limited.

2.2.6.2.2 Safety and openness

To develop an attitude of openness to incoming stimuli as well as internal thoughts is related to feelings. To make students aware that there are times when judgment is not allowed, to listen to one another and to try to build on the ideas of others are skills emphasized in the CPS-model (*cf.* 2.3.4.2). The idea is to cultivate respect and to build confidence. Students should feel safe to express ideas and know that every effort will be appreciated and could potentially contribute to solutions in group- and individual activities. Withholding ideas may compromise the quality of the solution.

2.2.6.2.3 Positive attitude towards novelty

By placing high priority on novelty and/original thought through rewarding it and emphasizing the fact that it will be expected and will serve as a criterion on the one

hand and not rewarding boring and learnt responses on the other hand, an attitude of valuing originality may be cultivated. Studies by Martindale (1999:142) and Eisenberger and Shanock (2003:121-130) found that knowledge of a demand for originality is a factor in enhancing creative output. To cultivate an attitude of valuing originality, it is therefore important to expect original thought and to communicate this expectation. This could be done by including opportunities for original work in different forms of assessment, using creative competences as evaluation criteria and by taking care not to reward boring and learnt responses.

2.2.7 Critical evaluation

Although creativity may be considered to be a common trait of all humans, there seems to be differences in the creative level and creative style of individuals.

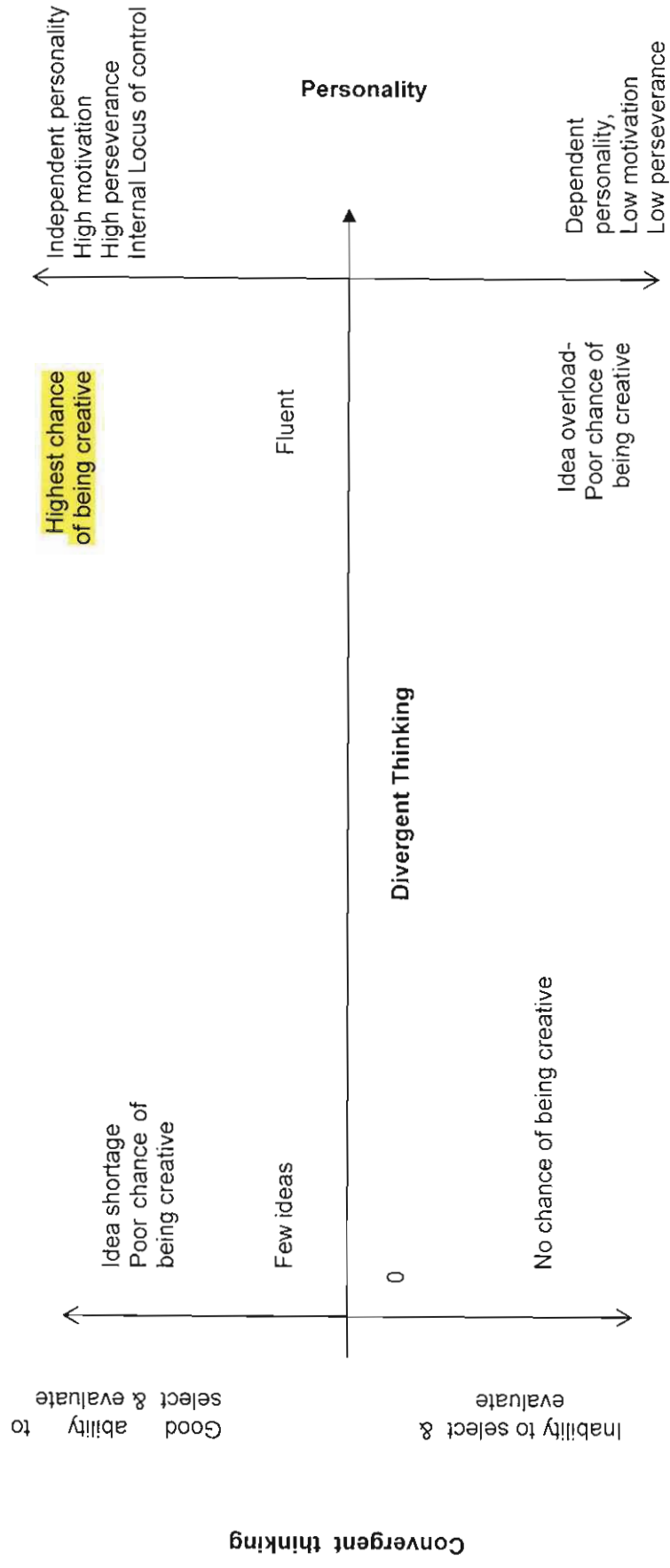
Creativity level seems to be directly proportional to general intelligence, up to a point where the relationship becomes blurred, so that very high intelligence and high levels of creativity are not related. Creativity level is closely linked to personality. Torrance (2002) concluded after a longitudinal study over 40 years that *"intelligence, creativity, and academic achievement were less important in predicting creative output than certain personality characteristics"*. Creativity further seems to depend on the degree to which a person has access to his/her right brain hemisphere and the ability to think both divergently and convergently as demanded by the task. Specific brain functioning is also implicated: a low level of latent inhibition so that the person stays open to incoming information, an ability to alternate between primary and secondary thought processes, a large attention span with a working memory that can process an optimum amount of information and memory stores that are accessible and from which the information appears in chunked form into the working memory. A mechanism to side-step cultural censorship may also be necessary (*cf.* chapter 3).

Creative styles differ greatly and are based on the concept of specialization: every individual has a unique and valuable role to play in the establishment and development of a joint creative effort such as in creative problem-solving, in a work place or in society. Knowledge of one's creative style may help a person in to make choices about career and methods of attacking a task. Understanding and valuing the unique contribution of every individual style may also lead to appreciation of diversity.

The typical creative personality may have genetic as well as contextual determinants and has both a positive and negative side to it. It seems to be a complex personality, on the border of psychopathology, but with coping mechanisms and skills that keep it from "crossing over". Intrinsic motivation, perseverance and a strong urge (almost an addiction) to find the answer, to reconcile paradoxes, to bring order to chaos or to apply certain untapped knowledge seem to be crucial for being creative. Specific habits, techniques and strategies for staying motivated are seen when the task is extended and complex. Torrance (2002) identifies the personality characteristics or attitudes that are associated with creative output as: "(1) *falling in love with your work*; (2) *learning to know your greatest strengths*; (3) *expectations and playing your own game*; (4) *not being well rounded*; (5) *loving the work you do*; and (6) *learning the skills of interdependence and shared creativity*."

To summarize: creativity depends on factors such as personality, intelligence, knowledge, thinking styles, motivation and environment (Sternberg & Lubart, 1992). If the degree of creativity is plotted on a line from zero to highly creative (figure 2.6), certain personality types, thinking styles and social factors may predispose a person to lie either towards the left or right hand side of x-axis. If critical thinking abilities are plotted on the y-axis with inability to select and evaluate on the negative side and good ability to select and evaluate on the positive side, the highest chances of being creative would be at the intersection of high fluency, high critical thinking abilities and independent personality with an internal locus of control coupled with mechanisms to keep motivation high and to persevere.

Figure 2.6: Chances for creativity



The context for creative thought, that will be discussed in 2.4, can reinforce certain personality traits, thinking, learning, working styles and motivation that might lead to or encourage creativity (Rossman and Horn, 1972; Csikszentmihalyi, 1996; Shi, 2004).

2.3 THE CREATIVE PROCESS

2.3.1 Introduction

The “creative process” is a term used to describe the mental processes through which an individual or group of individuals go when doing creative work. Initially the creative process was seen as a mystical process, inspired by the Muse, gods and goddesses. Current studies suggest that creativity uses ordinary mental processes (Weisberg, 1993; Boden, 1998 & Ward, Smith & Finke, 1999:189-212). What is extraordinary however, is the specific confluence of different features in a specific individual's biological and environmental make-up that bring him/her to use these ordinary mental processes in ways that result in creative output.

In this section, the creative process will be reviewed as a natural occurring process, as well as a deliberate, planned process. A neuro-scientific explanation of the occurrences during the process of creating something will be given. How the creative process is manifested in Technology Education and how it could be enhanced through Technology Education will be discussed. The section concludes with a critical evaluation about what was learnt from the literature.

2.3.2 Natural occurring creative processes

Most people who create minor or major creative works can testify about going through a certain process while creating. People also see the creative process in action in others; it occurs naturally. Researchers try to describe this naturally occurring phenomenon. A few of their descriptions and models are explained.

2.3.2.1 Helmholtz and Wallas

The classic description of the creative process by Helmholtz and Wallas (in Isaksen, Dorval & Treffinger, 2000: 1-13) describes the creative process in terms of the stages below:

1. **Preparation:** Thinking about, learning the mental elements thought to be relevant to the problem at hand, investigating the problem in all direction.
2. **Incubation:** Problem is set aside to incubate, subconscious processes continue.
3. **Illumination /Inspiration:** Solution simply occurs.

4. **Verification / Elaboration:** Idea is subjected to logical scrutiny and put into final form.

2.3.2.2 Eastern and African descriptions of the process

A description of the creative process as experienced by **artists** from Eastern countries such as India and China respectively (Maduro and Chaudhuri in Lubart, 1999:340-342), indicates that emotional, personal and intra-psychic elements are emphasized. They describe an Eastern creative process as also consisting of four phases, namely:

1. **Preparation** (individual tries to contact, by self-will and ceaseless effort, the subjective region of his/her mind; may involve meditation or seclusion)
2. Achievement of **internal identification with the subject matter** is achieved.
3. **Illumination**
4. **Verification**

Baer (2003:37-39) cites Niu explaining that the Confucian view of creativity emphasizes a process of self-cultivation towards enlightenment which constitutes a gradual learning process, whereas Taoism emphasizes a sudden enlightenment.

The Japanese doctrine of Shu Ha Ri, as applied in martial and other arts as well as in the tea ceremony (Penland), may also be seen as a kind of creative process if it goes through all the stages. It is a term the Japanese use to describe the overall progression of martial arts training, as well as the lifelong relationship the student will enjoy with his/ her instructor (Shuhari).

1. **Shu** means to obey and learn from tradition to follow the teachings of past masters with strict adherence (corresponding to preparation under mentorship of master);
2. **Ha** means to break, to reject or doubt anything that disrupts the following of Shu; and
3. **Ri** is to be set free: in the Ri -stage the student surpasses the master and brings renewal. He /she is therefore creative, still using the basic elements learnt in the shu stage. If the student does not surpass the master, the art stagnates; if the student does not at least equal the master, the art deteriorates. Penland

explains: *"We should follow tradition, but not become slaves to it."*

Shuhari is not a linear progression. It is more akin to concentric circles, so that there is Shu within Ha and both Shu and Ha within Ri. Thus, the fundamentals remain constant; only their application and the subtleties of their execution change as the student progresses and his/her own personality begins to flavour the techniques performed (Shuhari). This doctrine is also underlying the development of master-level performance in creative fields namely *"the 10 year rule"* as explained by Weisberg (1999:230-231). It is found that few composers, poets or painters produced any significant work before a period of 10 years of "preparation". Other researchers also observed this trend in other domains. The ten years of "silence" was spent on deliberate practice (Weisberg, 1999:232).

Descriptions of African creative processes are difficult to find since it seems as if little research has been done on them. Vincent Mantsoe (2001), a choreographer, dancer and teacher describes the creative process through which he goes as follows:

"The 'Spirits' or 'Ancestors' have been an important part of my creative process, with the belief that if I have to create a work, I always have to 'borrow' with respect, appreciation and the understanding of the movement source. It is not always that we can find ourselves completely knowing and understanding what and when the real spirit of dance introduces itself to us in our creative process (especially if we try too hard to!)."

Enwonwu (2000) explains that African Art, for example, *"is not really Art in the Western context, but an invocation of ancestral spirits through giving concrete form or body to them before they can enter into the human world"*.

Although this should be explored further, one may deduce from these two examples that inspiration often comes spontaneously in art forms and the source is seen to be from the *"other world"*.

2.3.2.3 Kris

According to Kris (in Sternberg & Lubart, 1999:6), psychoanalysts introduce the concepts of adaptive regression (primary process) and elaboration (secondary process) for the study of creativity. Adaptive regression refers to the intrusion of unmodulated thoughts in consciousness that can occur during active problem-solving, during sleep, intoxication, fantasies, daydreams or psychoses. Elaboration

refers to the reworking and transformation of unmodulated thoughts through reality-oriented, ego-controlled thinking.

2.3.2.4 Finke, Ward and Smith

Cognitive approaches also seek to understand the mental representations and processes underlying creative thought. Finke, Ward and Smith (in Ward, Smith & Finke, 1999:191-194) propose the Geneplore model. They are of the opinion that there are two processes involved: a generative phase and an exploratory phase. During the generative phase, an individual constructs mental representations called pre-inventive structures that have properties promoting creative discoveries. These properties are then used during the exploratory phase to come up with creative ideas. Mental processes involved in these phases of invention are retrieval, association, synthesis, transformation, analogical transfer and categorical reduction.

2.3.2.5 Piskoppel

Piskoppel (1984:33-46), a Russian researcher, identifies three stages in the process of scientific creativity namely: conception, formulation, and development. The conception phase represents the creative assembly of ideas in the cultural milieu to serve as an ideal object, a scientific and theoretical abstraction encompassing the essence of the phenomena observed. The ideal is to *"combine the ideal object with empirical data and pass into the formulation and development of theory"*.

2.3.2.6 Amabile

Amabile elaborates on Wallas's model and proposes that the process is the same for both high and low levels of creativity. All components are always necessary. Task motivation initiates and sustains the process. Domain-relevant skills are the materials drawn upon during operation and determine the pathways that will be available and the criteria that will be used during the search for the response. Creativity-relevant skills act as an executive controller during response generation, influencing the way in which the search will proceed (figure 2.7).

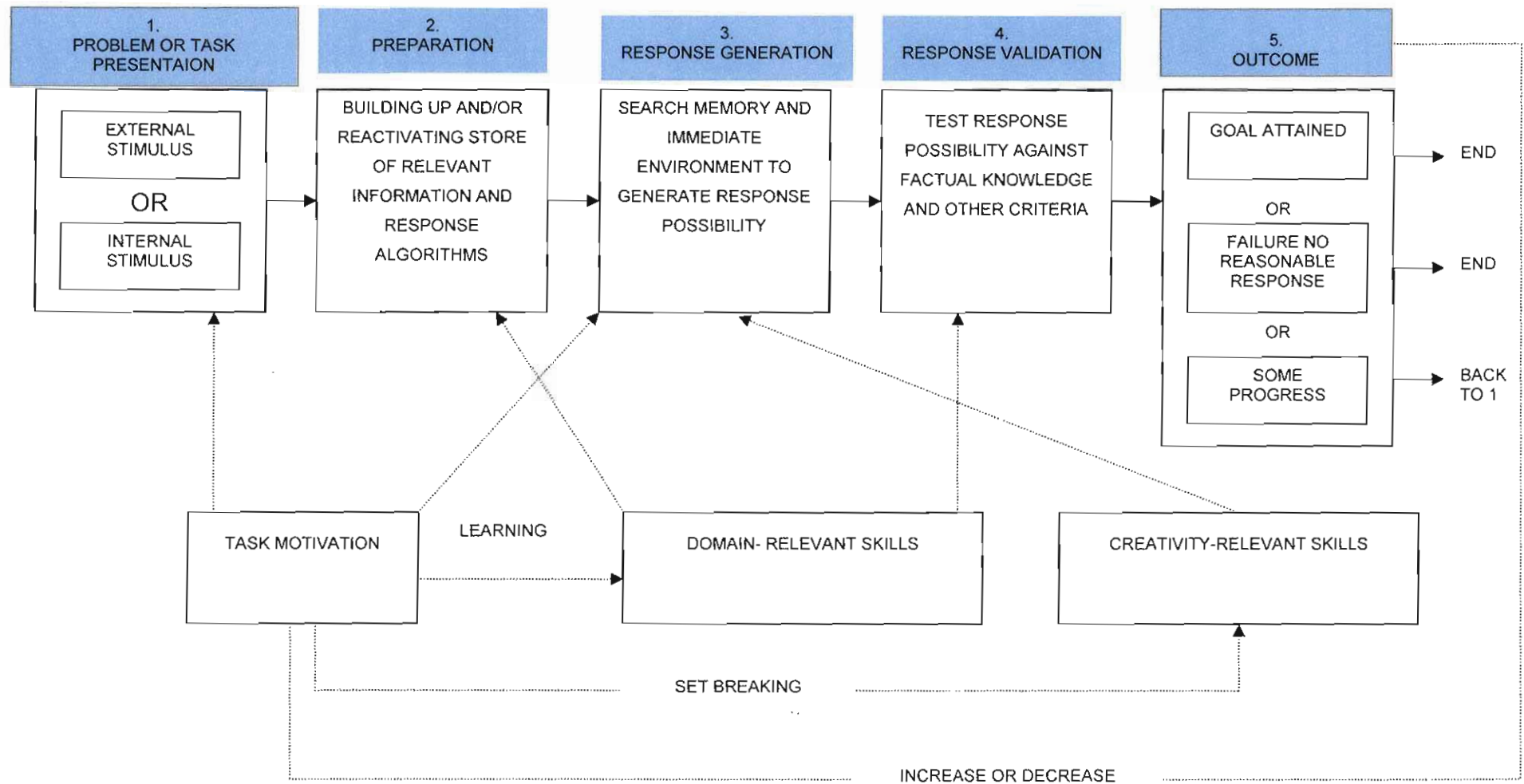
1. The process starts when a problem or a task is presented. High levels of intrinsic interest in the task will be enough to engage the individual in the task. Getzels and Csikszentmihalyi (in Amabile 1996:95) found that *"discovered problems"* are more likely to be solved creatively than *"presented problems."*
2. During the second phase of the process, an individual is building up a store of

information relevant to the problem or task. Domain–relevant skills already present at the onset of the task give an advantage and speed up the process.

3. During the third stage, the level of novelty of the product or response is determined. The individual searches through the available pathways and explores features of the environment that are relevant to the task at hand. Creativity-relevant skills that the person has available determines the attention given to particular aspects of the task, the extent to which a particular pathway is followed, the flexibility with which the cognitive pathways are explored and whether critical judgement will be temporarily suspended to generate many possibilities.
4. The fourth stage is when the usefulness of the solution is determined and it is characterized by its reliance on the domain- relevant skills. Analysis is employed to scrutinize the possible responses for validity, appropriateness and correctness.

If the outcome of the first four steps complies with the “specifications” or when there is a total mismatch, the process terminates. If there is some progress towards the goal, the process will be repeated from step 1. The experience gained, even in the case of failure, will serve as learning that might make success in similar situation more likely in future.

Figure 2.7: Componential framework of creativity (Amabile, 1996:94)



2.3.3 Barriers to creativity that are process-related

Jones (in Isaksen *et al.*, 2000:14) identifies the following barriers to creativity from literature: strategies, skills and behaviours inhibit one's ability to focus and direct problem-solving activities, to generate and identify options and to turn ideas into actions. Further barriers may be input problems (like poor language skills and various perceptual patterns that limit intake) and processing problems (like rigidity, solution fixedness, premature judgement or closure, habit transfer, poor problem-solving approaches and lack of disciplined effort).

In an attempt to help people to overcome these input, process and output problems, deliberate creative processes were developed and are used especially in the design and advertising world. A few of them are discussed in 2.3.4.

2.3.4 Deliberate creative processes

Some researchers are of the opinion that barriers to creativity can be overcome. The assumption is that one can, through knowledge of the process, develop and deliver training programmes and thereby improve the creative problem-solving skills of an individual. This assumption is made because a thought pattern that can be learned and taught is seen to be involved. Special techniques are employed to enhance the idea generation capabilities of individuals and groups. Another aspect would be the removal of barriers that stand in the way of fulfilling the potential for creativity. This would be especially important in product development in a competitive world where it is said that you need a hundred ideas to get one good product (Isaksen *et al.*, 2000:18). In this market you need creativity on demand and if the inspiration does not come, the company loses money.

Sternberg and Lubart (1999:5) criticize some of these deliberate creativity-on-demand-packages. They describe the work of people like De Bono (lateral thinking) and Osborn (brainstorming) as pragmatic, more concerned with practice than theory, commercialized and harmful to the scientific study of creativity.

2.3.4.1 TRIZ -Theory of Inventive Problem-solving

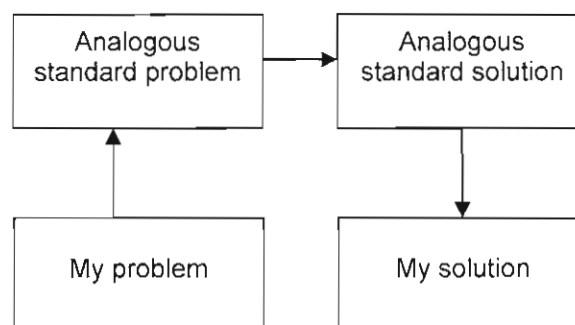
One deliberate attempt of demystifying the creative process is TRIZ. It is especially recommended to help engineers and developers solve technical contradictions and invent new technologies. TRIZ is the Russian acronym for the phrase "Theory of Inventive Problem-solving" or TIPS. This theory was developed by Genrich Altshuller

and his colleagues in the former USSR in 1946 and is now being developed and practised throughout the world. Altshuller felt a theory of invention should satisfy the following conditions. It should namely be:

1. a systematic, step-by-step procedure;
2. a guide through a broad solution space to direct to the ideal solution;
3. repeatable and reliable and not dependent on psychological tools;
4. able to access the body of inventive knowledge;
5. able to add to the body of inventive knowledge; and
6. familiar enough to inventors by following the general approach to problem-solving in the figure 2.8.

This theory claims that it changes the process of invention to a controlled process, using technology instead of psychology. TRIZ describes the phenomenon of "psychological inertia" as a situation where the solution of a problem lies outside the field of expertise of the people trying to solve the problem. The individual or group of individuals therefore cannot see the solution or may not try the solution.

Figure 2.8: TRIZ: general approach to problem-solving



TRIZ uses a number of different techniques such as ARIZ (Algorithm for Inventive Problem-solving). This is systematic procedure for identifying solutions without apparent contradictions. Five to sixty steps may be involved. From an unclear technical problem, the underlying technical problem can be revealed. The basic steps include:

1. Formulate the problem.
2. Transform the problem into a model.
3. Analyse the model.
4. Resolve physical contradictions.
5. Formulate the ideal solution.

2.3.4.2 Creative problem-solving (CPS) of the Creative Education Foundation (CEF)

The elaborate repetitive (polymeric) process described by the CEF uses a Wallas/Amabile type of process as basic unit (monomer). This description of the creative process is based on the ideas of Osborn and Parnes (in Isaksen *et al.*, 2000:45-57) and further developed by them and other researchers at the CEF. Problem-solving generally involves devising ways to answer questions, meet or satisfy a situation that presents a challenge, offers an opportunity or is a concern. It involves closing the gap between what you have and what you want. As illustrated in figure 2.9 and table 2.3 the CPS and CEF models, as described by Isaksen *et al.* (2000:30-38), proposes that every stage goes through a divergent (opening up) and a convergent (focusing) phase.

Figure 2.9: The creative problem-solving process as described by CEF

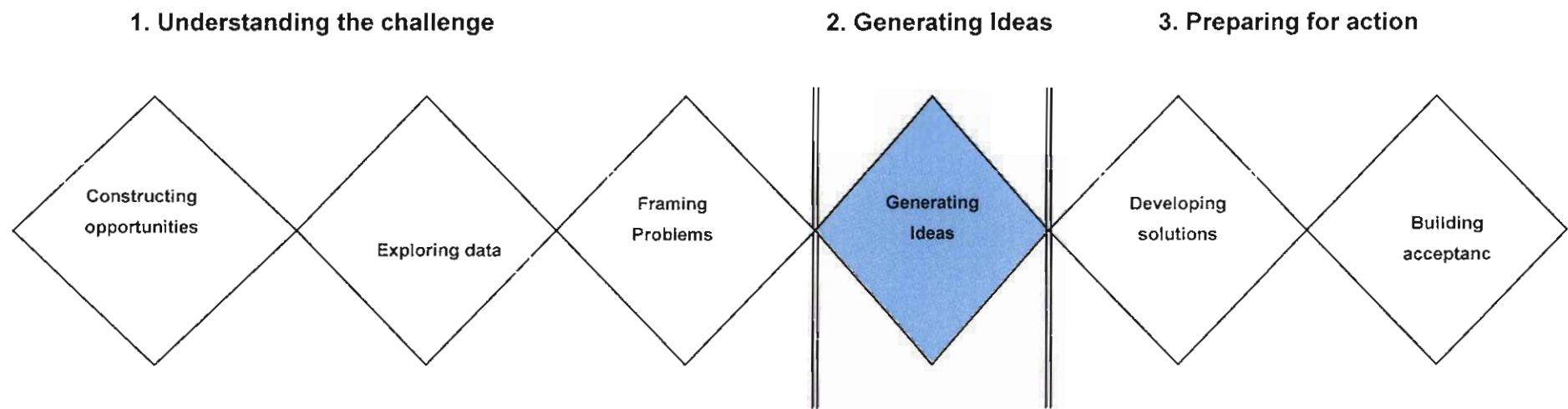


Table 2.3: Divergent and convergent stages of the CPS-model

COMPONENT	STAGE IN PROCESS	DIVERGING PHASE	CONVERGING PHASE
		GENERATING	FOCUSSING
Understanding the challenge	Constructing opportunities	Generate possible opportunities and challenges to consider.	Focus by identifying promising ideas worthy of pursuit.
	Data exploration	Many data sources are explored from different viewpoints.	The key or most important data are selected.
	Framing problems	Generate many, varied and unusual ways to state the problem.	Select or form a specific problem statement.
Generating Ideas	Generating ideas	Produce many, varied and unusual ideas.	Identify ideas with interesting potential to develop or use.
Preparing for action	Developing solutions	Find ways to develop and strengthen promising possibilities.	Analyse, evaluate, prioritize and refine promising solutions.
	Building acceptance	Consider various sources of assistance, resistance and possible actions for implementation.	Formulate specific plans to gain support for, carry out and evaluate actions.

During the diverging phases, fluency (generation of many ideas), originality (generation of new ideas) and flexibility (generation of different ideas) are among the skills needed. Exploration of different data sources and understanding the information so that different viewpoints can be formulated are further needed during these phases. People are taught techniques such as to deliberately get themselves in a relaxed state during the diverging phases and in doing so, to enhance the easy flow of ideas. Group diverging techniques, such as building on one another's ideas without judgment (neither positive nor negative) are taught. During the focusing phases critical thinking skills such as analysis, evaluation, ability to compare and select, prioritize and make decisions are needed. Again group converging techniques such as clustering, grouping and classifying ideas and selecting the most promising

ideas are taught. The phases are deliberately separated so that people must know what techniques are allowed during every session, keeping strictly to the rules in every phase, like no judgement during diverging phases, wise judgement during converging phases.

2.3.4.3 The Technologies for Creating (TFC) of Robert Fritz

This theory claims to be useful to accomplish change in an organization by changing the path of least resistance. Fritz (1994:21-24, 39, 58, 115-116) is opposed to the assumption that problem-solving and creativity can be seen as similar. He proposes that the creative process consists of three phases namely:

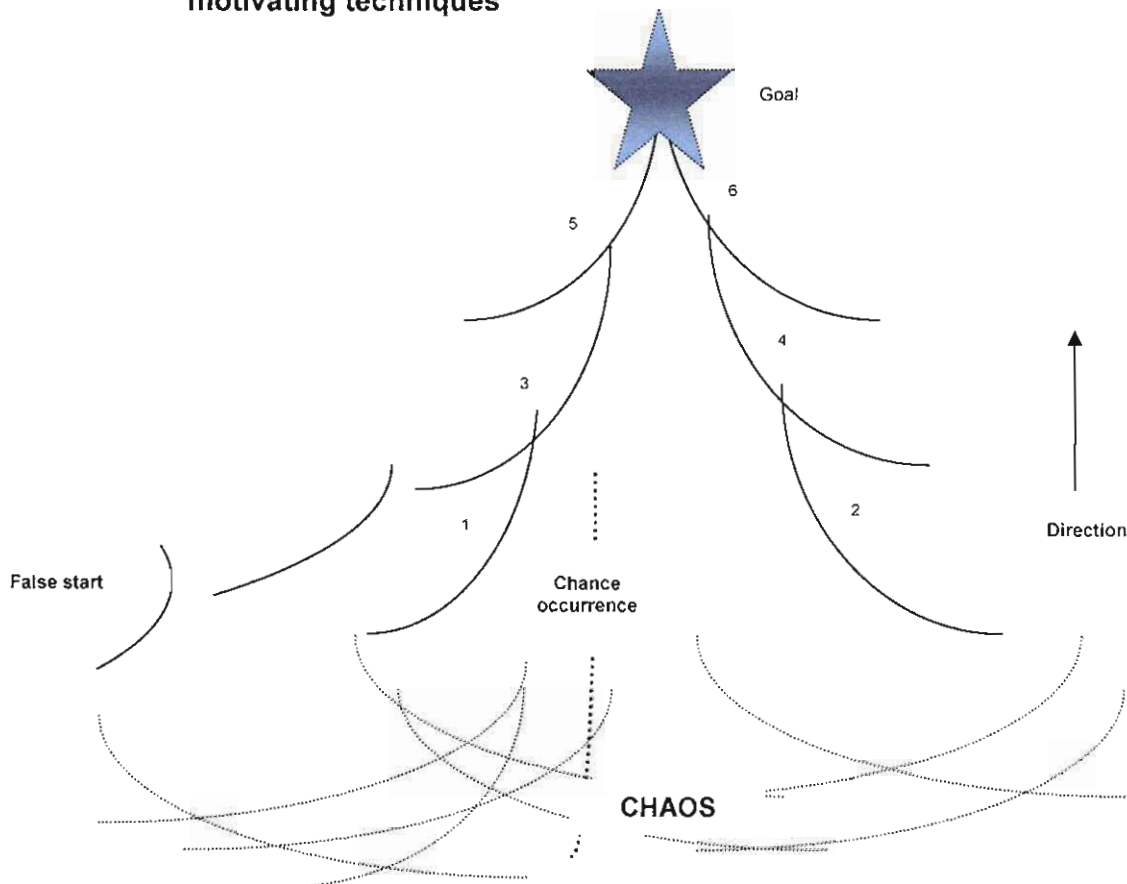
1. **Germination:** The creator feels energized, excited, has keen interest, obtains insight, realization and a sense of power are present.
2. **Assimilation:** This is an internalizing step.
3. **Completion:** Bringing to fruition, manifesting the whole, following through and learning to live with your creation. Not all people do this. Many might go through the germination and assimilation phases without following the idea through.

Fritz assumes that people are naturally generative and that the drive to create is independent of the circumstances of the individual. If a person wants to create something, he /she must first know what he/she wants. It is the most essential part of the creative process: a clear picture must arise. Then a structural tension arises between the vision of the result he /she wants to create and the current reality. This structural tension strives for resolution and drives the creative process. The discrepancy between what is wanted and what is, decreases and increases during the creative process (Fritz,1994:115-116). As one moves closer to the final completion, there is less discrepancy. The role of opposites is emphasized. Creative people have a higher ability to tolerate discrepancies than most others. They even appreciate and encourage it. Fritz opposes the idea that changes in circumstance can make people more creative. He is of the opinion that the desire to create comes from within. That is why, according to him, one must understand causality – why people and organizations act the way they do. Attention must be given to these underlying structures so that energy can be channelled differently. Otherwise it will keep following the path of least resistance.

Fritz's description of the creative process links up with a description given by Gruber

and Davis (1988:264-267). They emphasize that creative processes are time-consuming (months to years), difficult, improbable, new, effective and expected to have an outcome that will receive a favourable reception in at least some quarters. The description and figure 2.10 are interpretations of what they describe (*cf.* 2.2.3.2).

Figure 2.10: The creative process as an extended task requiring self-motivating techniques



Work starts in chaos. The creative person has a general idea of where he/she is going. The goal becomes clearer as work progresses. The task is often divided into sub-goals. The tasks (sub-goals) are pursued in a non-linear way. Knowledge is building up while working on task one. After a while no clear patterns emerge and the person becomes frustrated and de-energised. Work is abandoned on task one. In the meanwhile, task two, at this stage only indirectly related to task one, becomes attractive and a new focus of attention. This energizes the person and while working on task two, the focus is taken away from task one. This defocused attention may bring insight in task one's problem and can energize work on task one to be resumed. The body of knowledge and skills therefore grows from all sides as this rhythm of focus and defocus is perpetuated. The continuous alternation between tasks keeps the person motivated and interested and maintains an increasing sense

of awareness and interest. For some creative people this perpetual activity may be a coping mechanism developed to maintain psychological equilibrium and mental health.

2.3.4.4 De Bono's lateral thinking

Although both critical and creative thinking skills are addressed by De Bono's methods, he is very serious about creative thinking. He says:

"Critical thinking does have a part to play because if you know that your hypothesis is going to be criticized then you seek to make it stronger. But critical destruction of one hypothesis has never produced a better one. It is creativity that produces the better hypothesis. Culturally, we desperately need to break loose of the notion that critical thinking is sufficient." (De Bono, 2004:15)

Since 1967, Edward De Bono (2004:50) has used the term *"lateral thinking"* to specify the thinking process of changing perceptions during creativity. He explains that lateral thinking can be deliberate and formal and that tools exist for it. He describes the brain (2004:41) as an organ that organizes perceived information in a pattern. *"Once a pattern has been formed, the mind no longer has to analyse or sort the information. All that is needed is enough information to trigger the pattern."*

He further explains the concept of *"centering of patterns"*. In the absence of competing patterns, *"anything remotely similar to the established pattern will be treated as if it were the pattern"*. A further characteristic of this patterning is that the first information to go into the brain creates a channel in which the information following it will flow. The self-organizing patterning ability of the brain is used in processes such as **recognition** (recognizing familiar patterns), **abstraction** (pulling out hidden patterns), **grouping** (classification) and **analysis** (breaking down into familiar patterns and explanation without breaking into components). De Bono (2004:48) warns that although these patterns make it possible for us to make sense of the world, we must be aware that the *"repertoire of patterns which we have in our minds will determine all our thinking"*. From time to time a change of pattern is required (De Bono, 2004:51). The mechanisms for change of patterns are mistakes, accidents or humour, since working within the existing patterns will not lead to new patterns. Lateral thinking is defined as pattern-switching within a patterning system, to look for things in different ways (De Bono, 2004:55). In that sense, lateral thinking is seen as *"an attitude of mind"*.

Some of the numerous techniques proposed for critical and lateral thinking are: PMI (Plus, Minus, Interesting), CAF (Considering All Factors), C&S (Consequence and Sequel), APC (Alternatives, Possibilities & Choices) and "PO" coming from **hypothesis**, **suppose**, **possible** and **poetry** (2004:58) and meaning "provocative operation" or operating outside the judgment system. Methods such as "stepping stones", "escape" and "random stimulation" are derived from POS. The programme teaching these techniques and methods is known as the CoRT-programme (Cognitive Research Trust).

2.3.5 Neuro-scientific explanation

Technological advances in brain-imaging, especially since the early 1990s, allow researchers to observe the brain in action and lead to a rapid increase in information about the functioning brain. These techniques, known as PET (Positron Emission Tomography) and fMRI (functional Magnetic Resonance Imaging) show the part of the brain that is activated during a specific action or process. In PET-scans, radioactive substances like glucose, consumed by the active part of the brain, act as a signal that is picked up by sensors and fed into a computer. The fMRI detects differences in the way oxygenated and deoxygenated blood respond to magnetic fields (Audesirk, Audesirk & Byers, 2005:685). Other research instruments that are employed in the search for knowledge about how the structure and functioning of the brain interact includes electron-microscopy (Black, Isaacs, Anderson, Alcantara & Greenough, 2004) and mathematical modelling, coupled with in vivo, experimental observations and microscopic electrodes (Wen & Chklovskii, 2005).

Attempts to reconcile the varied research done by educationalists, sociologists, psychologists, technologists and neuroscientists on creativity and the creative process, lead Dietrich (2004:1011-1026), a cognitive neuroscientist, to a four-circuit model of creativity. This model can serve as a sensible and useful point of departure for explaining how learning and creativity relate and the relationship between intelligence and creativity.

In order to understand Dietrich's model, one needs to know the general outlay of the brain and specifically the forebrain: the seat of intelligent and creative thinking.

2.3.5.1 Brain anatomy that relates to the creative process

The forebrain is involved in intelligent behaviour and consists of the cerebral cortex, the thalamus and the limbic system. The cerebral cortex consists of two

hemispheres: left and right, and each of these consists of four lobes known as the Frontal, Temporary, Occipital and Parietal lobes (see figure 2.11).

The Temporary, Occipital and Parietal lobes (collectively called TOP) are involved in perception and long-term memory. They accommodate the input of the different sense organs, as well as associative areas for each. The associative areas are involved in memory, learning and reasoning. They associate incoming sensory information with information stored in the memory (leading to recognition) and with information coming from other sense organs (Audesirk *et al.*, 2005:680-686). The information is interpreted and meaning is given to it in the present context (Piaget's accommodation, assimilation, equilibration). Information items are stored in a highly redundant manner: thus colour, shape, odor and texture of a remembered item may all be stored separately and have to be recombined when one remembers the item (Scheibel, 1999). The frontal lobe has no sensory input. The anterior part of the frontal lobe, the **pre-frontal cortex**, is involved in self-reflected consciousness, complex social behaviour, abstract thinking, cognitive flexibility, willed action and integration of already highly processed information from the TOP. Certain areas in the pre-frontal cortex perform unique functions, such as the dorso-lateral pre-frontal cortex (DLPFC) acting as a **working memory buffer**, the site where bits of information meet in the conscious mind (like the RAM of a computer). According to Damasio (in Dietrich, 2004:1013), this seems to play an important part in creativity. The dorso-lateral pre-frontal cortex (DLPFC) of the left hemisphere is involved in **semantic memory retrieval**. **Sustained directed attention** is the responsibility of the right DLPFC. The ventral medial pre frontal cortex (VMPFC) is linked to emotions and is therefore critical in internalizing emotions. The VMPFC is connected to the **limbic system** that is involved in evaluation that is essential for creativity, ensuring logical, proper and rational decisions.

The brain's reward system is located in the **limbic system**. It consists of a diverse group of structures namely the **hypothalamus** (an important coordinating centre due to its neural connections and hormone production), the **amygdala** (the seat of fear, pleasure and sexual arousal) and the **hippocampus** (important in long-term memory) that work together to produce the most basic and primitive emotions. The **thalamus** is a complex relay system that channels sensory information to the limbic system and cerebral cortex.

2.3.5.2 A Four Circuit Model of Arne Dietrich (2004)

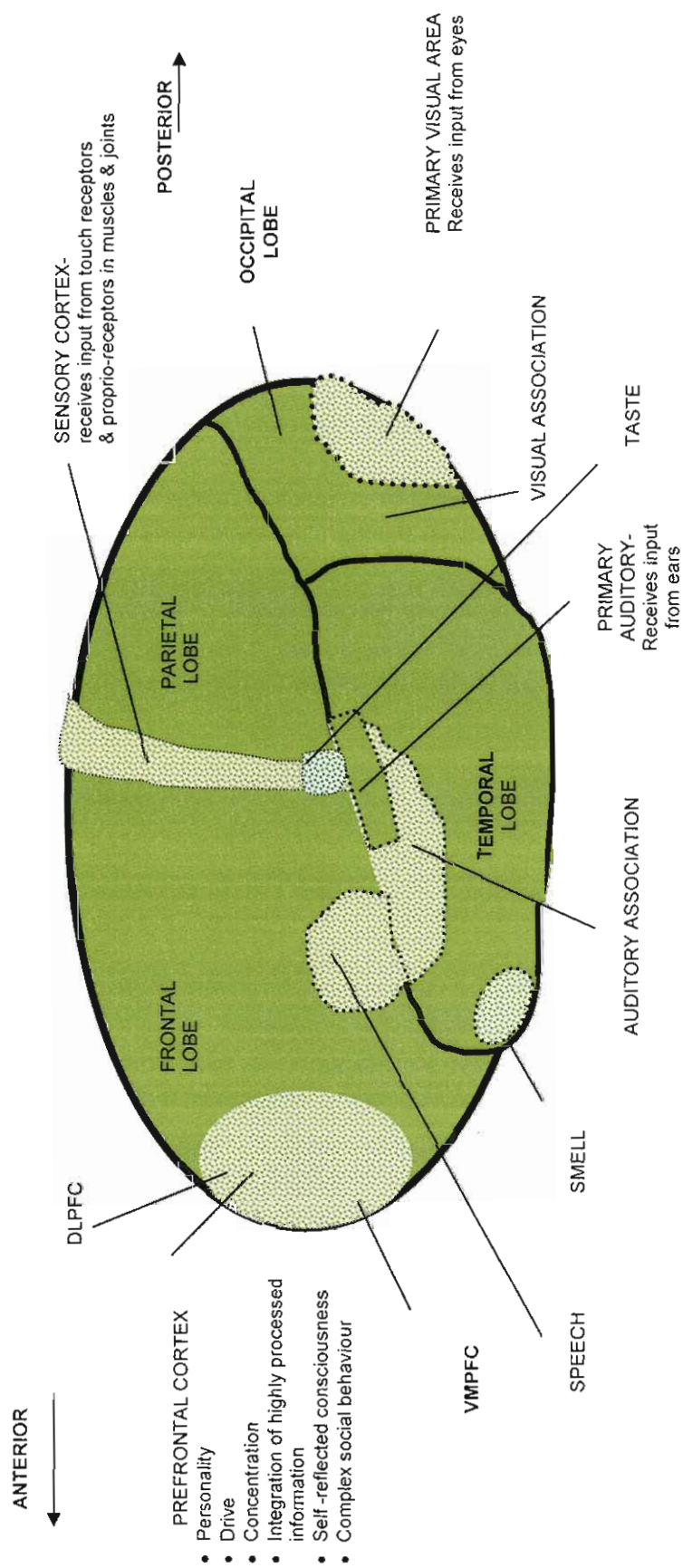
A creative insight comes as a sudden realization (Wallas's inspiration, *cf.* 2.3.2.1) in often a mental state of defocused attention (Wallas's incubation *cf.* 2.3.2.1). (Martindale, 1999:137-139; Nickerson, 1999:418), but can also come as a gradual realization as result of deliberate and methodical problem-solving (Sternberg & Lubart, 1999:7-8; Weisberg, 1999:233) or trial-and-error methods. Dietrich (2004:1016) explains the functioning of the human brain during creative problem-solving on the basis of classic and recent research. He proposes a model describing the brain as two parallel **information-processing systems** namely an **emotional brain** that attaches value to incoming information and evaluates it and a **cognitive brain** that analyses information. Further, he describes two **processing modes** namely **spontaneous** and **deliberate**. Cross combinations of these modes and brain types bring one to four types of creativity that are basic elements of information processing namely: Deliberate mode-Cognitive structure, Spontaneous mode-Cognitive structure, Deliberate mode-Emotional structure and Spontaneous mode-Emotional structure. Dietrich's model is summarized below and integrated with Wallas's model.

2.3.5.2.1 Deliberate mode-Cognitive structures

Examples of this mode are: the methodical step-by-step process in unravelling the structure of the DNA-molecule, Edison's experimental work to develop the light bulb and TRIZ.

The prefrontal cortex instigates this mode when the **frontal attentional network**, acting like a search engine, is recruited to search for task-relevant information in the parts of the brain with sensory input, namely the Temporal, Occipital and Parietal lobes of the cerebrum (*TOP*). The prefrontal cortex pulls task-relevant information from the TOP when **higher cognitive functions** in the prefrontal cortex manipulate the information in the TOP. It then presents this information in the **working memory buffer**. Recent memory from the hippocampus is recruited. New combinations can be formed, using its capacity for cognitive flexibility (Dietrich, 2004:1016).

Figure 2.11: A transverse section through the human cerebrum showing its different lobes, primary sensory input and associative areas



According to Damasio (in Dietrich, 2004:1016) the **working memory buffer** operates under constraints that may inhibit creative problem-solving. Three of these constraints are discussed here:

1. The prefrontal cortex is the part of the brain through which humans recognize and assume the habits and constraints of culture. Cultural values, belief systems and preconceived mental structures, predispose a person to retrieve knowledge that is consistent with his/her world-view and past experiences. One often needs special techniques to break these logical and entrenched patterns or paradigms (like De Bono's (1993:183-199) provocations).
2. The limited capacity of the working memory buffer is a further constraint for deliberate creativity because it constrains the number of possible combinations of ideas. A nimble prefrontal cortex is linked to the capability of playing with new combinations of stored items and improving the chance of an exotic synthesis - a new idea (Scheibel, 1999).
3. The success of this process further depends on the amount of relevant domain specific information available in the TOP.

2.3.5.2.2 Spontaneous mode-cognitive structures

Examples of this mode are: the discovery of the benzene ring by Kekulé, Einstein's concept of relativity, Newton's law of gravity and Archimedes' principle.

The spontaneous processing mode is seen as the underlying mechanism for intuition that is closely related to insight (the eureka phenomenon). Spontaneous insights are **not** initiated by prefrontal cortex data searches. They arise instead from the TOP – lobes of the brain where long-term memory is stored in associative networks (Hebb and Gabrieli (in Dietrich, 2004:1017). They originate in the subconscious as a result of a spreading activation through a knowledge-based network in the TOP lobes. They can be assembled subconsciously and represented in the conscious working memory buffer in their finished chunked form (*cf.* 3.5.3.4) as a new and sophisticated Gestalt (*cf.* 3.3.2.1). This results in a mental state of knowing without intentional reasoning. Spontaneous insights are not limited by the same constraints as deliberate insights like the limited capacity of the working memory buffer (the information is already chunked) nor the limitations of paradigms (the associations are made in the TOP without the censure of the prefrontal cortex: they can therefore be wild and bizarre). Being in an altered state of consciousness, as when the attention is

defocused, plays a vital role in the creative process. In this reverie-like state, when dreaming or daydreaming, thought is associative and a large number of representations are simultaneously activated. This state arises in three ways: low levels of cortical activation (when a person has access to primary thought processes), comparatively more right than left hemisphere activation and low levels of frontal lobe activation (the centre of cognitive inhibition).

Segal (2004:141-148) explains insight in a different manner, using the "attention-withdrawal" hypothesis. One may be trapped in a wrong Gestalt or schema (false organizing assumption) that may block a problem-solving or learning process. To escape the false organizing assumption one needs to get in a state of defocused attention regarding the current task (like when one focuses on another task). Simon (in Segal, 2004:142) asserts that during this time of defocused attention, the irrelevant material decays in the working memory (*cf.* 3.3.1.3.2) while the long term memory accumulates more substantial information and the senses more information from the environment. Segal (2004:147) proposes that nothing happens during the period of defocused attention, but it allows the individual to apply a new organizing principle.

Wallas's creative process may now be explained in new terms:

1. **Preparation phase-development of expertise:** Expertise is developed through learning when relevant information is committed to the memory in the TOP.
2. **Incubation:** According to Finke the problem is removed from the conscious awareness thereby relaxing the constraints so that new perspectives could be gained (in Sternberg & Lubart, 1999: 7; Segal, 2004:141-148). The problem is therefore given over to the spontaneous mode (described by expressions such as "sleep on it"). In the long-term memory in the TOP, associative unconscious thinking is taking place and/or wrong assumptions decay and new ones are formed.
3. **Inspiration:** A seemingly effortless solution arises as if out of the blue: the "Aha!" This represents a surprise violation of existing associations and activates the DLPFC when it comes out of the blue into the working memory buffer.
4. **Verification:** The *limbic system* is employed to evaluate the insight to determine its propriety and validity.

Once a novel idea has been generated, spontaneously (intuitively) or deliberately (through analysis) the roles of the prefrontal cortex are to:

1. evaluate the appropriateness of a novel thought;
2. bring into action the higher cognitive functions such as directing and sustaining attention, retrieving relevant memories and ordering information; and
3. implement the expression of the insight through goal-directed behaviour.

2.3.5.2.3 Deliberate mode-Emotional structures

Examples of this mode are insights gained during psychotherapy.

The frontal attentional network instigates this mode. The TOP areas are searched for affective memories. The result of this search is temporarily presented in the working memory buffer where it is consciously manipulated for further insights. Basic emotions are processed in the limbic system structures and VMPFC. Due to neuro-anatomical limitations, emotional insights that arise from basic emotions are unlikely. Insights based on complex social emotions can occur due to extensive connections between the VMPFC and the DLPFC. Prefrontal involvement in the process makes it inevitable that the insights will conform to a person's norms and values. These insights are independent of domain-specific knowledge.

2.3.5.2.4 Spontaneous mode-Emotional structures

Examples of this mode are paintings and poems where emotion is expressed.

According to Torrance (in Dietrich, 2004:1020), emotional experiences create a strong need for creative expressions. Spontaneously generated emotional information that enters the consciousness has a profound effect referred to as revelation, epiphany and may contain universal truth. This type of processing is not domain-specific, but might require specific skills for appropriate expression.

From the discussion above, one can deduce that the ease with which the subconscious thoughts are interacting and the accessibility of the subconscious thoughts to the conscious person, play important roles in creativity.

2.3.6 The creative process in Technology Education

In Technology Education emphasis is generally put on teaching and executing the Technological process. It is seen as the backbone of the learning area. During

investigative tasks, scientific processes may also be used to discover or verify facts and gather data. Overemphasis on following a certain predetermined set of steps is seen by some as problematic. Research, quoted by Williams (2000:49), has shown that a scientific process (as also a Technological process) is NOT generalizable. *"Neither students nor designers naturally utilize a predetermined process in their work. They invent a process as they proceed towards task completion. The process format is more a way of reporting than a way of working."*

Hodson (in Lewis 1999:54) criticizes the attempts of educationalists to enforce process approaches like discovery learning and constructivism onto science, since they misconstrue the real nature of science. Processes have their place, but *"doing science is a holistic and fluid activity, not a matter of following a set of rules that requires particular behaviours at particular stages"*.

Although the sequence and the precise steps followed may therefore differ from researcher to researcher and among designers, the described processes give an overview of possibilities. Some of these possible steps in the scientific method and the Technological process may be singled out for the opportunities that they provide for creativity and where teachers, if aware of them, can attempt to enhance creativity.

Using an integrated problem-solving approach, may give one an opportunity for developing creativity through Technology Education. Deliberate and/or spontaneous cognitive structures are implicated in creativity in Technology Education. The NCS policy of the Learning Area Technology (Department of Education, 2002:5) explains that one of the unique features of the learning area is that it gives learners the opportunity to *"solve problems in creative ways"*. Creative thinking is further given as one of the life skills addressed by this learning area. The Technological process lends itself naturally to the stimulation of creativity. Every step of the technological process, which is a specific application of the Creative Problem-Solving Process (Isaksen *et al.*, 2000:38), goes through consecutive stages of divergent and convergent thinking. For example, the opportunity /problem-finding step firstly goes through a divergent stage where all possible opportunities /problems are investigated within the situation. This is followed by convergence, when the most promising opportunities/ problems are identified. The same happens during the research phase (data exploration), design (idea generation), planning and making (solution development) and presentation phase (acceptance finding). Other processes involved in Technology Education are systems approach, invention and manufacturing (Williams, 2000:52-54). Four processes, namely investigation, design,

problem-solving and invention, will be discussed briefly below.

Investigation: The investigation phase aims to get a clear picture of the situation, the possibilities and the restrictions and to find a problem that could be solved. Problem-finding is a process requiring creativity. According to Einstein (in Soper 2003:951), *"the formulation of a problem requires creative imagination and marks real advance in science"*.

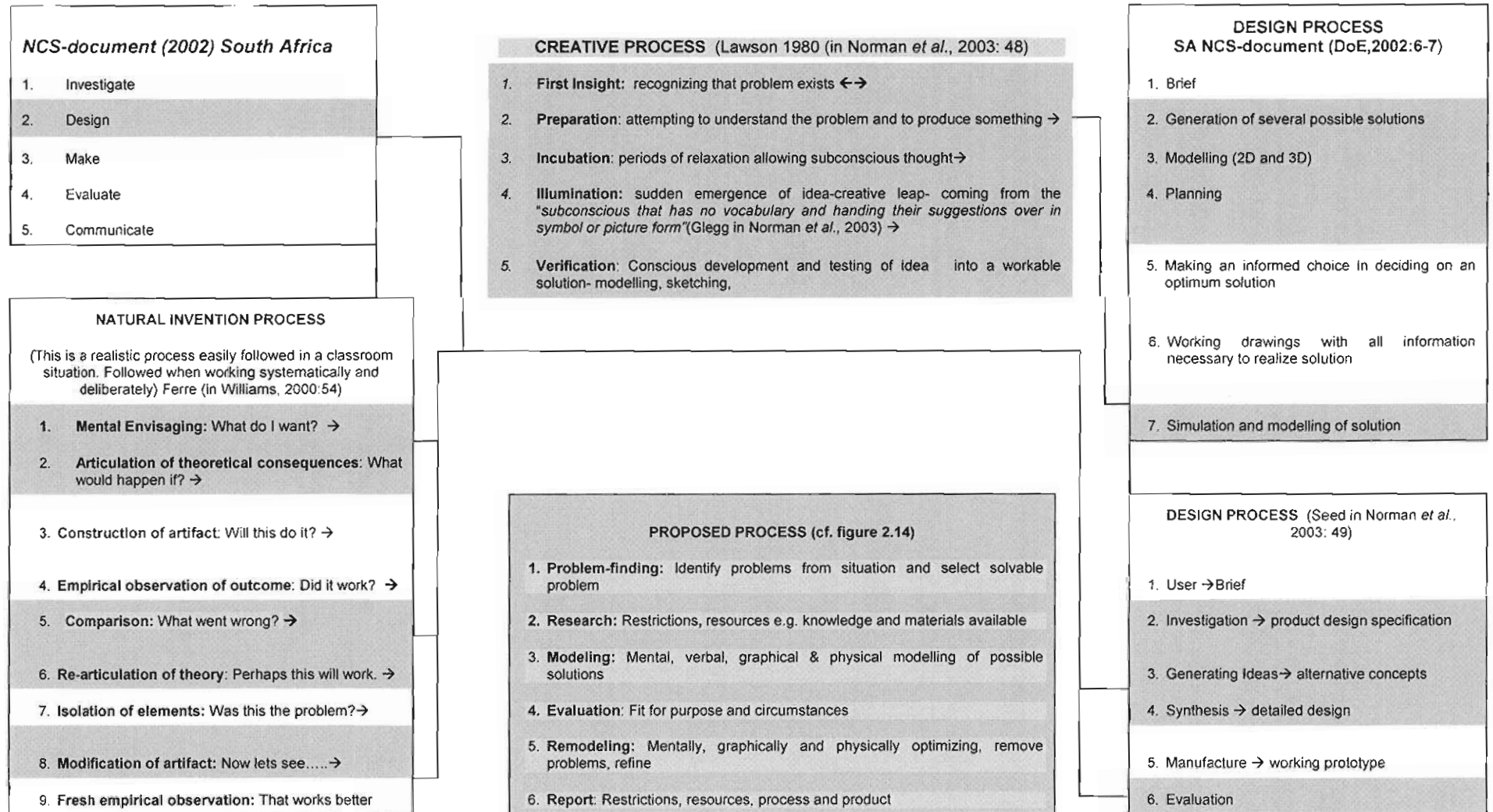
Design: Norman, Cubitt, Urry and Whittaker (2003:47) define design as *"the conceptual processes which bring products and systems into being"*. Baynes (in Williams, 2000:54) describes the design process as non-linear, *"not always starting from human needs, not necessarily orderly, reiterative processes spiralling back on themselves and proceeding by small incremental changes and occasional flashes of insight"*.

Often textbooks give the steps of the design process as brief, investigation, generating ideas, synthesis, manufacture and evaluation. The South African NCS document (Department of Education, 2002:6-7) gives the steps of the design process as: Investigate, Design (verb), Make, Evaluate, Communicate. The design step is further explained as Brief, Generation of several possible solutions, Modelling (2D and 3D), Planning, Making an informed choice in deciding on an optimum solution, Working drawings with all information necessary to realize solution, Simulation and Modelling of solution. Feelings may play a role in design processes especially in choice of colour, textures and other aesthetic aspects. Emotional deliberate structures may therefore be involved (proposed integrated model in figure 2.13).

Problem-solving: Problem-solving is sometimes seen as an approach to design (Williams, 2000:52-54; Liddament, 1994) (as creativity and problem-solving are also sometimes seen as similar). The NCS document (Department of Education, 2002:6-7) emphasizes that the processes and skills of Learning Outcome #1 are directed towards the development and implementation of practical solutions for realistic problems and needs. The CPS and Amabile's models are similar to this proposed process (*cf.* 2.3.2.6 and 2.3.4).

Invention: Ferre (in Williams, 2000:54) distinguishes between accidental (cognitive structure spontaneous?) or intentional invention (cognitive structure deliberate /mixed?). Accidental invention happens by trial-and-error and is associated with

Figure 2.12: Some of the processes used in technology education and the place of the creative process in the design process



practical intelligence. This model corresponds with Gruber and Davis's (*cf.* 2.3.4.3) description of the creative process. Intentional invention is deliberate and systematic, associated with theoretical intelligence. Figure 2.12 indicates some of the processes used in technology and how they link with the processes discussed earlier (*cf.* 2.3.2 and 2.3.4).

2.3.7 Enhancing creative process skills using Technology Education

The Technological process as part of the methodologies of Technology Education gives opportunities for developing creative process skills such as fluency (many ideas), originality (new ideas), flexibility (ideas from different categories) and elaboration (adding detail to ideas) (*cf.* 2.2.2.1.2). The mental habit, skill and ability to alternate appropriately between divergent and convergent thinking may be developed by allowing for brainstorming sessions on different levels (individual, group, class) during which judgment is withheld, alternating with evaluation sessions during which optimum answers are selected. This may lead to an attitude of openness to alternatives and different perspectives, an active effort to find and eliminate causes and factors leading to the situation in appropriate ways, rather than just looking for superficial and existing solutions. An increasingly clarified aim and focus may help students to stay motivated.

A variety of descriptions (see table 2.4) are found in the literature, all trying to describe the so-called Technological process. They range from processes like the five-step process described in the South African NCS (Department of Education, 2002:6-7), to reiterative processes such as the Natural Invention Process of Ferre (in Williams, 2000:54). Potgieter's (1998) version of the Technological process (design process) was followed in this study. It includes the steps investigate, design, plan, make, evaluate and communicate. It differs slightly from the process as described in the South African NSC document (Department of Education, 2002:6-7) that gives the steps of the design process as: investigate, design (verb), make, evaluate, communicate. The planning phase of Potgieter's description of the process is part of the design process in the NCS document. These differences are, however, mere technicalities and refer more to the format used when the project is finally recorded.

The different phases of this process as described by Potgieter (1998) will be overviewed below. Specific opportunities for creative work are discussed after a description of each of the steps. Although the process is presented as a linear process, it may be applied in both linear and integrated ways.

The **Investigation phase** is described as:

1. **Investigate situation:** Identify situation, observe situation to identify main characteristics and parameters, describe situation from a historical, cultural, economic, agricultural and environmental perspective and describe situation in terms of aspects that relate to the problem or need.
2. **Identify the real problem:** Determine whether the **apparent** problem is the **real** problem, determine whether the apparent problem can be translated into a real problem, identify the primary problem or need, determine whether there are any secondary problems impacting on the primary problem, identify and explain the real problem or need by distinguishing it from the secondary or apparent problems.
3. **Collect information about the problem:** Research the real problem, collect information on: persons with need/ problem, functions, materials, durability, appearance, processing, manufacturing methods, storage, ergonomics, safety, cost, care, environmental impact, finishing, shape, size. Organize, sort and record the information that you collected according to the relationship between it and the problem or need.
4. **Analyse the problem:** Interpret the information above in terms of the importance or priority in relation to the problem or need, describe the problem or need in terms of its components and describe the effect of every component on the problem or need.
5. **Write the brief:** Give relevant background information on the situation, give a general, but clear description of the real problem, describe the problem or need in terms of its components, explain the effect of every component on the real problem and list the relevant specifications, parameters, restrictions that might influence the possible solutions.

The investigation phase involves mainly analytical thinking: information is gathered and processed. Going through it should ideally lead to clarity about the situation, the factors that have an impact on it and restrictions that might influence the possible solution. Cognitive skills like gathering and selection of relevant information, data processing, interpretation of data and comparing information are useful in this phase. People with well-developed creative abilities may, however, already see the problem or need in the situation in different ways than people with less well-developed

creative abilities. For example: A lack of firewood in a rural area may be seen by some as the problem of a lack of electricity (because this is the logical and common perspective in the current urbanized society and forces the future solution in a certain direction). This response may, however, be seen as a case of premature closure (*cf.* 4.6.1). People with better-developed divergent abilities may have a wider perspective and open up the problem to be solved in a variety of ways, such as when seeing the problem as an energy crisis instead of a lack of electricity.

The **design phase** is described as:

1. **Preparation phase:** Generate many ideas, generate different ideas, generate ridiculous ideas and add on to improve
2. **Incubation phase:** Replace, combine, enlarge, modify, use for another purpose, rearrange, turn around, adapt, reduce, eliminate and add on
3. **Inspiration phase:** Identify ideas with merit, identify possible solutions, select the optimum solutions and refine the optimum idea
4. **Verification phase:** Verify the viability of the selected idea to see whether it is a good answer to the problem and satisfies the need / solve the problem and keep to the specifications
5. **Design document:** This document must be such that an independent person must be able to evaluate the possible solution, its applications and implications.

This is the phase that depends heavily on divergent thinking and creative abilities like fluency, originality, elaboration and flexibility (*cf.* 4.6.1). It may come in handy during the idea generation phase and may help an individual to go beyond the well-known solutions to the identified problem. The steps in this phase correspond with Helmholtz and Wallas's steps of the creative process (*cf.* 2.3.2.1).

The **planning phase** includes activities such as listed below:

1. **Specifications:** Must contain detailed information regarding: function of solution, reliability of solution and its parts, general appearance of the prototype, shape and size of prototype, final finishing requirements of prototype, type and amount of materials to be used, production methods that will be used, cost requirements of prototype, ergonomic requirements of prototype, environmental impact requirements, safety requirements regarding the prototype, storage requirements

of prototype, maintenance requirements of prototype and packaging requirements of prototype.

2. **Working drawings** must contain all the details regarding construction and production, contain enough information to enable a person to mark out materials accurately without wasting materials, be easy to understand and agree with the information in the specifications.
3. **The Production schedule** consists of a sequenced list of tasks, with the tools, materials, time and manpower needed. A flow chart is usually used to show which tasks will be done simultaneously and which tasks must be done before another can be tackled, as well as the stages where control and report-back will be done.

The **evaluation phase** includes:

1. **Developing an evaluation procedure:** Decide what must be evaluated, why, how and when it must be evaluated, the evaluation criteria that will be used and the format of the evaluation report.
2. **Formative and continuous evaluation:** To ensure that the product will be of high standard in the end, any mistakes in design, for example, must be picked up and corrected.
3. **Summative assessment:** At the end of the process an assessment will determine how successful the whole project was and how it can be improved.
4. **Evaluation Report:** The report summarizes the findings of the different evaluations that were done.

The generation of evaluation criteria requires creative and critical thinking abilities. The criteria must relate to the specifications, be relevant in the specific situation, but may also be original.

The **communication phase** includes:

1. **Situation, target group and needs analysis:** To determine possibilities and restrictions regarding presentation and communication. Who are the people to whom I must "sell" this idea?
2. **Determining the information needs of the target group:** To determine the type

of presentation that would be suitable. What will interest them? On what level must I present the information?

3. **Formulating of objectives:** To explain the purpose of the presentation: What do I want to reach with this presentation?
4. **Selection and structuring and programming of content:** To ensure smooth and cohesive presentation to form a logical interesting sequence.
5. **Visualizing content:** To make the presentation interesting, consumer-friendly
6. **Selection of media**
7. **Integration of media:** To avoid fragmentation so that presentation can be presented as an integrated unit.
8. **Design of presentation**
9. **Production of media:** Design of script: pictures and text. The media selected above are produced.
10. **Evaluation of presentation:** Before it is implemented, the whole presentation is evaluated.

The communication involves designing a presentation and is a highly creative task. It repeats the whole technological process, but now for the design of the presentation instead of for the product.

In conclusion: Fritz emphasizes the idea of knowing where you are going, getting a clear picture of your goal in creative work. In ordinary learning processes, the effectiveness of this idea is well-known. Mastery learning emphasizes that outcomes must be clearly stated for effective learning to occur. Ausubel names these outcomes "*advance organizers*". The basis of the Gestalt theory is "*seeing the big picture*". All of these point to the importance of creating a potential difference between where you are and where you are trying to go (*cf.* Chapter 3).

Proper problem analysis with research to find out all the details about the problem from literature and in the practical situation, researching the available knowledge already collected by other researchers, helps to attain a clear picture of the situation as it is here and now. Diverging techniques such as brainstorming as a group, but especially also as individuals, can help to clarify the current situation. The idea is to

create dissatisfaction and frustration with the current state of affairs, involving the cognitive and affective domains.

To get a clear picture of the goal mentioned by Fritz (1994), the following techniques might be useful: The creation of physical and/or mental models (Davies & Gilbert, 2003), role-play, drafts, one page proposals (Cronje, 2005), initial sketch, visualizing, communicating, discussing and brainstorming the goal (*cf.* 2.3). It may be seen as a process of self- and/ or group-hypnosis where the subconscious is involved in creating the picture of success, fulfilment and achievement once this problem is solved. The individual/group becomes willing to sacrifice time and resources, and to invest large amounts of energy into the pursuit of this goal.

Edison, for example, had a picture in mind when he developed a motion picture camera, to do *"for the eye what the phonograph does for the ear, which is the recording and reproduction of things in motion, and in such a form as to be both cheap, practical and convenient [by] photographing continuously a series of pictures occurring at intervals... in a continuous spiral on a cylinder or plate in the same manner as sound is recorded on a phonograph"* (Gorman 1999).

Ings (2001:10,14 and 17) suggests the use of *intimacy* (personal experience and personalisation of products), *synergy* ("marrying incompatibles") and *translation* (transfer of experiences between fields) given in briefs to stimulate creativity and increase motivation. Other methods to stimulate the creative process are further described in the International Technology Education Association's (ITEA) Standards for Technological Literacy (2000). They are tabulated in table 2.5.

Table 2.4: Examples of steps usually followed in technological process

Policy documents (Department of Education, 2002)	Design Process (Norman <i>et al.</i> , 2003: 49)	Design Process (Lawson in Norman <i>et al.</i> , 2003: 48)	Natural Invention Process (followed when working systematically and deliberately) (Ferre in Williams, 2000:54)	Design Process: Cross (in Norman <i>et al.</i> , 2003: 48)
1. Investigate 2. Design 3. Make 4. Evaluate 5. Communicate	1. User →Brief 2. Investigation →Product design and specifications 3. Generating ideas→alternative concepts 4. Synthesis →detailed design 5. Manufacture →Working prototype 6. Evaluation	1. First Insight: recognizing that problem exists 2. Preparation: attempts to understand the problem and to produce something 3. Incubation: periods of relaxation allowing subconscious thought 4. Illumination: sudden emergence of idea-creative leap 5. Verification: conscious development and testing of idea into a workable solution	1. Mental Envisaging: What do I want? 2. Articulation of theoretical consequences: What would happen if? 3. Construction of artifact: Will this do it? 4. Empirical observation of outcome: Did it work? 5. Comparison: What went wrong? 6. Re-articulation of theory: Perhaps this will work. 7. Isolation of elements: Was this the problem? 8. Modification of artifact: Now let's see..... 9. Fresh empirical observation: That works better	1. Client' area: nebulous ideas→Brief: 2. Ill-defined problem 3. Designer's area → 4. Well defined solution 5. Manufacturer's area: →specific object 6. As the task progresses from 1-3, it moves from vagueness to clarity and from many possibilities to one agreed-upon solution.

Table 2.5: Methods and techniques to stimulate creativity (Summarized from ITEA's Standards for Technological Literacy (ITEA:2000))

Methods and techniques	Examples in document
Brainstorming (Osborn)	Product characteristics (2000:70) In teams (2000:93) Possible design ideas (2000:96,122, 123) Possible methods (2000:101) As group problem-solving method (2000:103) As benchmark (2000:212)
Case studies	Creative thinking in past innovations (2000:25) Effects of creative thinking, culture and economics (2000:26)
Visualizing	Visualizing (2000:93)
Providing an encouraging environment	Team work Encouragement and rewards (2000:93) Group collaboration (2000:105) Open atmosphere Encourage creativity (2000:99) Used in assessment "Creativity of the design" as assessment criterion (2000:172)

2.3.8 Critical evaluation

Four different schools concerning the starting point of the creative process are identifiable from the ones discussed in this chapter, namely:

1. The problem /situation as the starting point (Amabile, Altshuller, CPS)
2. Idea (concept, inspiration) as the starting point (Fritz, Piskoppel, Finke)
3. Skill and knowledge acquisition as the starting points (Wallas, Shu Ha Ri)
4. Preparation through processes such as meditation as the starting point (Maduro, Chaudhuri, Kris)

For different people, different styles, different domains or different circumstances any one of the above-mentioned may be the starting point. The same people may start at different places in different tasks. Figure 2.13 illustrates a variety of available options. A foundation is always present. It comes from the domain that is part of

culture. Whichever way the culture is acquired and whether it will be supporting the processes that ought to follow, are discussed in section 3.3.3.2. For example, when a well-defined problem is given to a student or engineer, he/she will start at the problem and then start finding out about the background, restrictions and relevant knowledge. In real-life situations, skill and knowledge acquisition may occur first on a subconscious (unintentional) or conscious (intentional) level, leading to an identified problem or idea. In domain-dependent creativity such as seen in specialist fields (science and technology), the problem can be an unresolved conflict or an observed need. For both domain-dependent creativity, such as an engineering problem and domain-independent areas of creativity such as expressive creativity, an idea may arise seemingly out of nowhere. The effortless appearance may be an illusion because preparation may have taken place on a subconscious level. The idea may be followed by further intensive and deliberate knowledge and/or skill acquisition fuelled by curiosity and the tension between the envisaged resolution and the chaotic/unresolved current situation or unexpressed emotion.

In cognitive structure creativity, the amount of relevant knowledge available in the associative areas of the temporal, parietal and occipital lobes is important. Skill and knowledge acquisition may then usually be the starting point. Both an agile prefrontal cortex, practised in the skills of using higher cognitive functions and relevant domain-related knowledge, are important. Masses of knowledge without an agile prefrontal cortex would bring no contribution. If no relevant knowledge is committed to the memory, a nimble prefrontal cortex has nothing to act on.

A challenge /problem may arise from the knowledge acquired. The Shuhari concept and the 10-year rule emphasize the development of domain-specific knowledge and skills that lead to automatic retrieval of routines even without thinking. This may lead to chunking of knowledge in Hebbian connections (*cf.* 3.3.1.2). TRIZ, CoRT and CPS (*cf.* 2.3.4) try to minimize the need for the agile prefrontal cortex by providing elaborate checklists that may be consulted and /or techniques that may be used. The integrating function of the prefrontal cortex is therefore partially eliminated because combinations are formed on the cross points of the checklists. This eases the burden on the prefrontal cortex and avoids psychological inertia where a similar solution lies outside the domain.

For domain-independent processes, a repertoire of feelings and impressions may be required. This may be assembled subconsciously and consciously. Certain skills and techniques, necessary for appropriate expression, may be acquired through training.

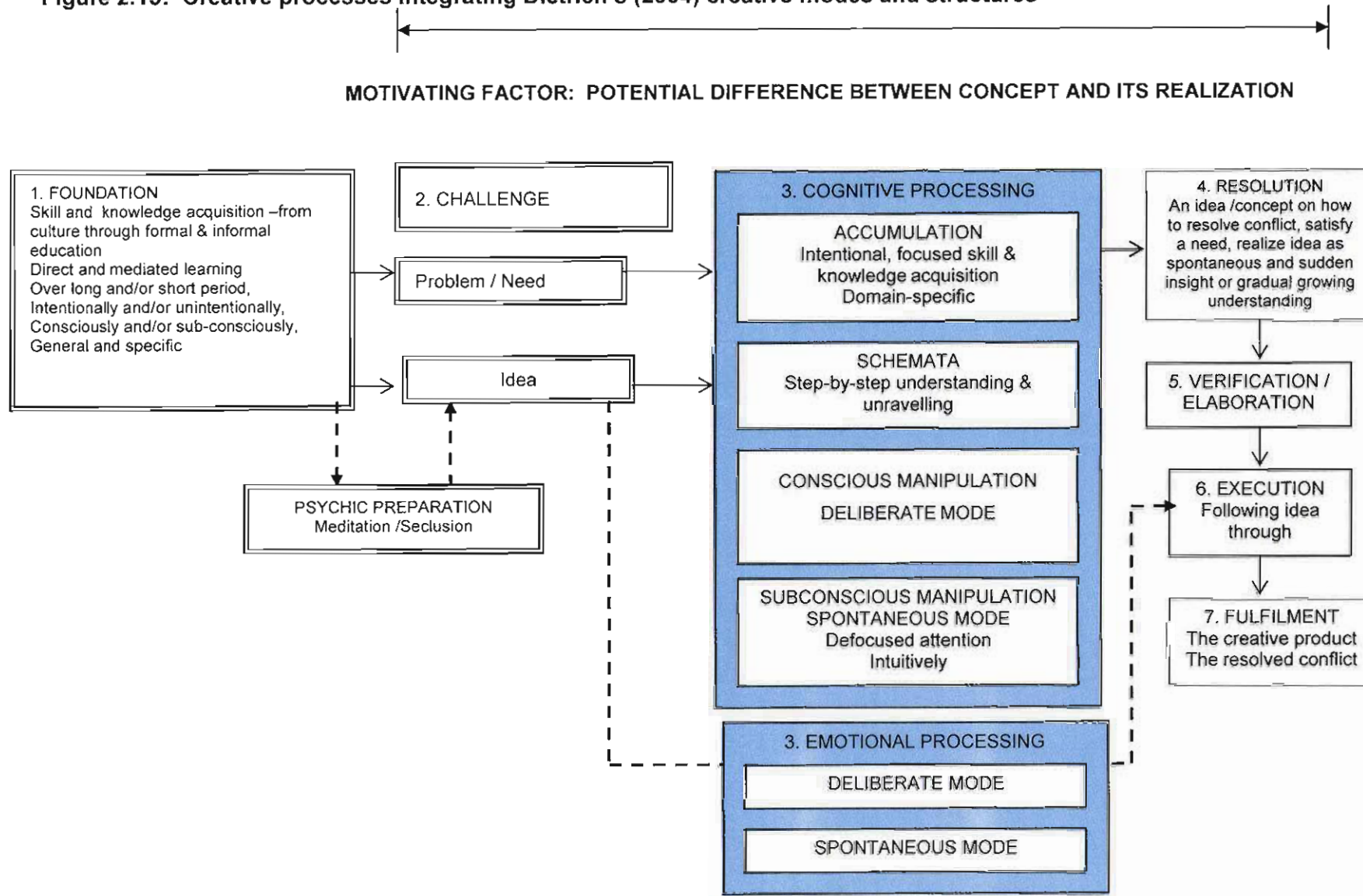
Although Fritz's model also describes a process from an artist's perspective, this model may be applicable to many creators and corresponds in broad terms to the natural invention process described by Ferre (in Williams, 2000:54). Once an engineer or scientist is inspired by a dream and passionate to solve a specific problem/ riddle, he/she will go to great lengths and make many sacrifices to realize it. Processes like knowledge and skill acquisition, finding the resources and optimizing the design, then become urgent, focused and driven from within. Frank Whittle (2007) may be given as an inspiring example of this phenomenon. He was the British inventor of jet-propelled engines for aircraft. He revolutionized aviation despite his struggle with ill health, lack of resources and the little assistance or recognition he received. He worked under constant stress with severe financial and time constraints, to realize his dream (Biographies-History Channel).

The Eastern descriptions by Lubart (1999:340-343) and the African artists (*cf.* 2.3.2.2) are for artists who have to pull on emotions and feelings. These processes are domain-independent and are mostly perceived as resulting from "inspiration" attributed to inner emotions, ancestral spirits or the muse.

The mental processes involved in the creative process are not unique to typically creative people. They can also be observed in most people in their daily lives. When, for example, one is looking for a lost object, one is often surprised that one remembers where one left it the moment when one stops fretting about it, therefore when attention is defocused. What might be different in people recognized as creative are factors like the scale on which this process occurs, the attention given by the individual to the problem, the perseverance of the person involved in solving the problem, the context where it occurs, the visibility of the outcomes to the society, the relevance and significance of the problem and the creative product to others and the consequential value attached to the solution by the individual and the society.

One may, based on these few examples, conclude that the creative process followed may depend more on the individual's creative style and the type of work (domain-dependent or domain-independent) than on his/her culture. In an educational context one wants to optimize conditions so that the necessary skills and knowledge, appropriate behaviours, habits and attitudes that enhance creativity can develop. On the other hand, one also wants to avoid inhibition that sabotages natural and learnt behaviour that is promoting creativity.

Figure 2.13: Creative processes integrating Dietrich's (2004) creative modes and structures



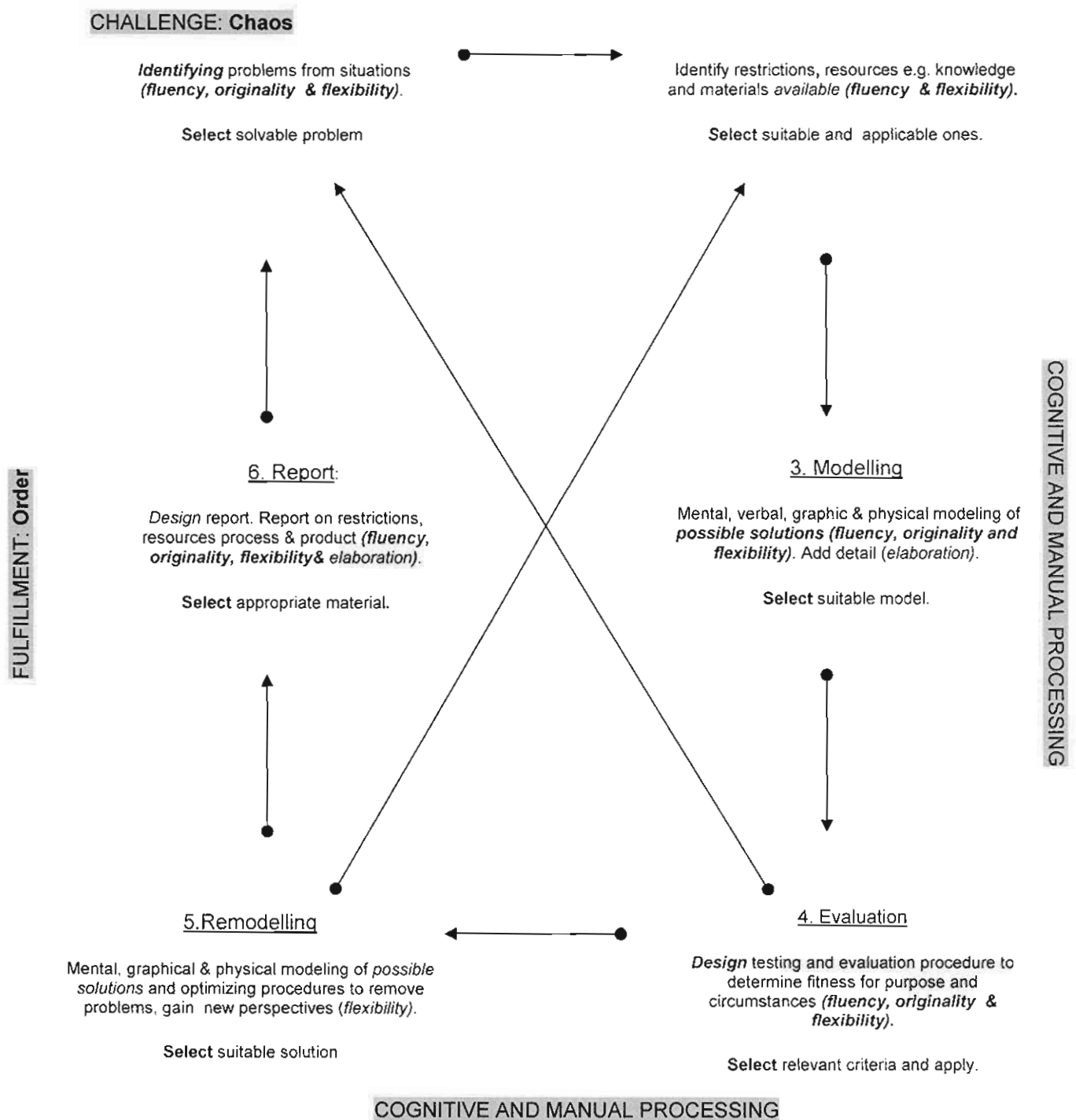
Attention to the barriers that inhibit the proper functioning of creative processes in education students should be one way to enhance their creative output. Technology Education is ideally suited to help students to overcome process-related problem-solving skills. The creativity promoting steps in the design and scientific processes, both used in Technology Education, may be utilized to help students with aspects like the inability to focus and direct problem-solving activities, to generate and identify options, to turn ideas into actions, solution fixedness and premature judgement. Techniques used in industries and the business world, such as brainstorming, CPS and TRIZ (cf. 2.3.4), may be used to support students' process skills, idea generation and associative skills. The initial clear vision of exactly what one wants to achieve during the creative process, suggested by Fritz, Finke and Piskoppel (cf. 2.3.2.4, 2.3.2.5), is essential since it increases focus, motivation and attitude. Visualization, diagrams, verbal descriptions, models and mind-maps may be techniques that may help students to form clear images. According to Sternberg and Lubart (1999:7-8) and Ward, Smith and Finke (1999:206), mental processes, such as the use of metaphors, diagrams, *"retrieval, association, synthesis, transformation, analogical transfer, and categorical reduction"*, are employed fruitfully in creative processes and should therefore be developed. Besides this, the knowledge base of the students should be broadened and deepened to provide knowledge that the brain can juggle with (cf. 2.3.5.2).

The model, given in figure 2.14, suggests and supports broadly alternating divergent and convergent steps in every phase, while also supporting knowledge acquisition (research). Opportunities exist within every phase for diverging (indicated in **bold italics**) and converging (indicated in **bold**).

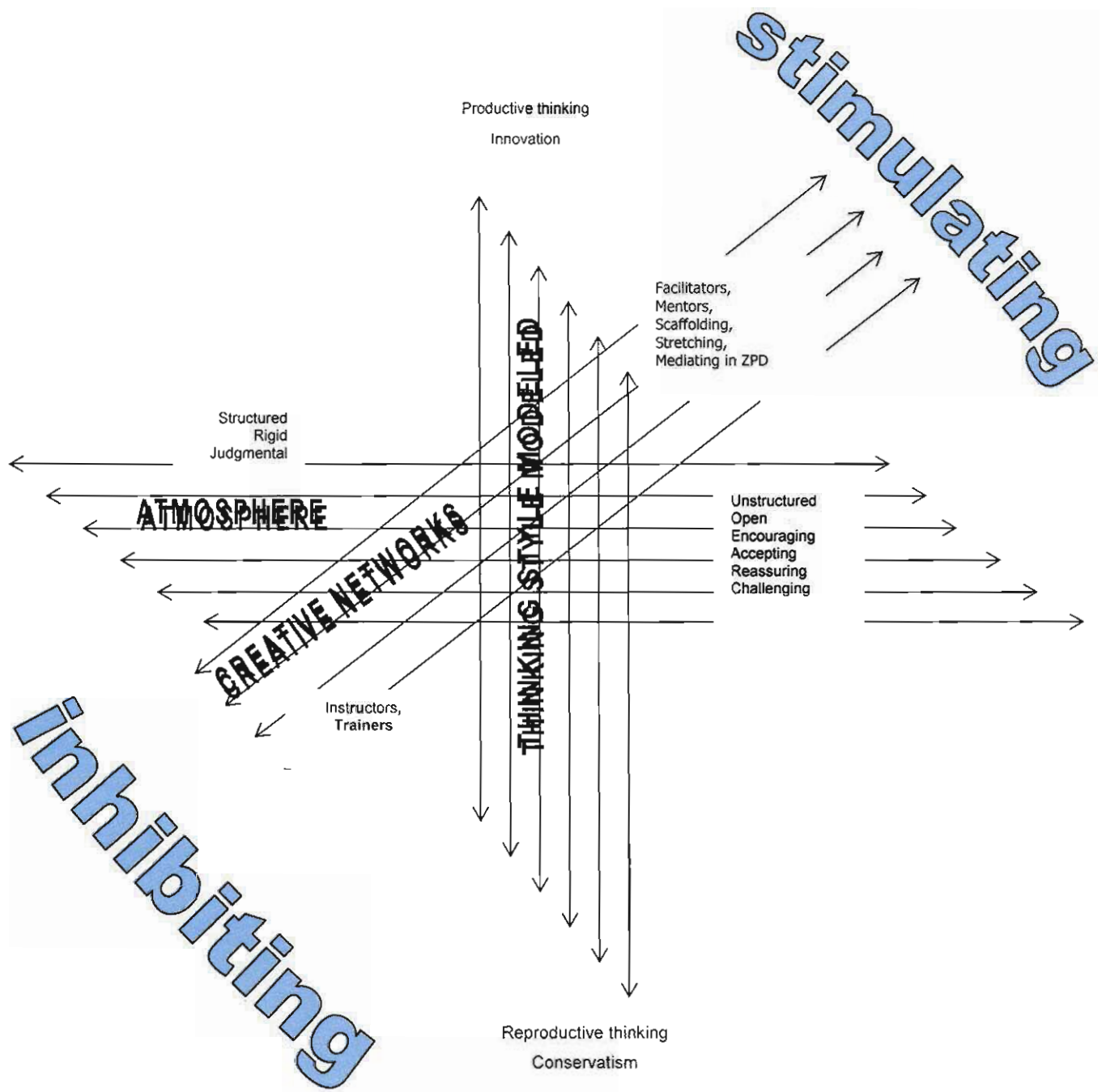
The creative process skills (fluency, flexibility, originality and elaboration) are indicated in the model where they will have a major impact. The two arrows in the centre suggest loops leading to rectifying problems by repeating prior phases with the newly acquired knowledge, skills and attitudes available. Going through these loops may result in the spiral suggested in figure 5.1. The teacher and peers may act as support and temporary scaffolds to help learners to come to fulfilment finally, as in figures 2.13 and 2.14.

As was discussed, Technology Education includes the creative process as part of the procedural knowledge that needs to be transferred and therefore provides an opportunity for the development of creative process skills.

Figure 2.14: Proposed Technological Process to support knowledge acquisition as well as alternating divergent and convergent steps in every phase



2.4 THE CREATIVE CONTEXT



2.4.1 Introduction

The context may be seen as the background, environment or framework of an individual or group of individuals.

A contradiction appears between the obvious need for creativity and its prevalence in

the community in reality. Huber (2000) found in a statistical analysis of the ratio between creative and less creative people that the creative ones represent a small minority.

Whittle (2007) explains the contradiction between the need for creativity and the reality as follows: *"Creativity is much praised in principle, but much derided in practice. Those in logical and ordered organisations may praise it, but be reluctant to set a creative individual 'loose' in their ordered system"*.

It is noted in the literature (Dacey & Lennon, 1998:69-73) that the pressure to conform is very strong, that unusual ideas are often ridiculed and that a low tolerance for failure exists in many educational contexts.

The main aim of this chapter is to explore the evolutionary and socio-cultural context in which creativity in an individual, but also in a community and human population, develops.

After the broad contextual influences have been addressed, the possible influences of the context will be discussed and a case study given.

2.4.2 Human community and culture are examples of complex natural systems

As with human thinking (cf. 2.3.4.4; De Bono, 2004:36-49), the human community and culture seem to be complex self-organizing systems. Feldman (1988:275-276) concludes that development results from changes within the individual catalyzed by transactions with the environment, as well as the coinciding and coordination of a number of forces, some internal and some external, that set the stage, stimulate and acts as a catalyst for change.

If viewed from this perspective, pure analysis of single factors is an inadequate method of investigating human communities, culture and behaviour. Von Bertalanffy (1969:19) explains that analytical procedures, in which parts of the system can be neglected for research purposes, cannot be used in strongly interrelated systems. To understand phenomena in the human community one should rather try to look at it from a systems paradigm and try to find general principles that govern the functioning of the system. This assumption leads to the choice of Structural Equation Modelling (SEM) as method to analyse the data in the *ex post facto* design in this study (cf. chapter 4).

2.4.2.1 Human culture is an evolving information system

Human culture develops over time. It develops because of variation and selection of certain variants and disposal of others. Creativity brings variation in culture. Usually these variations are more successful in being selected if they deviate only slightly from the previous. Radical variations are often less successful because they are not easily accepted. Whitley (1983), Blackmore (1999) and Gabora (2000) describe culture as an **evolving information system**.

As with the human mind and corresponding with Piaget's description of how an individual assimilates, accommodates and equilibrates schemas (*cf.* 3.3.2), Whitley (1983) explains that cultural change serves as an adjustment as information and experience accumulate in a cultural system. Individuals use culture as an "intermediating device" to interpret, understand and interact with their social and physical environments. Accumulation and integration of more and more facts and experience necessitate adjustments in inherited traditions, theory and world-view. This happens because the process of integration of new facts and experience subjects the current system to more and more internal stress.

Blackmore (1999) and Gabora (2000) explore the cognitive mechanisms underlying the emergence and evolution of cultural novelty. Langton, quoted by Gabora (1997:6) asserts: "*Evolutionary systems are poised on the edge of chaos with intermediate levels of connectivity.*" Langton explains that both complete synchrony (where little variation occurs) and complete chaos (without order) lead to stagnation. A society that only imitates and does not invent, stagnates. On the other extreme, if no connectivity and correlation exist between the parts of the system (no imitation), no creativity will be possible either (Gabora, 2000:6-9).

The development of human culture and the role of creativity in this development, may therefore fit the description of the chaos (Remer, 1998:1-24; Trump, 1998; Sterling, 2003) and complexity theories. Complexity theory explains that self-organizing systems, such as human communities, acquire patterns without any input from outside sources: different subsystems affect one another. Ihsen, Isenhardt and De Sánchez (1998:13) explain that the growth in global networks, change of work structures and the internationalization of markets are responsible for the increasing complexity characterizing the present social reality.

Chaos refers to the issue of whether or not it is possible to make accurate long-term

predictions about the behaviour of the system. According to the chaos theory, *"phenomena may appear to be locally unpredictable"*, but *"they may be globally stable"* (Society for Chaos Theory in Psychology & Life Sciences, 2006:1). When the history of millennia and the recorded history of humanity are studied, patterns may start to emerge.

Heylighen (1998:1-4) describes the nature of the chaos theory. Guastello (2004:1-20) lists the different applications of chaos theory in psychology and cognitive science. The anthropologist Remer (1998:1-24) applies the chaos theory to human culture. Remer defines culture broadly as the *"rules/ norms, both overt and covert, for the development of and adherence to patterns of behaving, thinking, and feeling-sensing"* Remer (1998:3). Cultural development, change and interactions between cultures, their influence on one another and processes such as enculturation and acculturation may be addressed, using this definition as point of departure. Remer (1998:3) sees cultural systems as recursive, interactive, dynamic and non-linear fitting the description of the chaos theory. The terminology used to describe these types of systems is explained below and applied to human culture.

Polkinghorne (in Remer, 1998:5) asserts that since the chaos theory views reality totally different from the generally used Logical Positivism in which most people have been trained, one must take note of the dynamic, non-linear, subjective, open, complex, inclusive, holistic and synergistic nature of this theory. Butz (in Remer, 1998:9) explains that patterns of behaviour, thoughts and feelings are reciprocally interactive, at multiple levels from individual to global, resulting in a dynamic system and they can be seen as chaotic. The focus points around which patterns evolve and are maintained in chaotic systems are called **strange attractors**. Human values may be seen as examples of strange attractors. (This corresponds with De Bono's concept of *"centering of patterns"* (cf. 2.3.4.4). Strange attractors have areas around them, the so-called **basins of attraction**, containing the patterns, elicited by the strange attractors, within their boundaries. Behaviour, thoughts, and feelings are best viewed as fluid, contained within relatively predictable boundaries (basins of attraction). Close to the strange attractors, quasi-predictability is therefore possible so that linear relationships may be described and some predictions may be made regarding human behaviour.

Between these basins, the so-called **fractal** (uneven, irregular, broken) **boundaries**, lines of demarcation, exist. Here, non-linear relationships are found which complicate the predictability and result in a complex situation. The perspective from which

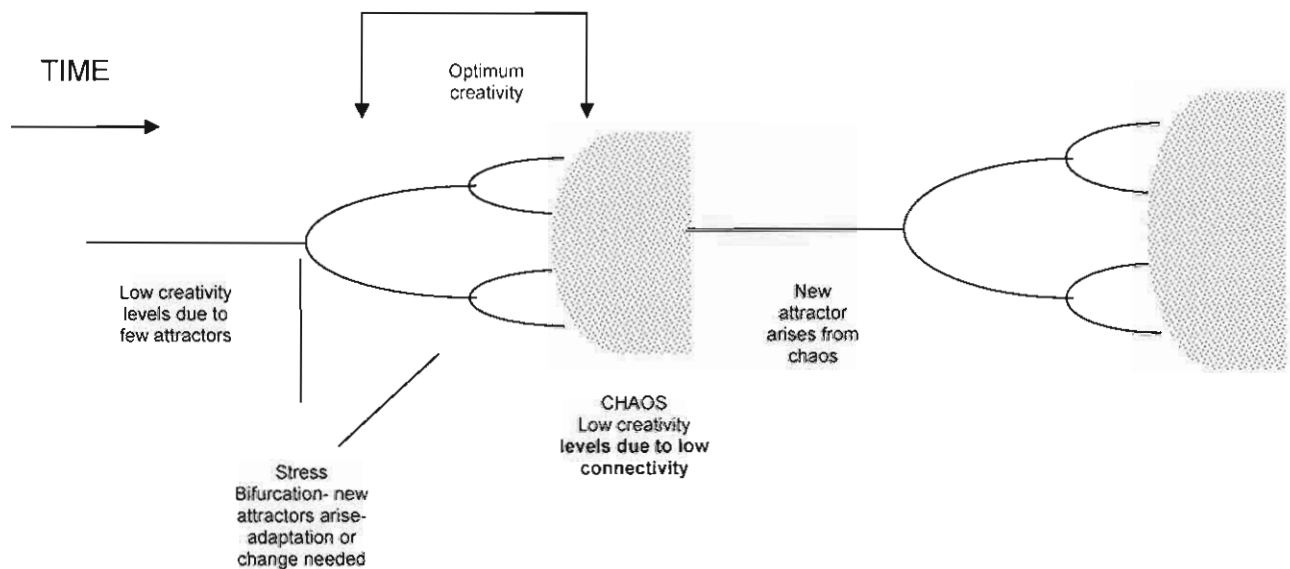
measurements are made, the ways in which measurements are made and the instruments and units used for these measurements determine the results. The fuzziness of the boundaries makes a perfect mesh between two systems impossible.

The principles of **self-similarity/ self-affinity** explain that motifs, the tendency of patterns to repeat themselves, occurs naturally in nature. This applies to genetic, physical and behavioural patterns. Some cultures are very similar in their patterns across spheres, some are alike only in certain spheres and others share very little.

Bifurcation (figure 2.15) occurs when a process or pattern splits in two. It adds complexity and addition of strange attractors. At **bifurcations**, systems change from periodic to chaotic modes of oscillation as parameters change. *"Close to the border, the system behaves chaotically"*, close to the attractor *"it moves predictably towards the attractor."* (Heylighen, 1998:3). The combination of the two influences, one dampening differences, one amplifying them, can produce the most complicated behaviours. Evolutionary changes occur when long intervals of stability occur between bifurcations. Given enough scope and time to adapt to and accommodate the new attractors, the system stays stable. Putting a dynamic system under stress, for example, by increasing the energy or flow through it, tends to increase the number of attractors till they become infinite and the system is erratically jumping from the one to the other. At a certain point, the **critical point**, the system must reorganize itself around a new strange attractor, creating a new basin of attraction. These chaotic states may therefore also be opportunities for creative, functional renewal. Change occurs in a linear step-by-step evolutionary manner, but also as discontinuous with leaps. Bifurcations or decision points where choices are made are encountered on all levels and in all cultures. Because of the self-replication principle, similar points may be reached by different cultures, but the choices made may not be the same every time (Heylighen, 1998:1-4).

Chaotic systems are largely **unpredictable**, since *"interactions between and among strange attractors and their basins of attraction (like value orientations and orderings) are non-linear and reciprocal, limiting predictability"* (Remer, 1998:9). Knowledge about the current state does not enable one to predict with certainty the next state of the system. The butterfly effect (Lorenz in Bradley, 2005) explains that *"small differences in the initial conditions of a process can produce large differences in outcomes, and conversely large initial differences can have very little impact"*.

Figure 2.15: Formation of bifurcations and increasing chaos



According to Piaget and Inhelder, and Sue and Sue (in Remer, 1998:14) dynamic systems in chaotic state have the inherent tendency to **self-organize** to form a new coherent pattern based only on the *"interactions of their components"* as self-organization-accommodation and assimilation occur. The newly emerged patterns will reflect all the strange attractors and their basins *"regardless of the dominance of one strange attractor or pattern over others"* (Remer, 1998:13).

The chaos theory may be used to explain cultural patterns at various levels, their mutual/relative influences and the processes affecting them. Concepts such as acculturation may be expressed in terms of the chaos theory terminology as the production of new patterns from the interaction of the strange attractors representing more than one culture. Enculturation may be described as the development/evolution of patterns from very basic patterns inherited genetically.

Remer uses the five-sphere model, developed by the anthropologists Kluckhohn and Strodtbeck (in Remer, 1998:2-14), as point of departure in explaining how cultural rules may be seen as analogous to the strange attractors as described by the chaos theory. The five spheres are based on the ways different societies approach certain universal dimensions and solve certain common problems of existence. According to Hills (2002:2-5), they are:

1. On what aspect of time should we primarily focus: past, present or future?

2. What is the relationship between humanity and its natural environment: mastery, submission or harmony?
3. How should individuals relate with others: hierarchically (which they called "Lineal"), as equals ("Collateral"), or according to their individual merit?
4. What is the prime motivation for behaviour: to express one's self ("Being"), to grow ("Being-in-becoming"), or to achieve?
5. What is the nature of human nature: good, bad ("Evil") or a mixture?

Cultural patterns may be attributed to the interplay between/among values orientation influences, both within a particular sphere and across spheres. Orderings within the different spheres within a culture will have a tendency to reinforce or stabilize each other. Orderings within the different spheres from different cultures may form all kinds of interference patterns. For example, Remer (1998:4) describes Native Americans to be approaching the time sphere as present>past>future. Westerners address it as future>present>past. As with two waves in water, interference patterns like misperceptions, miscommunication or conflict may result when these cultures meet: *"the more dissimilar (fractal) the patterns represented by the basins of attraction (such as values orderings of two cultures), the more chaos produced by their meeting. Fractal-ness is, however, also the motivator to innovation, adaptation, and change"* so that enrichment too may result from the differing conceptions of interacting cultures and*"the more fractal the boundaries, the more different the values orientations, the more tension will be generated in the establishment of a viable pattern"* (Remer, 1998:12-13).

The interference patterns may be seen *"immediately, forcefully, subtly, gradually, insidiously, consciously or covertly. Trying to control the outcome of the process is an exercise in futility, since the impact of any one intervention is virtually impossible to predict long-term (and may even have exactly the opposite of the intended effect). However, influencing the process is impossible not to do"* (Remer, 1998:13).

Perkins (in Mann, 2002:1) uses the *"Klondike space model"* to explain the factors influencing the development of creativity in systems. He compares creativity to a search for gold. It describes four critical challenges every creative system has to meet successfully in order to be described as creative:

1. **the rarity problem:** nuggets are rare (feasible problem solutions, viable designs, etc.);
2. **the isolation problem:** promising regions in solution space are separated by wide distances;
3. **the oasis problem:** the comfort with existing solutions discourages ventures that leave the known, recognized paths; and
4. **the plateau problem:** in the vast desert of non-solutions, non-designs, etcetera, there is no gradient indicating the direction to rewarding regions.

Close to the optimum solution, contours may start pointing in the direction of the solution; a random search now changes into a *“homing search”*. Mann (2002:1) explains: *“a homing strategy is one in which the local conditions of the problem suggest to the solver that a given direction is correct, and thus the solver’s task becomes one of homing-in on an optimum”*.

Mann (2002:2) further links the homing search to the creative style found in adaptors and the Klondike search to the creative style found in innovators. He sees the function of techniques such as TRIZ (cf. 2.3.4.1), as providing *“pointers to help problem solvers find ‘good’ places to dig for treasure (solutions). These pointers appear to be more liked by and more useful to the Adaptor character type”*.

This “homing search” may correlate with the areas close to strange attractors in the chaos theory, where quasi –predictability is found and linear relationships may be described so that some predictions may be made regarding creative behaviour.

2.4.2.2 A number of interacting subsystems exist in the context

Feldman (1988:275-276) identifies the following interacting forces that play roles in determining human behaviour as the:

1. evolving cultural context within the individual;
2. developmental trajectories of the significant other people who influence the child’s development;
3. particular historical events that bear on that individual;
4. many disciplines and fields with which the child will come to interact;

5. developmental histories of these fields; and the
6. long-term evolutionary trends that provide the backdrop for the rest of the process.

Other models of these interacting subsystems are Bronfenbrenner's ecological model, Shi's interacting person and Csikszentmihalyi's context and domain, person and field model.

Ecological models- a spider's -web

The different role players in the development of an individual and their interactions are described by ecological models that compare the ecological environment in which an individual finds him/herself to a spider's web: touching one part of the web affects all the other parts (Donald, Lazarus & Lolwana, 2002:45). In his ecological model of child development (Bronfenbrenner, 1979:3 & Bronfenbrenner in Donald *et al.*, 2002: 51-58), Bronfenbrenner describes the ecological environment as a set of nested structures, each inside the next with the developing individual in the middle. Bronfenbrenner defines personal development as: *"the person's evolving conception of the ecological environment, and his relation to it and the person's growing capacity to discover, sustain or alter its properties"*.

The interacting dimensions are identified and their relative importance is weighed against one another. The dimensions are:

Person factors: e.g. temperament

Process factors: e.g. forms of interaction in family

Contexts: e.g. families, schools

Time: (Changes over time and development)

Changes in proximal interactions, face-to-face long-term relationships, are most important in shaping lasting aspects of development. The process is affected by person factors and the nature of the contexts. Changes take place over time as a result of maturation of the child and environmental changes.

Bronfenbrenner (1979:9-10) agrees with Anderson and Krathwohl (2001) by putting creativity right at the top of cognitive functions in Bloom's taxonomy of the cognitive domain by viewing the ability to remold reality to meet human requirements and

aspirations as the highest expression of development. Bronfenbrenner explains that an individual's ability to fantasize, create and imagine a world of his/her own expands along a continuum from the micro-to the meso-, exo- and macro-levels as explained below:

1. **Microsystems:** the family and school where children are involved in continuous face-to-face interactions with familiar people. These involve patterns of daily activities, position in the family, roles and relationships and are seen as the *key proximal interactions* (Bronfenbrenner, 1979:5-6).
2. **Mesosystems:** the neighbourhood: peer-groups, school, families interact with one another. A set of micro-systems is associated with one another. What happens at home affects what happens at school and *vice versa*.
3. **Exosystems:** the child is not directly involved, but is influenced by it. It includes factors such as the parents' work and sibling's peer group.
4. **Macrosystems:** dominant social structures, beliefs and values that influence and may be influenced by all other levels of the system, for example, the cultural values like developing obedience to authority, respect for senior family members, influence proximal interactions in micro-systems.
5. **Chronosystem:** all the interactions between these systems are crossed by developmental time frames- the systems in which the developing child is involved, may be seen in a process of development itself. These interact with the child's progressive stages of development.

Bronfenbrenner (1979:8) states further that within a given society or social group, the structure of the micro-, meso- and exo-systems tend to be similar, but that between different social groups, the constituent systems may vary markedly. By comparing these micro -, meso - and macro-systems, one can distinguish and describe systematically the ecological properties of the larger social context as the environment for human development.

The following variables are further described within the system.

1. **Goals and values of the system:** Obvious such as economic survival/ education and hidden such as male domination/ authoritarian discipline and control.

2. **Subsystems within the system:** Different/sometimes overlapping e.g. family, classes may overlap with subsystems based on race or gender.
3. **Communication patterns:** Between subsystems. Clarity of communication directly influences functioning and interaction e.g. communication can be inadequate, unclear and indirect, causing tension between subsystems.
4. **Roles within the system:** Definition of roles and the acting out of these roles: Roles such as blame- taker, peacemaker, income-earner, problem-solver, parent, child.
5. **Boundaries:** Boundaries can be rigid (closed) or flexible (open), affecting the effectiveness of for example the individual, family or school in the community.

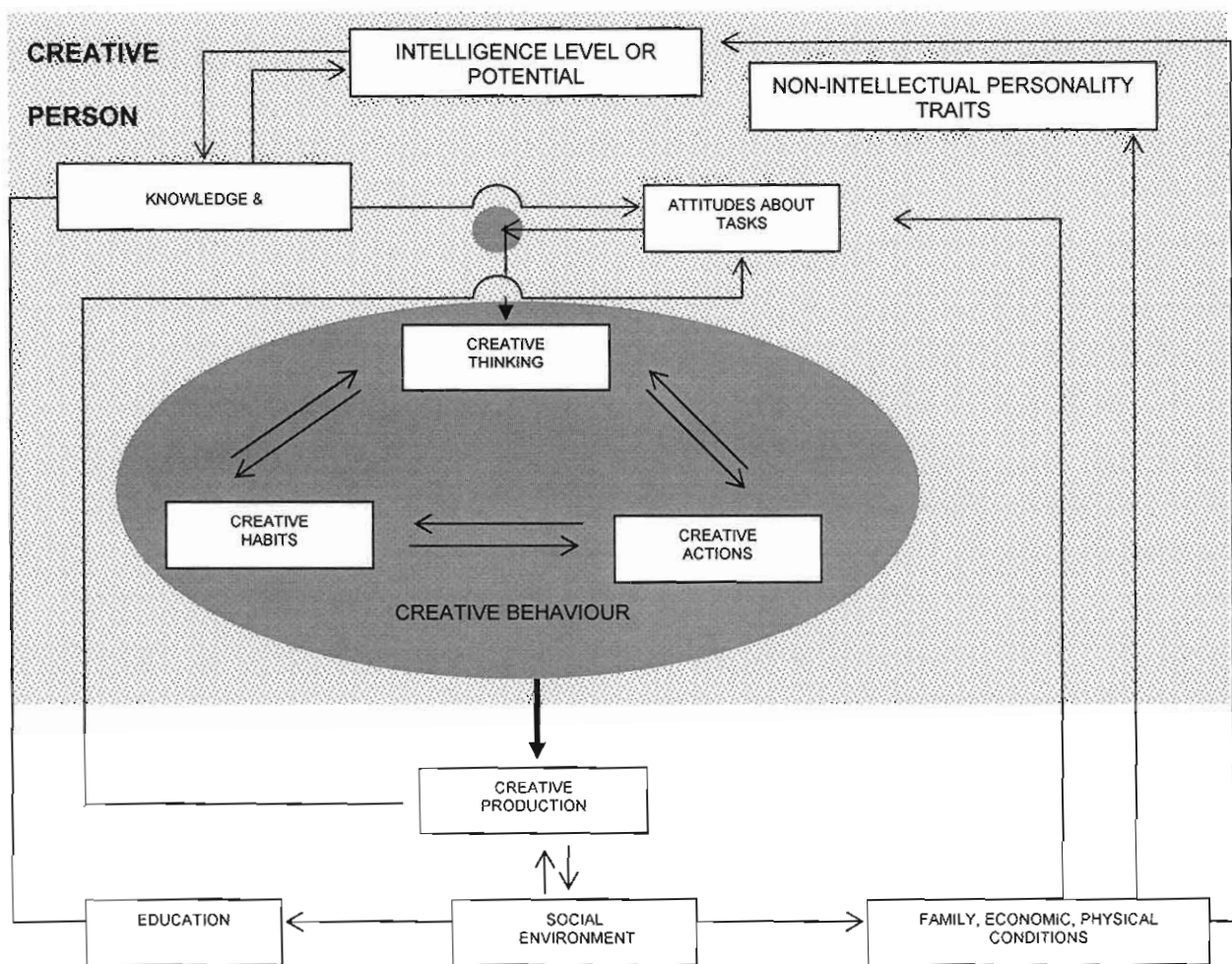
An interacting person and context

Shi (2004) also proposes a detailed system depicting the context interacting with person factors like personality, intelligence, knowledge and experience, resulting in creative behaviour as shown in figure 2.16. Personality provides a tendency for an individual to do certain things and to respond in certain ways to challenges. Attitude is described as either intrinsic or extrinsic which are seen to be closely related to intrinsic and extrinsic motivation. One's intellectual potential impacts on one's knowledge and that, combined with experience, can in turn lead to a realization of one's intellectual potential. Habit is defined as an unconscious pattern of behaviour that is acquired when repeated frequently or practised continually over a long period of time.

In the case of the creative person, this would mean habits like persisting till the problem is solved and to keep up the interest and commitment continuously. The environment provides an atmosphere stimulating, hindering or even harmful to a person's creativity.

The product is neglected and rejected by the society or recognized and selected in which case it becomes part of the social environment. This in turn changes the context and affects creativity in the individual

Figure 2.16: A context for creative behaviour (Shi, 2004)



Domain, person and field as interacting components

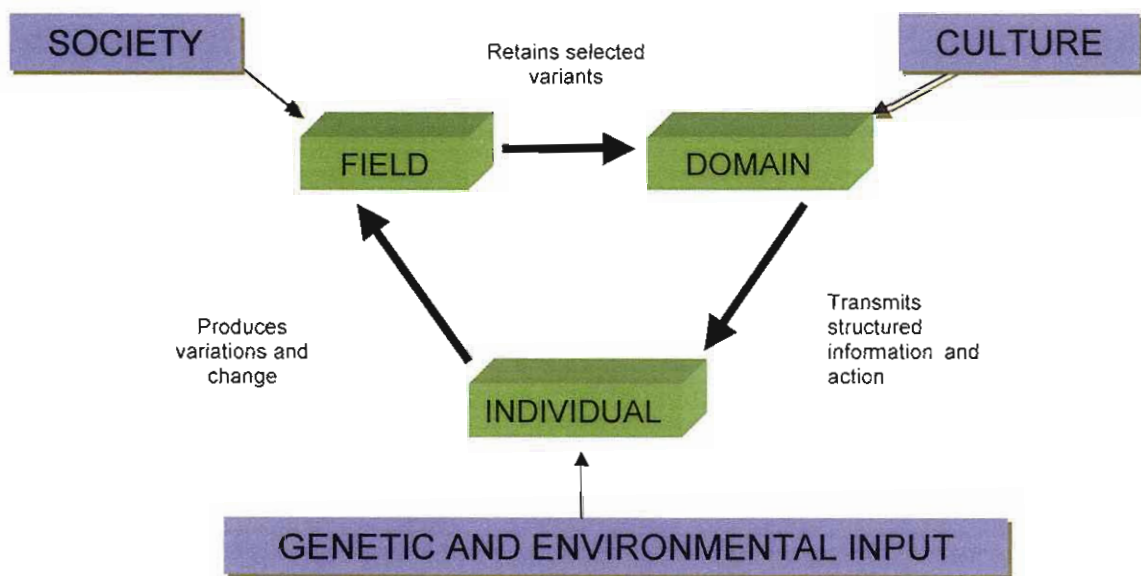
Csikszentmihalyi (figure 2.17) uses an evolving systems perspective (1988:329; 1996:27-50) to describe the interactions among the components involved in specifically stimulating creative behaviour within the context. He identifies the components as the individual, the domain and the field. Precise notation of the domain, such as writing, will make changes easy to observe so that original ideas are detected.

- **The Domain** is the symbol system of the culture, the customary practices and the language.
- **The Individual** draws upon the knowledge in the domain. This is Newton's "standing on the shoulders of giants", learning and taking from those that came before you. Via cognitive processes, personality traits and motivation the

individual transforms or extends the knowledge obtained from the domain.

- The **Field** is the people involved in the specific area like art and medicine. It is supported by social structure - the community at large that will help to support the idea. Experts in the field evaluate and select the transformations and extensions.

Figure 2.17: Creative behaviour in context (Csikszentmihalyi, 1996)



Some ideas are recognized long after the person's death, e.g. Mendel (Father of Genetics) and Harrington (inventor of water closet) when the field becomes ready for the idea. People must become attracted to the idea for it to become a "meme" (cultural gene) that will be passed on to future generations. They can either accept or reject it. If accepted, the field recognizes these changes and they become part of the domain. If the unusual ideas produced by an individual are not noticed and if the ideas are not supported, even excellent ideas might come to nothing – sometimes the community at large recognizes an idea, sometimes only a subset of people within the field (especially revolutionary ideas). For an idea to go from individual to field, from field to domain and again to an individual needs a gestation period. Major breakthroughs usually need long gestation time in the domain e.g. Atomic Theory, Periodic Table, Theory of Evolution. Breakthroughs sometimes come out of the blue: Roentgen's discovery of radiation and Fleming's discovery of penicillin. The individual

must be sensitive to recognize the significance of an idea. Multiples (when two or more scientists discover something simultaneously) often occur. Merton (in Simonton, 1988:416) is of opinion that

"discoveries and inventions become virtually inevitable as prerequisite kinds of knowledge accumulate in man's cultural store, as the attention of sufficient number of investigators is focused on the problem – by emerging social needs, or by developments internal to the particular science, or by both."

2.4.2.3 Certain processes may lead to inhibition and /or stimulation of creativity.

Fog (1999:12) explains that cultural evolution is much faster than genetic evolution. Saltatory periods of rapid change (revolution and /or stimulating creativity) alternate with periods of relative quiescence (slow evolution and /or inhibition of creativity). When a certain threshold has been passed, the evolution goes relatively fast until a new equilibrium is established. Gradual change (adaptations) is more common than dramatic ones. The crossing of thresholds has low probability and consequently happens very infrequently. Burns & Dietz (in Fog, 1999:3) explain that a new idea cannot easily gain a footing in a society if it does not make sense or if it is not compatible with the existing rules and structure of that society.

Similar to Csikszentmihalyi's theory given above, the "*Cultural selection theory*" (Fog, 1999) describes three basic processes in cultural evolution, namely:

1. **Innovation:** the idea / phenomenon arises
2. **Reproduction or transmission or imitation or diffusion:** the idea/phenomenon spreads from one human to another, from one group to another.
3. **Selection:** any mechanism or factor that has an influence on how much or how little the phenomenon will spread.

A culture may have a large meme-pool: Fog (1999:5) describes culture as a storehouse of immense latent unrealized ideas. Some outmoded customs and rituals, upheld by only a few deviants, may become (re)activated again as altered selection conditions come in place and favour them.

Deviations are often repressed to preserve the social system. Social innovations are often regarded as deviations, and the persons representing them, are sometimes

persecuted as deviants. Social change occurs if a deviation spreads and wins acceptance in significant parts of the society despite all attempts at suppression (Fog 1999:6). Communities may become caught up in behavioural patterns, paradigms and customs that can be hard to break, even if they serve no further purpose and/or may be detrimental.

In many cases there may be a time-lapse between the need for change and the actual change in culture and educational practices. Catastrophes caused by human behaviour, may perhaps be due to this time-lag between environmental and social conditions, and a necessary renewal of minds needed to avoid the catastrophe.

The culture and its transfer through education in a community may determine, for example, which of Sternberg's three intelligences (*cf.* 2.2.2.1) will be emphasized: **componential intelligence (analytic)**, **experiential intelligence (synthesis)** or **contextual intelligence (practical)**. As was indicated in section 2.2.2.1, all these intelligences play an important part in creativity (Sternberg, 1988:135-138). Should any of these intelligences or any of the components of componential intelligence be emphasized at the expense of the others, it may influence the rate at which creative work may appear either positively or negatively. Changes in the environment as one generation replaces the previous, as the next regime comes into power, are further involved in selecting certain memes.

Chase-Dunn, Hall and Manning (1998:2) note that all systems, including even very small and egalitarian ones, exhibit cyclical expansions and contractions in the spatial extent of interaction networks. Petrov (1992:255-268) proposes that an alternation between analytical (representing the left hemisphere of the brain) and synthetic (representing the right hemisphere of the brain) qualities is found in human, social and other informational systems. He argues that the analytical (L) and synthetic (R) types of activity alternate in their domination of a society for a given period of time. He proposes that the domination of these processing styles is tied to human generations (about 20 to 25 years) and occur in cycles of 40 to 50 years.

As should be clear by now, creativity is not dependent on an individual alone. A society allows creativity and may inhibit and /or stimulate it. The frequency of the occurrence of creativity may be under the control of the interaction between stimulatory and inhibiting factors.

Stimulation may occur when:

1. A society opens up its filters to allow ideas through. The conditions that may lead to open filters may be factors such as a challenge, a crisis like changing environmental conditions, a new disease or new territory that needs to be made habitable, the ability to adapt would depend on the ability to find new ways of behaviour depending on new information about the changed circumstances.
2. Changes in the social environment occur such as when cultures come into contact. The different cultures, each with its own strange attractors, may give rise to new interference patterns. Another change in the social environment may be when levels of connectivity increase so that more information is available to more people or an increase in competition between and within societies. The need in society then acts as a pulling force (*cf.* 2.2.4.2 and figure 2.5).
3. Increasing internal stress due to conflicting ideas or information overload “begs” for clarification within a domain or between domains (*cf.* 2.2.4.2 and figure 2.5). This is a chaotic situation. The pressure mounts from within the society and results from ideas (strange attractors) that gain support in subgroups and may lead to either evolution or revolution (bifurcations).
4. The emergence of individuals that gain a following over a short or long time. These individuals act as accelerators of change in a community and create opportunities for others (*cf.* 2.2.4.2 and figure 2.5). They observe and anticipate societal needs, stresses and /or bring together accumulated knowledge in ways that open up new areas and make knowledge useful or understandable. They may create new knowledge through research and discovery or they may express the emotions and conflicts in the community appropriately. An individual is very powerful in influencing society. The curious, head-strong and intrinsically motivated personality of a highly creative person with a persuasive personality and/ or powerful network, having an idea in his/her head that he/she wants to be realized, acts as pushing force for the whole community. An individual's power may be used negatively or positively and unethically or ethically. It lies in gaining the following / respect of people generally or within a field of expertise, by recognizing and “solving” problems that are relevant to society at large, by enthusiastically pursuing the ideal in such a way that attracts other people to use a product or to believe in an idea.

Inhibition may occur:

1. As result of lack of the factors named above. A flat landscape of constant unchanging conditions and little competition brings little challenge. The best way to survive would be to do things as they were always done.
2. As result of strong cultural rules and taboos that are imposed to ensure survival. Societal stresses are kept low by physical or psychological removal of deviants using repression, ridicule, taboos, cultural rules, exclusion from privileges and so forth. Sudden change in the social or natural environment may lead to extinction of the whole group or its culture.
3. After a period of rapid evolution (revolution) and would have a consolidating function.
4. As result of actions of a society at large (as through families and educational systems) or from an individual person (such as a ruler) or from a group (like a religious order or ruling cultural group). It may impact on the individual in his/her proximal relations, extending from there to the society. Repression may also happen on a larger scale to groups of people.

The result of this dynamic interaction between encouragement and repression of creativity as well as genetic factors leads to a situation as hypothesized by Leary (in Taylor, 1988:109-110). He divides people in four types and estimates the percentages of each in the American population. They are:

1. Type 1. The reproductive blocked (no novel combinations, no direct experience) constituting approximately 75% of the American population and perceived socially as "unimaginative, incompetent hack" or a "competent, responsible reliable worker".
2. Type 2. The reproductive creator (no direct experience, but crafty skill in producing new combinations of old symbols) comprising 12% of the American population and perceived socially as "reliable nihilist, unsuccessful innovator whose stock value changes to morbid curiosity as fads of performance change" or a "bold imitator who wins fame and recognition but whose fame crumbles as fads of performance change".
3. Type 3. The creative creator (new experience presented in novel performances) estimated at 1% of the American population and perceived socially as "the mad genius, the undiscovered far-out crackpot creator who is recognized by later

generations as a creative giant” or a “truly creative giant recognized by his own age and the ages to come”.

4. Type 4. The creative blocked (new experiences expressed in conventional modes) estimated at 12% of the American population and perceived socially as “psychotic, religious crank, eccentric who uses conventional forms for expressing mystical convictions” or a “solid reliable person with a ‘deep streak””.

2.4.2.4 An increase in creativity may benefit and/or have detrimental effects on the community

As described by the chaos theory, the initial input may be amplified by the system to become a large output or *vice versa*. One may think that trying to enhance the creativity of a community may be a good thing since it may help to fulfil the immediate needs of a group of people and give them a competitive edge in a global community. On the other hand, it may have detrimental effects in the long run. A dynamic balance may exist between stimulating and inhibiting forces. As human culture may be seen as resulting from demands on a community to select an environment, adapt to an environment and /or change or rehabilitate an environment, the culture of a community at a particular point in time may be a snapshot of the types of behaviour that led to advantages in the past. A particular culture favours certain personality types, thinking and learning styles and motivation in the individuals who are found in it. Because these human characteristics influence creativity, creativity is also directly under cultural control and indirectly under the control of the natural environment. A time-lag may arise between the culture and the characteristics needed for successful adaptation after a rapid change in natural and social environmental conditions has occurred.

Seitz (2003:391) makes the statement that creative activity and self-expression in arts, sciences and entrepreneurship are greatly constricted by historical, political and social influences such as differential distribution of power, political and religious censorship, corporate control and influence, copyright restrictions, as well as cultural and economic constraints.

Creativity is a double-sided sword. On the one hand, it brings renewal and improved adaptation to a community. On the other hand, it may bring revolution, disruption and chaos in well-functioning systems. A high percentage of creative individuals, whose ideas and products may be seen as cultural “mutations” and “deviations”, may give

their community an advantage under certain circumstances (such as establishing themselves in new territories) because they may increase the adaptive / environment-changing-rehabilitation abilities of their community. On the other hand, forces for preserving the social order (Csikszentmihalyi's (1994:21, 150-157) proven ways of "energy extraction") are at work discouraging renewal. An optimum ratio between highly creative and less creative people in the society may therefore develop under each set of environmental circumstances.

Social manipulation and imprinting over centuries may be one reason for the low ratio of productive thinkers to reproductive thinkers found by Huber (2000). Culture and learning have to do with social imprinting - under many environmental conditions, imitation brings success and efficiency. Human culture developed in such a way that creativity is generally discouraged more than encouraged. Following the same proven route improves chances for success and ensures efficient use of time and resources. If every person wants to do everything in a unique way, bifurcations occur rapidly, chaos results and time and energy are sacrificed. The whole mechanism of balancing encouragement and discouragement of cultural variation may therefore be an important survival mechanism. Censuring and selecting only certain forms of uniqueness according to a certain set of criteria may result in optimizing processes and products. It might, however, also be a trap! Under changing environmental circumstances, it might lead to inevitable extinction, especially if the activities that are imitated are responsible for harmful environmental effects. Re-assessment of the selection criteria may then be necessary. Large reserves of creative potential might be present in the human population, ready to be unleashed, but inhibited, often with reason, but sometimes blindly, by sometimes an unthinking culture.

Creativity leads to change and development. Less technological inclined cultures may have reached equilibrium with their natural environments and may have existed in states of homeostasis. This may be an advanced form of ensuring sustainable survival. Modern cultures may, because of the constant input of energy from the past in the form of fossil fuels, be far from homeostasis and may destroy the earth and return it to a state of inhabitability.

Would it then be beneficial for the community if more individuals were more creative (*cf.* 2.1.3)? Perhaps: environmental and social circumstances change continuously, but especially now. The human population explosion since the industrial revolution is built mainly on the use of fossil fuels. The use of fossil fuels has led to an increasing rate of deterioration in the natural environment of all the inhabitants of the earth. As

Kluger (2006:34-40) puts it, we are close to "*tipping point*". The ecological footprints of wealthier nations, seen as innovative, such as in Europe, North America, United Arab Emirates and Kuwait are the largest. Venetoulis and Talberth (2005) estimate that at the current rate of consumption we need on average 1.39 earths to ensure that future generations would be able to sustain our current standard of living. The lifestyles of people in Africa, Asian-Pacific, Latin America and the Caribbean are seen to be sustainable (Wackernagel & Onisto, 1997; Venetoulis & Talberth, 2005:8)

Although the life-styles of poorer nations are sustainable, many poorer nations aspire to the life styles and products of the wealthier nations. This phenomenon, known as colonial mentality, leads people to regard foreign ways highly and as better than the indigenous ways. They therefore become mentally dependent on the innovation of the foreigners. If an increase in creativity can unblock this kind of bias, lead to a post-post-modernistic world-view, it may help the world's inhabitants to rehabilitate the environment, develop technologies for exploitation of alternative and cleaner energy, and generally design sustainable ways of survival possible for all. An increase in creativity may then lead to radical change in the direction humanity has taken and may help to steer it away from the self-destructive road it is currently on. If an increase in creativity however leads to an increase in environmental degradation, perpetuation of social injustices or establishment of new injustices, the answer to whether it would be beneficial to stimulate creativity must be "No".

The argument for a balanced education may perhaps be more important than expecting all people to try to live like the poor nations of the world. Since formal education is executed on millions of people, the effect of an imbalance between the three desirable educational outcomes isolated by Sternberg (1986:177) as wisdom, creativity and intelligence may be dangerous. Sternberg laments the emphasis placed on educating for intelligence to the detriment of creativity and wisdom. To ensure that creativity gets a rightful place in education, creating awareness of creativity and how to educate for its enhancement seems to be the right thing to do.

2.4.3 The role of socio-cultural context in the development of creativity

A number of roles that the socio-cultural context plays in the development of creativity are discussed below. It ranges from determining behaviour, influencing personality to the provision of models, mediators, support and stimulation of cognitive development.

2.4.3.1 Determining behaviour

Lewin (in Smith, 2001), in his field theory, stresses the importance of the social context in determining human behaviour in seeing human behaviour as the function of the person (P) and the environment (E), expressed in symbolic terms: $B = f(P, E)$.

Lewin (in Smith, 2001:2-3) explains that this means that one's behaviour (B) is a function of both one's personal characteristics (P) and the social situation (E) in which one finds oneself. Individuals were seen to behave differently, according to the way in which tensions between perceptions of the self and of the environment were worked through. In order to understand human behaviour, a study of the total psychological field or life space (that includes a series of life spaces such as family, work, school and church) in which individuals participate, is advocated. Various force vectors influence the construction of these life spaces.

Rotter (in Mearns, 2000-2005:2) also concerns himself with the effects of context on behaviour. He proposes that in order to change behaviour, one must either change the way a person thinks or change the environment the person is responding to.

Talking specifically of creative behaviour, Fritz (1994:23-25, 48, 56-59) agrees with the first part of Rotter's statement above, but disagrees with the second part. Fritz is of opinion that the assumption that the creative force is outside a person is a trap. The idea that people are always responding or reacting to the external world places the person at the mercy of the environment. He proposes that creativity comes from within the person him/herself and enhancing creativity would mean changing a person's thinking from a reactive-responsive orientation to a creative orientation where a desire for the creation to exist fuels the creative act.

Although what Fritz says is important, the context plays a role in determining the attitude a person has towards life and therefore whether he/she would see him/herself as a victim of circumstances or a pro-active creator. This in turn may be an important factor in determining a person's behaviour.

In this current study, the assumptions of Rotter and Fritz, explained above, were adopted. It was namely assumed that creativity must be viewed as acceptable and desirable behaviour before a person would tend to think creatively. It is therefore necessary that the context interacts with the person and that the wish for creativity should be made explicitly and communicated in such a way as to show its desirability.

2.4.3.2 Providing Intrinsic motivation

Attitude and motivation go together. Motivation is a process that leads individuals into experiences in which they can learn. It energizes and activates them to keep them interested, alert and focused on a specific task.

People are, according to Rotter (in Mearns 2000-2005: 2-3), drawn forward by goals, seeking to maximize their reinforcement effects. He expresses the likelihood of engaging in a particular behaviour in formula form, namely in his predictive formula:

$$BP = f(E \text{ \& } RV)$$

In this formula BP represents Behaviour Potential (likelihood of engaging in a particular behaviour), E represents Expectancy (subjective probability that a given behaviour will lead to a particular outcome) and RV represents the Reinforcement Value (subjective perception of the desirability of the outcomes of behaviour). If behaviour brings positive effects (Watson's law of effect) it is reinforced and the likelihood of its reoccurrence is strengthened because it creates the subjective expectation that its positive stimulation will be repeated.

Why would creative behaviour bring positive effects and reinforce itself? For some creative people the answer may be in their biological make-up and/or social situation as is speculated about in the argument that follows.

Marginality, professionally and/or culturally (when a person is not part of the in-group), is pointed out as a factor contributing to creativity (Simonton, 1988:414; Csikszentmihalyi, 1994:74; Csikszentmihalyi, 1996:312, 316), by giving access to different disciplines and cultural heritages without becoming too entrenched in it. This marginality may, however, carry an emotional burden of "not belonging". The creative person's personality may further be viewed as situated to one side of the spectrum of normality with a number of socially less-desirable characteristics (*cf.* 2.2.3.1). These put him/her also in a situation of social marginality. The tendency for odd behaviour such as observed in schizotypic personalities, leading to a degree of rejection by some others, forces the creative person to develop strategies to become emotionally self-sufficient and independent. This may be done by the development of coping mechanisms to give positive feedback to him/herself, not depending too strongly on others such as the in-groups of the profession or culture. Martindale (1999:143,145) notes that creative people tend to be oversensitive, they withdraw, their arousal levels are lowered and they begin to crave for novelty. The

characteristic openness of creative people, may also lead to a nearly unmanageable information overload, leading to mental chaos. The creative person learns that creating order in this chaos brings relief from the overload and the frustration accompanying it. The motivation to persevere lies in the situation itself. The recognition of patterns in the chaos brings about feelings of elation, relief and satisfaction. Goldman (in Blum, 1997:1) explains that it is the release of pleasure chemicals, such as dopamine, that reinforces behaviour that makes one feel good and stimulates the pleasure centres in the brain. Siddiqui (2005:3) notes that dopamine "*persuades humans to create*". This forms a cycle of positive feedback, making the creative person crave for more chaos so that he/she can find patterns and can experience the relief (in the form of dopamine secretions) he/she craves for. Whether critical outsiders view the recognized patterns as important, may not be important to the creative individual at this stage. Having the time and opportunity for self-expression, however, is important. A cycle of chaos and order establishes itself in the life of the creative person. The creative act itself may be seen as motivated by an effort of the creative person to maintain stability by exerting "*meta-cognitive control*" (Simonton, 2005:4) over unpleasant feelings or thoughts (*cf.* 2.2.3). Depue (in Blum, 1997:2) notes that strong evidence exists that feeling elated, because of moving towards achieving an important goal, is bio-chemically based.

When participants in a creative team share the creative experience, build on one another's ideas and gain joint insight, the individuals in the team experience the same elation effect. The team becomes as one psychological unit, a network.

Vygotsky (1997:207-209) describes another mechanism for the development of creativity in an individual, resulting from the effects of conflicts arising from education in the contemporary social world. He explains that there is (in terms of work by Pavlov, Freud and Zalkind), a conflict between the pleasure principle (gratification?) and the reality in the world, since learning must result in mastering certain forms of inhibition and reining in own desires. These conflicts are banned to the subconscious and create a world of unfulfilled desires within the individual. A potential tension is created. The imagined reality is known as a censor, distorting the suppressed desires that come into the conscious mind during sleep or distraction (defocused attention, *cf.* 2.3.4.3, 2.3.5.2). This results in a situation where most of man's unconscious potentiality, his biological and emotional forces, is restrained, hidden from the outside world, directed towards isolated internal processes nourishing uncreative sensations. Only a negligible scrap of it manifests as creative potentiality. Vygotsky explains that

three possible outlets exist for energy that is not banned to the subconscious, namely: firstly psychoneurosis; secondly, a constant conflict between the individual and his environment and within himself; and thirdly, socially useful creative directions. This process of sublimation, therefore constitutes, according to Vygotsky, the greatest realization of all desires, but only in socially useful directions.

Intrinsic motivation is seen as very important for creativity. Studies by Hennessey and Amabile (1988:12) indicate that linking reward or expected evaluation to being creative is counterproductive, at least in young children. Hughes and McCullough (in Hennessey & Amabile, 1988:12) explain that a delicate balance exists between the *“desire for attention, praise and support from friends, supervisors, editors, or colleagues, on the one hand and the necessity to maintain a safe distance from the opinions of these very same people”*.

Extrinsic motivation may be detrimental to creativity especially in individuals with poor self-esteem. It blocks the process of free play, risk taking and free roaming of the mind (Hennessey & Amabile, 1988:12). Amabile (1996:149-152) gives the conditions where knowledge of a pending evaluation can be stimulating, such as when students have low skills, when constructive feedback results from it, when persistence is expected and when the task is focused. Under these conditions it can be used to overcome intellectual inertia and loafing in a class situation. Eisenberger and Shanock (2003:125-127) explain that it is not extrinsic reward as such that inhibits creativity. It is rewards for conventional performance that decrease intrinsic motivation and thereby creativity. Society tends to reward conventional performance. Rewards for novel performance, according to their research, increase intrinsic motivation and creativity.

2.4.3.3 Shaping the individual's personality

Mansfield and Busse (in Feist, 1999: 288) link creativity to certain childhood conditions and educational practices that precede personality characteristics, which in turn precede creativity. They name factors such as low emotional intensity of parent-child relationship, parental fostering of autonomy, parental intellectual stimulation and apprenticeship. These then lead to autonomy, flexibility and openness, the need to be original, commitment to work, professional recognition and aesthetic sensitivity. Phillips and Silverstein (2003:115) describe a mechanism for the contextual influences acting on receptive individuals in the ontogenesis of schizophrenia, namely developmental environments that can affect expression of N-

Methyl-D-aspartate (NMDA) receptors. Lower than normal maternal or environmental care is one of these factors. A similar mechanism may be implicated that lead to expression of certain genes that leads to creativity. It is perhaps not coincidental, seen in the light of a strong link between creativity and mood disorders, that many highly creative individuals report childhood trauma, like the death or illness of a parent or sibling, an incident that forces the child to become autonomous, but also the stimulating and supportive presence of a relative or family friend (a mediator).

School is often seen as the least likely place for creativity to be nurtured, with examples like Edison, Einstein, Bernard Shaw and Newton that could not cope well at school (Simonton, 1988: 411- 413; Csikszentmihalyi, 1996:173). After studying many people who achieved creatively, Csikszentmihalyi (1996:174), however, concludes that teachers who noticed a specific student, believed in his/her abilities, cared for and challenged him/her with extra (or more complex) work, played influential roles in the development of the creativity of some creators. A good example of this phenomenon is Mrs. Alexa, the fourth grade teacher, who noticed and challenged an under-achieving boy in her class. He later became the well-known cognitive psychologist Robert Sternberg (Plucker, 2007:2).

2.4.3.4 Providing models

Bandura's social cognitive theory (1986:48-50) explains the importance of the systems, subsystems and the variables identified by Bronfenbrenner (*cf.* 2.4.2.2). Modelling (a concept related to imitating a person and identifying with a model) is seen as a powerful way of learning. Modelling is used to transmit thought patterns. It is important for acquiring, strengthening and prompting the modelled behaviour. Furthermore, modelling has environmental enhancement (direct attention to certain objects in the environment) and emotional arousal (affecting values and attitudes) effects. Bronfenbrenner (1979:6) also explains that active engagement with or mere exposure to what others are doing often inspires the person to undertake similar activities on his/her own. Creative thinking and its opposite, namely conventionality, are two of the behaviours that could be modelled. Bandura (1986:48-50) explains that different alternative models are available in a society. The models that prevail within a social milieu partly determine which qualities will be selectively activated. Amabile (1996:190) cites the study of Mueller (1978) who found a positive correlation between the performance of students in a Torrance test for creativity and whether they had watched a creative role model. They performed better in flexibility, originality

and elaboration and specifically in the figural part of the test than those who watched an uncreative model.

Simonton (1988:412) distinguishes two roles for role models: impersonal “paragons” who are admired at a distance and personal “mentors” who are involved in a more direct fashion. In terms of the chaos theory, the creative role model may act as a strange attractor that may, by his/her example, influence people to think and do more/or less creatively. Adequate exposure to creative role models, mentors or networks is therefore seen as stimulating creativity (Amabile, 1996:179-202).

Modelling can also have an inhibiting effect on creative behaviour: if it is intimidating or when it leads to imitation. Davies and Elmer (2001:174) find that students, with a desire to emulate professional designers, change the purpose of their modeling, so that instead of pushing their own thinking forward, they try to meet some perceived ‘professional’ expectation. Because mere imitation inhibits creativity, exposure to a large number of role models is less likely to result in imitation of just one and would therefore be more likely to result in creativity (*cf.* 6.2.3.1). Simonton (1988: 413) proposes a U-shaped curve to describe the relationship between creativity and the influence of role models: one role model may lead to imitation and inhibits creativity; a number of role models are therefore advisable.

The relationships mentioned in the previous paragraph should be considered in classroom practice: *Teaching creatively* may not always be equated to *teaching for creativity*. A teacher with a creative personality may perhaps even inhibit the creativity of learners when it leads to imitation and/or feelings of inferiority in the learner. A creative teacher may further, due to his/her own personal thinking style and complexities (*cf.* 2.2.3.1) confuse some learners and leave them in chaos and unable to learn properly.

2.4.3.5 Providing mediation

Pintrich and Schunk (2002:146) quote Rotter in saying “*the major or basic modes of behaving are learned in social situations and are inextricably fused with needs requiring for their satisfaction the mediation of other persons.*”

Also according to the Activity Theory (*cf.* 2.5.2) (originally developed by Leont’ev, Vygotsky and Luria and later expanded further by researchers such as Rubinshtein, Bernshtein and Engeström), human activity is goal-orientated (Ryder, 2005:2). Culturally established tools, in collaboration with other humans, mediate human

activity. Cultural conventions (rules) and social strata (division of labour) within the context restrain human activity.

Tools of both physical and psychological nature are involved in this process of mediation. These tools include language, physical instruments, artifacts and praxis (established rules, procedures and knowledge). They shape the way humans react with reality, reflect the experiences of others who tried to solve similar problems before, carry particular cultural and historical remnants from their development in them and are a means of accumulation and transmission of social knowledge. The relationship between the tools and the human is dynamic. Through the tools, the mental processes of humans change, but at the same time the tools also change. Tools in this broad sense therefore act as a bridge between the past, present and future. They facilitate co-evolution (*cf.* 2.5.2) because the external shaping and reshaping of tools affect the shaping of the internal mental processes in humans (Vygotsky, 1978:52-57, 132-133).

Vygotsky emphasizes the importance of social interaction and specifically mediation in stimulating thought in individuals and ultimately in society (*cf.* 3.3.3.2). One of the main ways of communication, namely social interaction, forms the basis of cognitive development. Language is an important tool of cognitive development itself and is the carrier of understanding and a means for its development. The development occurs both horizontally, across people in groups, communities and cultures AND vertically, in processes of individual cognitive development.

Vygotsky describes knowledge as socially constructed and not given or unchanging. Knowledge varies across different social contexts and historical times, is built up and passed on through constant processes of social interaction. It is always in process of construction and is of great importance in cognitive development. (Vygotsky (1978:125-128). Feuerstein (*cf.* 3.3.3.2) also agrees that higher cognitive functions need mediation. These ways of reasoning are learned behaviour: the result of cultural evolution. It is therefore impossible for it to originate spontaneously in a human being without mediation.

According to these models, it is therefore the social and cultural system in which the individual finds him/herself that plays a major role in intentionally "stretching" the individual. This corresponds with stretching the learner into the zone of proximal development (*cf.* 3.3.3.2) versus the zone of actual development (Vygotsky, 1978: 84-91). If a learner is to learn, he/she must be challenged. These challenges cause

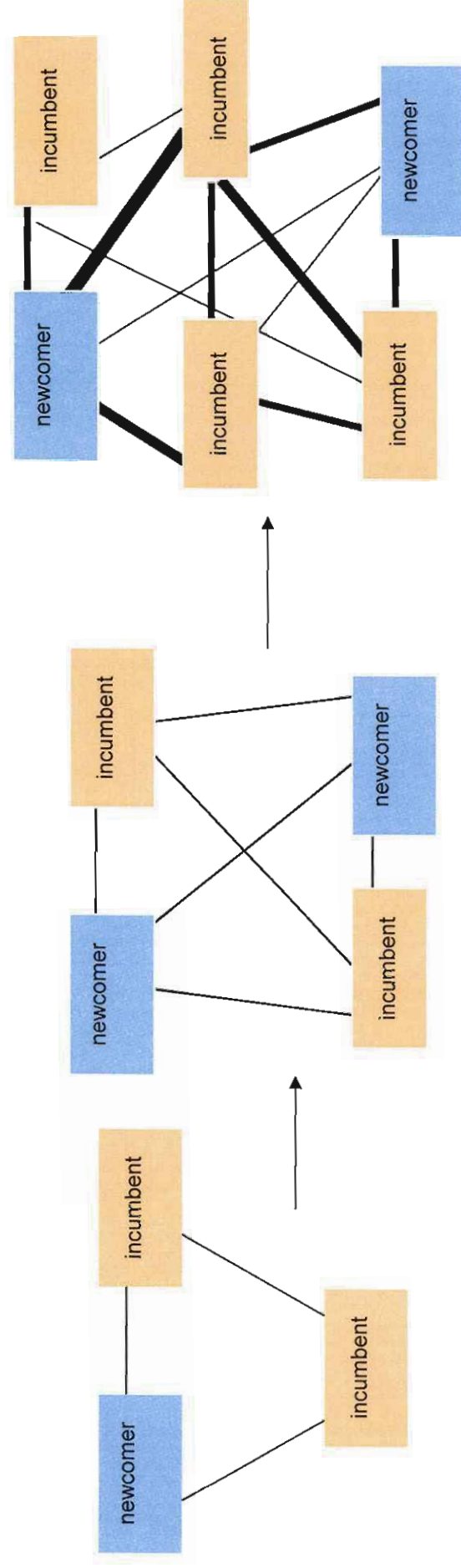
stress and anxiety. Mediation by competent and emotionally engaged mediators can make the stress and anxiety to which he/she must inevitably be exposed if he/she is to learn, manageable (Hüther, 2006:341). Both mediation and challenge must be present for learning to occur. Without mediation, the anxiety and stress of the challenge may become overwhelming, causing an emergency reaction, so that the learning process is sabotaged. On the other hand, without a stimulating environment that provides challenges, no adaptive modification of the brain takes place and no learning occurs.

2.4.3.6 Providing support

Wood, Bruner and Ross (in Wood, 2003:280-292) describe scaffolding (*cf.* 3.3.3.3) as a teaching strategy that provides students with specific support to accomplish tasks and develop understanding that they would not be able to manage on their own. The teacher provides temporary supporting structures at particular points in the learning process. Over time, support is withdrawn and responsibility for learning gradually shifts to the learner. As with mediation, scaffolding helps to optimize brain development caused by controllable stress resulting from “stretching” the learner into the zone of proximal development (Hüther, 2006:341).

Bronfenbrenner (1979:5-6) describes the simplest mentorship system, namely the dyad: a two-person system that is considered as one of the basic units of the ecological schema. Both members of the dyad are influenced by the interaction between them. Dyads can be extended to triads, tetrads and larger interpersonal structures. The concept of “invisible colleges” extends this mentorship model. It uses the assumption that a supportive environment with an optimum size and ratio of newcomers and incumbents may encourage individuals to use their creative abilities and to show them to the world (Guimera, Uzzi, Spiro & Amaral, 2005:697-702). Numerous examples of creative people who were embedded in networks comprising other artists and scientists can be given. The model for formation of creative networks (fig 2.18), is called *De Solla Price’s* “invisible college” (Guimera *et al.*, 2005: 698). They describe the optimal conditions for interaction. The development of successful invisible colleges is a dynamic evolutionary process. It spurs creativity when proven innovations in one domain are introduced into a new domain, solving old problems and inspiring fresh thinking. Kurtzberg (2005) also finds that cognitive diversity in a group may be beneficial for objective functioning, but may damage team satisfaction, and affect members’ impressions of their creative performance.

Figure 2.18: Occurrence, complexity and quality of networks become more as organization/culture evolves



A heterogeneous composition of teams, so that newcomers (providing fresh insights) and incumbents (providing expertise) interact, is preferable for supporting creativity above homogenous groups consisting of newcomers only or incumbents only (Guimera *et al.*, 2005:698). Cognitive diversity in a group may be beneficial for objective functioning. Diversity may however also promote conflict and miscommunication.

2.4.3.7 Stimulating cognitive development

If one assumes that creativity depends on ordinary mental processes, the factors responsible for the development of these mental abilities must have an influence on the development of creativity. Bandura and Vygotsky's ideas of the importance of models and mediation in stimulating cognitive abilities are discussed above (*cf.* 2.4.3.4 and 2.4.3.5). Other authors like Gauvain (2001) further emphasize the importance of the social context in cognitive development. Although exceptional intelligence is not needed for creativity and giftedness may even inhibit creativity (Carr, 2004:150), authors agree that a certain basic level of analytical intelligence is essential to ensure creativity (Getzels & Jackson in Dacey & Lennon, 1998:7; Gardner & Wolf in Dacey & Lennon, 1998:8; Sternberg & O'Hara, 1999:269; Nickerson 1999:96 and Carr, 2004:156). Ng (2001:12) explains Ericsson's observation that below an IQ of 120 there is a direct relationship between creativity and IQ. Beyond the 120 threshold the relationship blurs, since other factors then become more important predictors of creativity.

According to Gauvain (2001:140) *"cognitive development in everyday life is nested within and emerges from a social world that contains historical, contemporary and prospective influences-these influences help define and steer the developmental course and provide opportunities for and impose constraints upon intellectual growth. These opportunities and constraints help organize the developing mind in ways suited to the needs and aspirations of the communities in which growth occurs. It is in this way that the social and cultural context operate as mechanisms for cognitive change"*.

2.4.3.8 Providing the brain development needed for creativity

Another reason why context is so important in stimulating or inhibiting creativity is because it is one of the main factors that drive the development of the brain. As will be seen in section 3.3.1.2, both genetic and environmental factors are today

recognized as important in the development of an individual and his/her mental abilities. The environment in which an individual grows up and lives determines which genes will be expressed. Scheibel (1999) describes the process as a "*melding of nature and nurture*" that helps determine the extent to which each individual can tap his/her creativity. A human being's brain is shaped predominantly by his/her social, emotional, cognitive and physical experiences during infancy and childhood. The brain is seen as a plastic, reactive organ that, both literally and figuratively, grows with use and decreases with deprivation. Svoboda (2002:1-3) explains the role of experience in "*wiring*" a person's brain. Perry (2002:2-5) describes the different processes that depend heavily on nurture (so-called activity-dependent processes) involved in the formation of connections in the brain (*cf.* 3.3.1.2.3)

Contextual factors play a key role in the development of the brain, since different genes are expressed under different conditions such as the language spoken and the culture exposed to. Neurodevelopment is activity- dependent. By adolescence, the majority of the changes taking place in the brain are determined by experience and not by genetics. There exist certain windows of opportunity and windows of vulnerability. The sensitive period for brainstem-mediated functions is during the prenatal period. For the neo-cortex it is throughout childhood and into adult life (Perry, 2002:6).

2.4.3.9 Providing a conducive atmosphere and variety

Ekvall (1996) describes environmental prerequisites to nurture creativity. They include:

- Time and resources
- Openness
- Lack of autocracy and fear
- Sharing and collaboration
- Proper rewards and recognition
- Enthusiasm for ideas

Isaksen *et al.*, (2000) suggest the following for encouraging an atmosphere nurturing imagination:

Respect individuality

- Permit activities and tasks to be different for various individuals
- Respect an individual's need to work alone or in groups
- Respect individual differences, styles and viewpoints
- Build a feeling of individual control over what is done and how it might best be done. Encourage individuals to have choices and involve them in goal-setting and decision-making processes.

Training and resources

- Learning and application of specific creative problem-solving tools and skills
- Resources and room rather than controls and limitations
- Right amount of work in a realistic time frame
- Toleration of complexity and disorder, at least for a period

Supporting originality:

- Encourage expression of ideas
- Allow freedom to try new ways
- Encourage open safe atmosphere by supporting and reinforcing unusual ideas and responses.

Open relationship

- Communicate confidence in the individuals with whom you work. Encourage feeling of interpersonal trust and teamwork.
- Use mistakes as learning opportunities by giving affirmative feedback and judgment.
- Achieve high quality of interpersonal relationships: spirit of cooperation, open confrontation, resolution of conflicts, mutual respect and acceptance among individuals

Variety

- Being part of more than one cultural group, being uprooted from traditional cultures, and having access to more than one discipline enables an individual to “combine elements in a truly unique *fashion*” (Simonton, 1988:414).

2.4.3.10 Inhibiting creativity

When considering the contextual factors that can inhibit creativity, the creative person, the process followed, the context within which the process takes place and the product of the effort must be seen as a unit. Jones (in Isaksen *et al.*, 2000:14) identifies the following contextual barriers to creativity:

Social

Resistance to new ideas, isolation, negative attitude towards creative thinking, limited resources, limited time, over- emphasis of competition or cooperation, autocratic decision-making and reliance on experts may all be social factors inhibiting creativity. When doing creative work, there is a risk of failure. Failing makes one lose face. Davies (2000:9) finds that teachers are often concerned about student failure and therefore do not encourage learners to be “*skeptical about success nor taught its value in the rigorous thinking and problem solving essential for creativity*”.

Cultural

Culture is highlighted as a factor strongly impacting on creative abilities because of its censoring role: it allows high creativity, low creativity or no creativity. As pointed out in the description of the creative process (*cf.* 2.3.5), the prefrontal cortex is involved in creativity (Dietrich, 2004), acting as a filter through which conscious creative combinations are sifted. It will only allow creative ideas through if the learned culture allows such combinations. Radford (2004:53-64) notes: “*Creative acts involve the risk of falling into non-sense. In the intelligent selection and processing of information, we are guided by subconsciously assimilated emotional markers that are the result of acculturation. When the creative act challenges the boundaries of sense, a higher level of emotional consonance takes place.*”

Culture is therefore one of the factors involved in creating a context for creativity. Cultural values are imprinted before the age of ten (Hofstede, 1991:8). According to Makgoba African culture is described as communalistic / collectivistic and generally characterized by low levels of individualism (Lassiter, 1999:4; Tshikuku, 2001:7-24;

Van der Walt, 2003:70-71 & Rudowicz, 2003) whereas Western culture is viewed as individualistic.

Hale-Benson, an African American (1986:54-60), cites a number of studies such as those by Shelton, Ebsen and Robert and Ruth Monroe that point out that the Sub-Saharan African child is socialized for expressionism (a preference for clear, uncomplicated and unreserved behaviour), for compliance (obedience and conformity) and cooperation (being "*his brother's keeper*", having a "*care syndrome*", extended families and dependence are seen as virtues). Hale-Benson (1986:59) quotes Shelton saying: "*Each age group is interdependent to the extend that a network is created among children, parents, grandparents, and ancestors on a vertical plane and extended family, relatives and members of other families on a horizontal plane.*"

Hale-Benson argues that, wherever African people are found in the world, this pattern is perpetuated. She contrasts this with the way in which Western children are raised (more impersonal and detached from others, more emphasis on individual rewards, independence and nuclear families). Van der Walt (2003:70-71) reiterates Hale-Benson's arguments in his description of the communalistic and individualistic cultures: a communalistic culture is characterized by, among other things, the elevation of the group above the individual, working for group rather than individual status and discouragement of individual initiative, resulting in a large degree of uniformity. Young people are not encouraged to have their own opinions because of hierarchical and paternalistic views of authority. Novel ideas threatening existing traditions that aided survival in the past are viewed with skepticism. It might be considered wrong to show that one has opinions of one's own that differ from those of the elders, the in-group or ancestors. There is a strong adherence to taboos, traditions, rules and custom-bound thinking. This description corresponds with Zich's (1996) list of blocks to creativity (*cf.* 2.2.5).

In global culture, it is usually seen as the responsibility of a creative individual to make his/her ideas visible within the field. The ideas of highly competitive and individualistic individuals are therefore more likely to become visible and accepted in the field than those imprinted to conform.

School education in South Africa generally equals acculturation in a global (Western) culture. Gabora (1997:20) and Simonton (1988:414) point out that exposure to a variety of cultural influences stimulate creativity, while isolation limits it. The chaos

theory maintains that one cannot predict whether cross-cultural influences would be stimulating or inhibiting, but they have the potential to be stimulating. Hong, Morris, Chiu and Benet-Martinez (2000:710) refer to the concept of *"frame switching"*. This happens when two or more cultures are internalized. They are internalized as a loose network of a domain-specific knowledge structure and cannot simultaneously guide cognition. The cultures are not necessarily blended and the second culture does not replace the first one. Particular cognitive processes become operative in particular interpretive tasks and in guiding an individual's construction of meaning (Grosser, 2006: 117-118). Cognitive processes that are not operative in the culture of the learner need to be developed and modelled (Kozulin & Presseisen, 1995; cf. 3.3.3.2). If values are imprinted before the age of ten and exposure to another culture occurs after that, it can follow that a person may basically adhere to the early values, but switch to another frame as circumstances demand. Loyalty to the earlier imprinted culture may be the stronger of the two and the second culture may have only a superficial influence on a person's behaviour and thinking (Hofstede, 1991:8).

There are further indications that bicultural individuals possess separate cultural schemas for the different cultures that are activated by cultural cues. Those viewing their different cultures as compatible, respond in culturally congruent ways to cultural cues whereas individuals who perceive their cultures as opposing exhibit a reverse priming effect (Benet-Martinez, Leu, Lee & Morris, 2002:509).

Historical factors

Creativity may also be inhibited by historical factors on micro-, macro- and meso-levels in the context. Bronfenbrenner (1979:4) explains that a person's development can be profoundly affected by events occurring in settings (and in times) in which the individual is not even present. In a person's personal history, factors that seem to be less favourable may be the trigger for the creative personality to develop. On a meso-level, a lingering low self-esteem and being overwhelmed by the technology of foreign origins, the so-called "colonial mentality" (cf. 2.4.2.4), may result from colonialism, slavery, migrant labour practices, neo-colonialism and "apartheid", as were seen in Africa (Davidson, 1991: 281-316). Tillman and Tilman (in Hale-Benson, 1986:152-153) are of the following opinion:

"Black people wherever they are found in the world, are in a colonial relationship with white people. This colonial system has perpetuated their political, economic and cultural exploitation."

These may be inhibiting factors that impact on the psyche of a whole population of people. The strong paternalistic, authoritarian, conservative thinking in the Afrikaans community may also be seen as a possible inhibitory factor.

Bronfenbrenner (1979:4) states that it is the perceived world rather than an objective reality that matters for behaviour and development. If a person views his/her culture as inferior and that of another as superior, it becomes his/her reality. Memmi (1991: 90-141) indicates that colonialism has a number of universal consequences. A colonized mind becomes dependent on the instructions and the ideas of the colonizer. The technology and knowledge systems of the colonized are viewed as inferior by both colonizer and the colonized. The colonized simultaneously hate and adore the colonizers and their culture, and aspire to it.

According to Simonton (1988:413), a further factor involved in the stimulation and/or inhibition of creativity, may be literacy-levels. A curvilinear inverted U-shaped curve is proposed to represent the relationship between formal education and creativity, as well as between creativity and the influence of role models (This means that the chances of creative contribution increases with education up to a certain maximum, whereafter formal education becomes an inhibiting factor). Again the prefrontal cortex is implicated as the filter (*cf.* 2.3.5) through which humans recognize and assume the habits and constraints of culture (Scheibel, 1999). Compulsory school education and literacy are very recent in South Africa. Black South Africans had an oral tradition until contact with the Europeans came 350 years ago. Initially, learning to read and write was not valued as today. It came from a foreign culture and had few applications in the context on which it was imposed. Mwamwenda (1995:109, 112, 116) explains that parental education, exposure to urban life styles where Western culture has more influence, formal schooling and quality of school education are shown by researchers like Greenfield, Reich and Olver (1966), Rogan and Macdonald (1983) and Lloyd and Easton (in Mwamwenda, 1995) to have an influence on the cognitive development and school success in African children to a large degree. Low literacy levels limit the exposure to the general domain of written human knowledge, thus blocking creativity (Csikszentmihalyi, 1994:131-136). The individual is limited to what other people tell him/her or to what is experienced in his/her own lifetime. Many of the African students participating in this study may come from rural backgrounds, may only be first or second-generation literates and few may come from households where parents or siblings were exposed to senior high school or to tertiary education. To become an expert in a field, as many

inventors are, will then take extra effort and support. Students from rural areas may further have limited exposure to, among other things, technological ideas, products and vocabulary that might be considered as common by other cultural groupings. This situation equals cultural deprivation in the culture in which the students are expected to perform and could impede their creativity. This corresponds to a situation where an individual receives adequate, but deficient Mediated Learning Experience that does not support Higher Order Psychological Tools (HOPT) to which he/she is exposed at school (as described in model C of Kozulin & Presseisen (1995) (*cf.* 3.3.3.2)).

2.4.4 Enhancing the creative context in Technology Education

Both the physical and social contexts in a classroom situation seem to be important for the development of creative thinking.

2.4.4.1 The physical context

In two consecutive studies, McCoy and Evans (2002) investigated the potential role of the physical environment in fostering creativity. The first study identified five environmental characteristics that were perceived by students to be conducive to creativity. These characteristics were: (a) complexity of visual detail, (b) view of natural environment, (c) use of natural materials, (d) fewer cool colors used, and (e) less use of manufactured or composite surface materials. They found that the creative performance was indeed higher in the physical environment rated higher by the participants in the first study. Using a variety of arrangements of the physical objects and hands-on experiences may be further stimulating factors.

Physical models, often used solely as evidence of creative output, may be used as a source of knowledge, a teaching aid and/or a research topic. In a classroom, existing physical models may be used with worksheets or in demonstrations to guide in the discovery of certain principles. Having the freedom and available resources for making physical models may be used to teach skills and knowledge and / or discover knowledge. It may be used in a trial-and-error discovery experience, directed discovery or as an opportunity for applications of knowledge. A model may also be used as a springboard from which certain weaknesses can be identified and improved on. It brings the ideas that students had in mind into reality and shows strengths and weaknesses in thinking. A product on the market may be a useful research topic when thinking about aspects like historical development, social and

environmental impact, ergonomics, cultural aspects, variety available, trends in its development and possible future developments.

This way of learning was used by famous innovators like Faraday and Edison who used to create “*mechanical representations*” (Gorman, 1999). Gooding comments (in Gorman, 1999) that it is easy to retain these mechanical representations in the memory and that they are so well understood that it is easy to understand their use and the properties of their components can easily be worked out.

2.4.4.2 The social context

The context interacting with person factors like personality, intelligence, knowledge and experience results in creative behaviour (*cf.* 2.4.2.2). Technology Education gives opportunity for creating a classroom where interaction takes place between the individual and the context in such a way that creativity can be enhanced. Opportunities exist for presenting, networking, publishing and marketing ideas and products within a supportive environment. The emphasis here is on provision of supportive networks (*cf.* 2.4.3.2 and 2.4.3.6), mentoring and mediation (*cf.* 2.4.3.5) and role models (*cf.* 2.4.3.4) on the one hand and, on the other hand, on valuing creative output and providing an atmosphere of openness. In doing so, one has to set up a reward system rewarding novelty and originality that should break the mold that is sometimes established in families and schools.

Mediated creativity (like the CPS-model (*cf.* 2.3.4.2) and guided discovery (*cf.* 3.3.4.2) may be the way to go with inexperienced students. Very few students on first year level could be expected to be independent enough to start in chaos (figure 3.9). Even senior students may need a degree of scaffolding, mentoring, mediation and guidance.

Supportive networks (*cf.* 2.4.3.6) may consist of lecturers, co-students, senior students such as facilitators or experts outside the classroom or even artifacts, like printed and electronic sources. Cooperative learning groups, Socratic dialogue and tutoring are techniques that may be used. Ideally the groups should consist of individuals with different levels of competence and expertise in different fields. This situation is not so easily attainable within a classroom situation with, for example, only first year students with no exposure to the domain. The closest that one can come to this is by grouping students for certain tasks and letting every group member or group of students become experts in some areas and share their expertise with

others. Networks can be established within groups and also between groups. The formation of supportive networks is essential for any individual, but perhaps even more so in communalistic cultures where competitiveness and individualism are viewed with suspicion and support is considered as a given.

Chi, Siler, Jeong, Yamauchi and Hausmann (2001) investigated one-to-one tutoring between students. Their research indicates that, even though the tutors in their experiment were suppressed from giving explanations and feedback and encouraged only to prompt the students, the students learned just as effectively. They attributed this success to "*construction from deeper and a greater amount of scaffolding episodes, as well as (a) greater effort to take control of their own learning by reading more*". Vanlehn, Siler, Murray, Yamauchi and Baggett (2003) find that the readiness of the student is a key to tutoring. They mention that the student should reach an impasse for tutoring to be successful.

Technology Education emphasizes an understanding of the interrelationships between science, technology, society and the environment. This gives scope for a more personal intervention like exposure to creative role models. Role models (people who achieved despite obstacles such as bias and less than ideal social situations) may be one useful way to help and encourage students to use their creative abilities, especially if low creativity is due to cultural inhibition (*cf.* 2.4.2.1 and 2.4.2.2). The role of creative role models in the enhancement of creativity is discussed in section 2.4.3.4.

2.4.5 Critical evaluation

The ideas of chaos and complexity theories, highlighted in section 2.4.2.1, have a number of implications for this study:

Quasi-predictability: Although the phenomena of cultural change and creativity, which is instrumental in this change, are complex and are largely **unpredictable**, quasi-predictability is possible close to strange attractors so that *linear relationships* may be described and some predictions may be made regarding human behaviour. Experiments such as the ones in this current study may therefore have some value.

The butterfly effect: Small differences in the initial conditions of a process can produce large differences in outcomes, and conversely large initial differences can have very little impact. Although a small change in the attitude and perceptions of students may result from intervention programmes, one need not be discouraged.

This small improvement may lead to large changes in the community over time. Because of the butterfly effect one should, however, also be cautious rather to go for a balanced education and be careful not to overemphasize any aspect to the detriment of others.

Strange attractors: Interference patterns emerging from contact between cultures with different value systems and orderings as in South Africa may be seen as a factor stimulating creativity. Every culture comes with its own strange attractors. Acculturation occurs as new patterns are produced from the interaction of the strange attractors representing these cultures, but *"the fractal-ness is also the motivator to innovation, adaptation, and change"* so that also enrichment may result from the differing conceptions of interacting cultures (Remer, 1998).

The presence of a number of strange attractors also explains the role of marginality in the life of creative individuals. A prefrontal cortex where more than one culture has an input may perhaps help an individual to be more creative.

One must remember that it is the evolving conception of the context that has an effect (*cf.* 2.4.2.2). To provide the appropriate conception of the context is therefore important. Some of the contextual factors indicated as playing a role in providing support for creativity such as mediators, models and networks could be simulated in a classroom situation at tertiary level. Inhibiting factors in the context can be attended to by providing support and an atmosphere of mutual respect and openness, letting students know that originality will be rewarded in certain appropriate tasks, giving opportunities for original work and discussion that stimulates the consideration of alternative perspectives and ideas. Others that depend on genetics, the family, very early developmental aspects and school education are unattainable. One must realize that the effects of any programme may be limited.

To encourage students to leave the "safety" of the oasis and venture into the Klondike space (*cf.* 2.4.2.1) despite sometimes few or no indications of where the solution might be found, is a challenge that some students may be reluctant or even unable to meet. The discomfort and uncertainty may leave some confused and discouraged. Lots of encouragement, support and assurance may be needed for these students.

Most people accept that the context plays an important role in human behaviour. The roles that the context plays in creative behaviour are highlighted in this section. The

socio-cultural context seems to influence the levels of creativity in a community, as well as in an individual. In the community it seems to fit the description of a natural system that may follow the patterns suggested by the chaos theory. Creativity may be instrumental in causing gradual evolution or rapid revolution. The occurrence of the phenomenon of creativity in the community may depend on the individual, as well as on the natural and socio-cultural environment. The components involved in creating the context range from the proximal face-to-face to the distal macro-systems, all of which are interrelated and interacting with one another. Factors like history, politics, culture and time all play roles in establishing a context in which creativity can be inhibited or stimulated. Cyclical patterns may be involved in the inhibition or stimulation of creativity in communities.

Contexts that shape the behaviour and personality towards openness and independence and provide appropriate role models, motivation, networks of support, mediation and cognitive development are needed to stimulate creativity. Cultures that allow the individual to express him/herself and where individual freedom exists are more likely to produce more creative individuals. Traditional communalistic African, conservative Afrikaans culture and historical factors such as low literacy and "colonial mentality" may be inhibiting factors regarding creativity in South Africa. The increased interactions and resulting cultural exchange between the different cultures in South Africa, especially since 1994, may on the other hand be factors stimulating creativity. New strange attractors may lead to new bifurcations that may bring new patterns into action.

In the next section the role of the creative product will be discussed.

2.5 THE CREATIVE PRODUCT

2.5.1 Introduction

The products of creativity may be solved problems, needs that are met or desires that are satisfied. They may also be ideas, expressed emotions, feelings and/or resolved conflicts or paradoxes. These products can be tangible (such as a concrete object) and intangible (such as a social system). Products can be useful in themselves, but may also be used as evidence of creativity, as sources of information, inspiration and ideas and reflect the values and attitudes of the culture and society. In a teaching and learning situation, the learning environment, opportunity or programme, designed, planned and constructed by the teacher, may all be seen as creative products. In Technology Education models are often the products. Davies and Elmer (2001:164) distinguish between cognitive models (reflecting the generation and manipulation of ideas in the "mind's eye") and/or concrete models (the externalization of the cognitive models).

In this chapter, the role of creative products will be discussed. Measuring creativity, the creative products expected from teachers and how Technology Education may be instrumental in enhancing the creativity of the products will be addressed. A critical evaluation about what was learnt about the creative product will be given.

The section will be concluded with a summary of the sections 2.1 to 2.5.

2.5.2 The role of creative products

Creative products serve as mediators and context creators, as evidence of creativity, as sources of information, ideas and inspiration and as reflection of the values and attitudes of culture.

2.5.2.1 Products as mediators and context creators

Activity Theory points out that tools are mediators for learning. A tool can be anything used in the transformation process, including both material tools and tools for thinking. Bedny and Engeström (in Wilson, 2006) compiled the figures 2.19(a) and 2.19(b) respectively to explain the basic and extended frameworks of the Activity Theory. Figure 2.19(a) refers to individual activities and figure 2.19(b) refers to communal activities. Engeström (in Rajkumar, 2006) describes the Activity Theory as follows:

"An activity is undertaken by a human agent (subject) who is motivated toward the solution of a problem or purpose (object), and mediated by tools (artifacts) in collaboration with others (community). The structure of the activity is shaped and constrained by cultural factors including conventions (rules) and social divisions (division of labor) within the context".

Artifacts are created and transformed during the development of an activity and in turn transform the individual(s), a process known as co-evolution (*cf.* 2.4.3.5). Learning takes place as a transformation process, and as seen in figures 2.19(a) and 2.19(b), rules (praxis), community, division of labour, as well as tools are involved in an activity. Tools or products of creativity, (material and symbolic: such as sign systems, instruments, procedures, machines, methods, laws, processes), are therefore also involved in creating context. That brings creative products into a mediating role. Culture, language, writing systems, resources such as books and communication systems all play mediating roles in learning, as well as in creativity.

Figure 2.19(a): The basic Activity Theory Framework

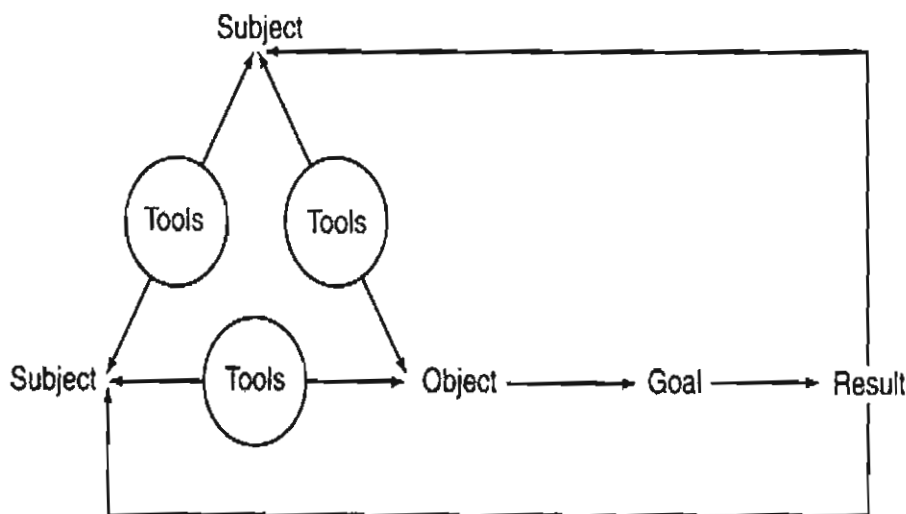
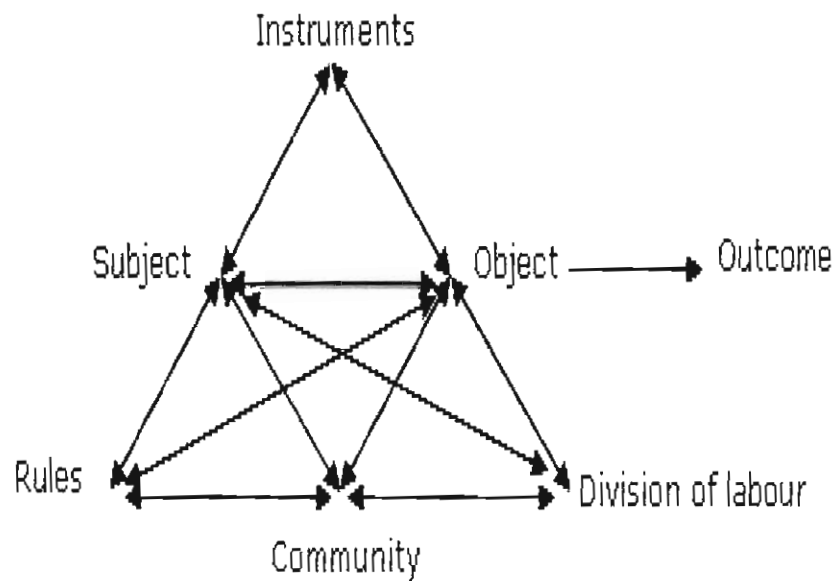


Figure 2.19(b): Engeström's extended Activity System Model (in Wilson, 2006)



2.5.2.2 Products as evidence of creativity

Hennessey and Amabile (1988:14) are strong advocates for the use of creative products as evidence of creativity, rather than pen-and-paper tests. They define a creative product as one that is a novel and an appropriate, useful, correct or valuable response to an open-ended task. They add that the product can only be described as creative to the extent that observers recognize it and agree that it is creative. It therefore depends on the experts. One may say that, according to this viewpoint, creativity is in the eye of the beholder and may depend on what is currently fashionable. They propose that the judges should all have experience in the domain and make their assessments independently. Assessment criteria should include criteria besides creativity, the products should be rated relative to one another and not against an absolute standard and each judge should view products in a different random order. There are also different levels of manifestation of creativity in creative products.

MacKinnon (in Isaksen *et al.*, 2000:15) expresses concern about the lack of explicit qualities for defining creative products. He is of the opinion that much of our view of what a creative product is, is based on subjectivity. Since 1975, Besemer, Besemer and Treffinger and O'Quin and Besemer (in Isaksen *et al.*, 2000:16-19), have developed instruments, the Creative Product Analysis Matrix and the Creative Product Semantic Scale, to assess the creativity of a particular product or outcome.

Novelty (newness), Resolution (how well the product solves the problem) and Style (elaboration or synthesis, elegance, well-craftedness, attractiveness) are the aspects proposed in Besemer's instrument.

2.5.2.3 Products as sources of information, ideas and inspiration

Patterns can emerge from the study of the evolution of products that can predict future trends. One example of this is TRIZ (Mazur, 1995; TRIZ; *cf.* 2.3.4). TRIZ research began with the hypothesis that there are universal principles of invention that are the basis for creative innovations that advance technology and that, if these principles could be identified and codified, they could be taught to people to make the process of invention more predictable. Altshuller and his colleagues scrutinized over a million patents and extracted 40 inventive principles to help engineers find highly inventive and patentable solutions to problems. They found that:

- problems and solutions were repeated across industries and sciences;
- patterns of technical evolution were repeated across industries and sciences; and
- innovations used scientific effects outside the field where they were developed.

These three findings are applied to create and to improve products, services and systems. In the 1960s and 1970s, Altshuller categorized the solutions into five levels shown in table 2.6 below.

Table 2.6: Levels of Inventiveness (TRIZ)

Level	Degree of inventiveness	% of solutions	Source of knowledge	Approximate number of solutions to consider
1	Apparent solution	32%	Personal knowledge	10
2	Minor improvement	45%	Knowledge within company	100
3	Major improvement	18%	Knowledge within the industry	1000
4	New concept	4%	Knowledge outside the industry	100,000
5	Discovery	1%	All that is knowable	1,000,000

What Altshuller tabulated, was that over 90% of the problems engineers faced, had

been solved somewhere before.

The trends that TRIZ researchers identified are:

- Technology follows a life cycle of birth, growth, maturity and decline.
- Increasing ideality (the quotient of the sum of positive effects of product divided by the sum of the negative results)
- Uneven development of subsystems resulting in contradictions
- Increasing dynamism and controllability
- Increasing complexity, followed by simplicity through integration.
- Matching and mismatching of parts
- Transition from macro-systems to micro-systems, using energy fields to achieve better performance or control
- Decreasing human involvement with increasing automation

According to Osborn and Eberle (in Isaksen *et al.*, 2000:110) most products evolve from previous products. CPS (*cf.* 2.3.4) describes the use of checklists like SCAMPER (**S**ubstitute, **C**ombine, **A**dapt, **M**odify/**M**inify/**M**agnify, **P**ut to other uses, **E**liminate, **R**earrange/**R**everse), to generate ideas about a product and come up with many variations. These checklists act as triggers for new ideas in a brainstorming exercise.

2.5.2.4 Creative products reflect the values and attitudes of a society

Creative products, lastly, reflect the values and attitudes of a society. Designers are part of society. They express the needs of the society (fig 2.5). For example: we may say that we currently live in a “garbage society”. Many products are used once and are discarded before their natural “lives” have expired, creating garbage. Designers design products for this society. Since the concept of global warming came into the spotlight recently, “eco-chic” is the new buzzword. Edelkoort (2007) describes the concept “Zeitgeist”: *“it’s the spirit of our time, politics, the economy, war debate – the creative world reacts to all these forces. It’s like the collective unconscious.....everyone from their own realm will come to the same conclusion at a particular time”*.

The role of cultural and social influences is also seen in Technology Education classroom. Davies and Elmer (2001:178) conclude that modeling outcomes are strongly influenced by social and cultural influences.

2.5.3 Measuring creativity

To measure creativity is a controversial matter. A number of pen-and-paper tests exist. Torrance (1974) based the Torrance Tests of Creative Thinking on Guilford's ideas (cf. 2.2.2.1.2). The Torrance Tests consist of several simple verbal and figural tasks that involve divergent thinking plus other problem-solving skills. The tests can be scored for fluency (the number of relevant responses), flexibility (number of different categories of relevant responses), originality (statistical rarity of the responses) and elaboration (amount of detail in responses). (The validity and reliability of the ATTA are described in 4.6.1).

2.5.4 Creative products expected from teachers

Teachers are involved in a continuous process of generating products such as learning resources, learning programmes, tools, instruments and experiences for optimizing, enriching and assessing learning. Mason (2000:3) interprets Dewey's work in describing the role of the teacher as vital *"in carefully structuring an educational environment with which the learner, given his current knowledge and potential, can interact"*. Halloun (1998:7) explains that learning programmes are seen as guides that allow teachers to be innovative and creative in designing programmes. Vygotsky (1997:50-54) describes the highly creative role of the teacher as follows: *"the teacher is directing and guiding the environment, fashioning, taking apart, putting together, carving out elements of the environment and combining them in the most diverse ways in order to reach whatever goal has to be reached – in such a way that both the teacher and learner are active and the environment between them becomes active."* The teacher is the designer of the learning environment and must provide for the needs of the different learners in his/her care.

This can be done creatively or non-creatively. Creatively would imply working towards a product that is new, unstructured and open-ended. It may use Janusian thinking: looking in two opposing directions at the same time, actively and simultaneously considering opposites, such as analysis and synthesis, parts and wholes, past and future, bigger and smaller. Non-creatively would involve: looking at the situation in only one way, lack of consideration for alternative solutions,

mindlessly defending the status quo, application of worn out or habitual responses, resistance to exploring new opportunities, reaction before reflection on alternative responses, overlooking the need for improvement, develop or refine a solution, acting on faulty assumptions or incorrect data (Isaksen, *et al.*, 2000:26-27).

2.5.5 Enhancing the creative product in Technology Education

The participants in this study were all enrolled to obtain a qualification in teaching. One of their future creative roles would therefore be to develop relevant and original learning programmes (*cf.* 1.2). The model for the development of learning materials that is described below was taught at various in-service courses attended by the researcher and found in the material from the Heads of Education Committee (HEDCOM) (1996:15). It is based on the “Big Three Pedagogy” first developed by the Secondary Nuffield Design and Technology Project that started in 1990 (Barlex, 2001:5). This pedagogy uses three task types (*cf.* 5.4.3), namely case studies, resource tasks and capability tasks, as shown in table 2.7.

Table 2.7: Three Task types used in the “Big Three pedagogy”

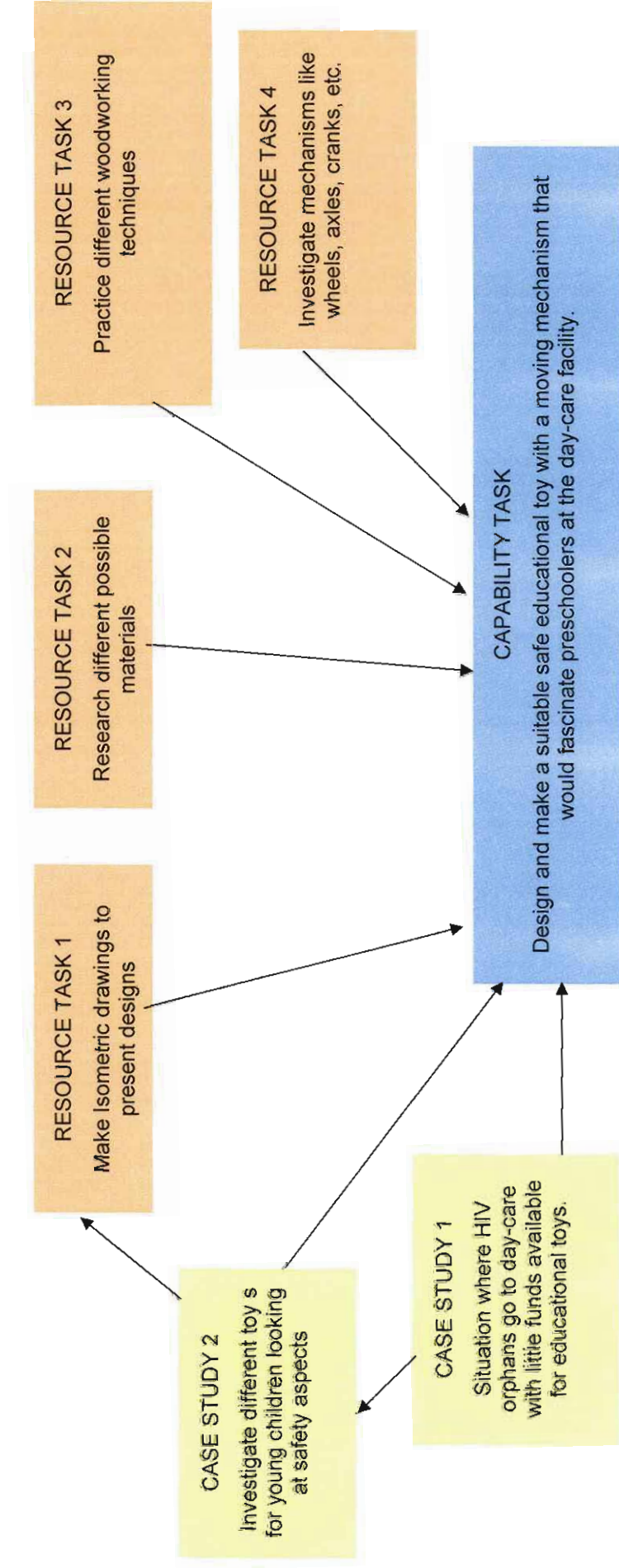
TYPE	CASE STUDY	RESOURCE TASK	CAPABILITY TASK
Structure	Short, structured	Short, structured	Expanded, open-ended
Aim	To link learning at schools/ universities to real life situations	To develop learner's resources of technological knowledge and skills	To integrate knowledge and skills. To utilize a range of resources to 1. analyse problems 2. design solutions 3. develop solutions 4. make solutions 5. evaluate solutions 6. present solutions
Example	Examining ethical, social, environmental issues related to development of technology and its applications	Examining materials, processes, elements of design and problem-solving	Finding possible solutions to technological problems by following the technological process

These task types are then combined to form integrated programmes such as the example in figure 2.20. A problem identified in a case study leads to the capability

task. The aims of the programme are:

1. Making learning relevant to the learners by contextualizing it through case studies. Case studies may be the source of a problem that may be solved, using the technological process. They are true stories about life outside the school and may elucidate the impact of technology (Barlex, 2001:5).
2. The empowering of learners with knowledge and skills through the use of resource tasks, enabling them to solve the identified problem on a technological more advanced level than without the interventions.
3. Giving learners an opportunity to solve the identified problem individually or in teams and using the knowledge and skills obtained in the resource tasks and case studies to complete the capability task (also known as the "design and make" task).

Figure 2.20: Example of a Technology Learning Programme outline



2.5.6 Critical evaluation

The ultimate aim of programmes for improving creativity is to enable students undergoing the training to produce creative products. Assessing the creative output of trainee teachers by using creative products should be the most valid way of assessment of the success or lack of success of a programme. Using creative products in assessment immediately brings one to the dilemma. Where does a researcher find products that all students did under optimum and similar controlled conditions, using their creativity to the utmost? This is why it is more practical and fair to use pen-and-paper tests like the ATTA to assess the effects of a programme. Other possibilities for assessing creativity may be exercises like thinking of multiple entrepreneurial opportunities arising from a situation or possibilities of lessons that a particular situation may provide. Exercises, using the same situation and done as a pre- and post-test, separated by a long period of time, may be compared.

The study of teaching and learning resources and trying to identify trends and principles as was done by Altshuller with technological products, could be a worthwhile exercise. From this, one can compile guidelines and checklists that can be used by newcomers to the field. Existing creative products such as models, drawings, portfolios, planned worksheets, learning programmes or learning experiences may be useful sources of inspiration, ideas and support in a classroom situation (especially in Technology). They may be analysed, compared and/or improved upon, but it must be clearly stated that mindless copying should be avoided.

2.6 SUMMARY

In Chapter two, creativity as a concept was defined. Different components involved in creativity were identified, namely the creative person, process, context and product. The available literature about each one of these components was discussed in detail and critically evaluated.

Creativity may be viewed in an elitist way to look at contributions of creative geniuses only. It may also, as in this study, be viewed from a democratic viewpoint as a universal human characteristic.

The highly creative person stands out as a complex person about whom a number of studies are available. From these studies, a lot can be learnt about creativity in all

humans. Aspects such as creativity, intelligence and learning styles, personality, thinking and creative styles were addressed in section 2.2. The use of Technology Education to support the individual to be more creative was discussed in the last part of this section.

In section 2.3, the creative process, natural and planned, and as described by people from different cultures was discussed. The available knowledge about the neurological processes occurring in the brain was also described. The section concluded with suggestions about how Technology Education may be utilized to enhance the creative process.

Creativity as a factor causing change in human culture, which is described as an evolving information system, was discussed in section 2.4. A number of systems theories representing the role of creativity in cultural change were discussed. It was found that certain contexts and certain conditions encourage creativity while others inhibit it. Factors that need to be present in a context to encourage creativity were discussed, as well as factors that inhibit it. How Technology Education may be instrumental in using contextual factors to develop creativity was discussed as conclusion to this section.

Section 2.5 discussed the creative product. The roles of the product as related to creativity were described. How products may be used to measure creativity, the creative products expected from teachers and how Technology Education may be instrumental in enhancing the creativity of the products were also addressed.

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about learning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER THREE

THEORIES ABOUT LEARNING AND THE STIMULATION OF CREATIVITY

3.1 INTRODUCTION

Learning involves the acquisition and memorization of information (content knowledge), but also the acquisition of ways of thinking and doing (procedural knowledge). Sonnekus (in Duminy, Dreyer & Steyn, 1990:297) sees learning as happening from the inside out, namely the *“changing of a person as a whole because of a dynamic, intentional directedness to act on, to change, to create, to explore and to discover the world”*. From this viewpoint, learning is a process that must not be inhibited. In designing a learning environment, the designer must provide for the innate ability and directedness of the learner. The learner will learn spontaneously, unless inhibited. Other authors see learning as a process happening from the outside in, when they define learning as *“a process by which people’s behaviour is modified through experience or training”* (Hamacheck, 1998:228). Learning is therefore a process that must be stimulated by optimal engineering of the learning environment. The learner *must be enticed* to learn by providing optimum conditions for effective instruction such as presenting information in an easy-to-learn format on levels that are appropriate to the learner, creating incentives for the learners and allocating enough time to each activity (Slavin, 2005).

Since each of these two viewpoints shows learning from a different perspective, they both contribute to understanding the full picture of how learning takes place. The first deals with the individual: the inner world: the psychological aspects, the knowledge acquisition and retention processes, as well as neuroscientific and genetic aspects that have an impact on learning. The second viewpoint would deal with the context: the outer world: the socio-cultural aspects of learning and how the individual can be supported and stimulated for optimum results. These two worlds are interacting dynamically. Increase in knowledge about the inner world impacts on the practical application of it in creating the optimum outer world and *vice versa*.

During the learning process, knowledge is transferred. Knowledge is transferred for reuse. Cheung, Chau and Au (2005) distinguish between knowledge reuse for

replication (KRR) and knowledge reuse for innovation (KRI). The purpose of knowledge reuse may be to increase productivity by replication of best practices leading to reproductive thinking. If the purpose of knowledge reuse is innovation leading to productive thinking, the knowledge needs to be integrated in such a way that another's knowledge can be *"adapted (integrated) into one's existing knowledge stock in order to accomplish an innovative task"*.

Is an environment that entices a learner to learn also the best environment to support the acquisition of creative behaviour? Is it possible that instruction (good or bad) may inhibit creativity? Is it possible that the conditions that enhance creativity in certain individuals may inhibit it in others? Why is it that many highly creative individuals could not cope at school? Can there be a compromise between a school-environment engineered for teaching reproductive thinking, making it also suitable for teaching productive thinking? Are the conditions leading to reuse of knowledge for replication and those leading to reuse of knowledge for innovation, in conflict with one another or are they attainable in the same environment?

Creativity may also be seen as an innate ability, an intentional directedness and an inborn way of thinking that may be inhibited by certain personal or environmental factors. What are these factors?

The assumption in this chapter is that creativity is a normal mental process that can be learned by most people. One assumes that normal learning processes underlie the learning of creativity and what is true of any learning is also true for learning creativity. How the individual learns and how the context influences the learning that takes place are the topics of this chapter. They will, however, not be discussed separately, but integrated in the different learning theories, as proposed from pre-historical times till more recently.

3.2 PRE-20TH CENTURY THEORIES ABOUT LEARNING AND STIMULATION OF CREATIVITY

How humans learn, how their learning abilities could be optimized and the practices that result in humans acquiring certain desired behaviours are topics that were constantly debated through the centuries. From the earliest times till the present day, educationalists and philosophers have usually viewed human beings as rational creatures whose thinking abilities could be exploited and developed. References to the intriguing concept of creativity, why some people tend to be more or differently

creative than others and how creative behaviour comes about, are also found in literature sources dating back into the pre-history of mankind.

Creativity in primitive communities was linked to mysticism and spiritual experiences. Insights often originated during trance-like states after taking special brews, but were also attributed to chance occurrences when trial-and-error led to the discovery of some natural principle or natural source. Learning was focused on survival in the natural environment. Utility and conservatism, taboos and customs were emphasized. The pedagogy of the primitive condition was built on the foundations of **imitation** and **trial-and-error**. Play and learning by doing were the methods through which learning occurred (Power, 1970). The individual learned because he/she could observe what others were doing and how they were responding to certain stimuli. He /she could imitate the actions of others.

In Greek society, creativity was seen as due to the influence of the gods and goddesses, muses (inspiring the arts) and daemons (intermediate spirits between men and gods): concepts linked to mysticism. The classical Greek philosophers like Socrates supported the notion of innate knowledge. They believed in **reasoning**, **intuition** and in the **intellect** as the source of knowledge. This knowledge was already seen to be in the person and dialectic was used to bring the knowledge out. The teacher's task was to stimulate thought, to encourage investigations, and to challenge students to think for themselves. Plato tried to lead his students through pertinent thought processes. Wenger (2005) attributes the success of the Greek civilization in producing a disproportionate number of geniuses relative to the size of the population, to the method of dialogue that Socrates introduced.

Aristotle believed that good character does not come from nature, but from education and habit. He was of the opinion that the aim of education is to direct man towards happiness. Imitation (replicate) and emulation (try to be like) of the grand ideals of orators, heroes and generals were emphasized (Power, 1970:10-12, 89-115). Aristotle's idea of learning was that experience and the senses play a crucial part in learning. He used the concept of "*contiguity*", namely putting two ideas together or forming associations.

During the Middle Ages education was the domain of the church and it focused mainly on preparing man for eternal life. Dialectic was seen as dangerous and logic became rules for correct thinking (Power, 1970:287-289). Learning helped to preserve the *status quo*.

During the late middle ages, the Renaissance and the later Age of Enlightenment followed a progressive relaxation of the rigid social and religious order. Every individual was seen to be responsible for his own thoughts and actions, both good and bad. Human creativity, personal achievement and individualism were encouraged and rewarded. The humanist Erasmus saw the aim of education as to lead man towards knowledge, honesty and independent judgment, thus leading the individual to autonomy, both intellectually and morally (Power, 1970:366-376). In the 20th century, existentialist thinkers like Sartre and DeBeauvoir, took this responsibility of man even further. They argued that a human being should not only be autonomous, but *"has to create or imagine him or herself: to create an image of the self and the relationship to the world around. Man defines its own being by its own ends"* (Sartre, 1943:443).

The idea of John Locke, an empiricist, of a *tabula rasa* opposed the idea of innate knowledge. He concluded that the mind is empty at birth and that the key to learning is the intake of knowledge through the senses. All ideas therefore come originally from experience, from outside our minds, rooted in external reality. The simple ideas link to reality and can be considered as true, whereas complex ones are compiled through imagination. The mind will also process the experiences and compare, categorize, generalize and discriminate among them (Linskie, 1977:124).

In most current theories about learning, the philosophy of innate knowledge brought out by reasoning is reconciled with that of learning through the senses. It is generally accepted that the input for learning takes place through the senses and experience, but it is through the processing of that input that it is retained and made meaningful. The idea of innate knowledge is therefore replaced by Erasmus's innate capacity. Training and instruction channel and optimize learning.

3.3 20TH CENTURY VIEWS ON LEARNING

Even today, educationalists are still speculating about the nature of creativity and how it is learnt and taught. It will therefore be useful for the purpose of this study to revisit the different learning theories that relate to creativity to see what perspectives one may gain from them regarding the topic, since many of these concepts are still relevant in contemporary viewpoints.

The focus in this section will be on objectivistic, cognitive and social cognitive theories. These theories have specific perspectives on how learning takes place and

how to best establish the optimum conditions for learning (Hamacheck, 1998:229). Objectivist theories start at small measurable, observable entities and combine them into more and more complex systems. They are usually viewed as atomistic, analytic and mechanistic. Cognitive theories are usually viewed as holistic and see learning from the perspective of the learner and /or the learner in his/her social context.

3.3.1 Objectivist theories

Objectivist theories such as Behaviourism, Connectionism, Neuro-science and information-processing contributed to the understanding of learning processes by respectively starting at the basic unit of learning (stimulus-response-feedback), studying the effect of learning on the basic unit of the nervous system (the neuron) as well as on the brain, and comparing the human nervous system to an intelligent machine such as the computer. Human intelligence and learning are understood in terms of electronic circuits and components.

3.3.1.1 Behaviourists

Behaviourism is an objectivist theory and looks at learning from an atomistic, analytical viewpoint. Behaviourists start at the basic unit of learning: the stimulus and the organism's reaction to it. Since problem-solving and creativity are seen by researchers like Bloom, Englehart, Furst, Hill, and Krathwohl (1956) as right at the top of the hierarchy of learning, one can expect problems in trying to explain behaviours involving synthesis, like creativity, using the classic form of this philosophy. The reason why it is discussed here is because it explains the role of feedback and provides a backdrop for a neuroscientific explanation of creativity.

Behaviourists believe that specific ways of behaving are learned. Stimuli are followed by responses that can be reinforced or discouraged by reward or punishment. Learning is therefore seen as an inductive process and goes from the specific aspects of the learning situation towards the more general aspects. Behaviourists are primarily concerned with observable and measurable aspects of human behaviour, stimuli and responses and they formulate rules that help to explain the formation of relationships between observable components of behaviour. According to Mayer behaviourists view the learner as a passive recipient of stimuli whose learning is shaped by practice and reinforcement (in Hamacheck, 1998:232). Early behaviourists like Pavlov, Bechterev and Guthrie (in Duminy *et al.*, 1990:229-239) represent a simplistic view of a human being reacting to stimuli in a machine-like

fashion. Behaviour is described in terms of **unconditioned** and **conditioned** responses. The latter is the result of learning. **Reinforcement** is necessary to maintain the conditioned reflex and prevent it from extinction. Some stimuli can be generalized so that similar stimuli cause similar responses. Different stimuli can be discriminated from one another. Reward and/or fear of punishment are the motivating factors. Watson applied the principles of conditioning to human learning and believed that everything we do is predetermined by our past experience. Watson's ideas were refined and applied to behaviour control and the learning process. These ideas gave rise to the stimulus-response psychology school lead by Skinner. The theory studied the use of reward and punishment to modify connections between a stimulus and a response.

Skinner (in Duminy *et al.*, 1990:233-237) combined the ideas of learning from the inside out (classic behaviourist) and learning from outside in, by distinguishing two types of responses that are present in learning situations: **respondent** (in a response to a stimulus: from outside in) and **operant** (simply emitted by a person : from inside out). Both of these responses can be reinforced. Operant behaviour can be conditioned when attention is paid to it or inhibited if it is ignored. Conditioning can therefore change the behaviour of a person. Rewarding positive behaviour and ignoring negative behaviour is how people learn. Skinner goes further by showing the importance of **regular feedback** in re-enforcing desirable behaviour.

The Gestalt psychologist, Köhler (1947:8 & 30) criticized the emphasis placed by behaviourists on measurability and objectivity. He was of the opinion that in their analytical perspective on reality, they lost the perspective on the whole. Köhler describes the subjective mind-shifts that physicists like Newton, Galileo and Huygens had to make in the following words: *"Luckily they just went about their business pragmatically naïve and happily undisturbed by behaviourists- some steps unjustifiable on logical grounds."*

In the study of creativity and specifically when creating an environment in which creativity *per se* can flourish, the feedback principle is very important. If creative behaviour is receiving negative feedback in a classroom, boardroom or society, it will be discouraged. The person with a creative inclination will be taught that thinking and acting differently from the norm is wrong or sinful. This individual will be viewed with suspicion, experience his/her behaviour as shameful and may tend to suppress thoughts and behaviour that are different. Amabile (1996:90 & 205) quotes Getzels and Jackson saying that teachers usually view children showing creative behaviour

as bothersome and difficult to control.

3.3.1.2 Neuroscientific views on learning

The father of the theory of **connectionism**, Thorndike, describes learning as the result of connecting the right stimulus with the correct response, initially by trial-and-error, but gradually the bond between the stimulus and response is strengthened. He formulates his laws of learning such as the **law of readiness** (bond can only be made when it is ready to be made), the **law of repetition** (frequent use strengthens bonds and disuse weakens it) and the **law of effect** (satisfying bonds tend to be repeated). The basic assumption of the connectionists is that enrichment is the essence of the learning experience. Enrichment stimulates neuron and brain activity (dendritic, synaptic), not only in so-called critical periods, but even into old age (Scheibel, 1999).

In 1949 the psychologist Donald Hebb published his work "*The Organization of Behaviour*". This provided a neurological explanation for the work of Thorndike and Skinner. Hebb's studies (in Klein, 1990) of intelligence led him to the conclusion that experience plays a much greater role in determining intelligence than was typically assumed. In 1953 he pointed out that every bit of behaviour is jointly determined by heredity and environment, just as the area of a field is jointly determined by its length and its width. Hebb's theory rests on three basic assumptions:

1. When an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells, such that A's efficiency, as one of the cells firing B, is increased.
2. Groups of neurons which tend to fire together form a cell-assembly whose activity can persist after the triggering event and serves to represent it.
3. Thinking is the sequential activation of sets of cell-assemblies.

3.3.1.2.1 The role of genetic factors

Genetic factors play an important role in the ability to form the connections described above. Neuroscientists believe that structural changes in neurons due to learning are initiated when neurons are activated, causing calcium ions to flow into cells and alter the activity of genes. Ghosh, Aizawa, Hu, Bobb, Balakrishnan, Gurevich, and Cowan (2004) discovered the gene CREST in mice that mediates changes in the

structure of neurons in response to calcium. They explain that their discovery *"parallels some learning disorders in humans where the child appears normal initially, but by the age of two or three years it becomes clear that there are failures in the acquisition of new knowledge"*.

3.3.1.2.2 The role of social factors

The growth of the brain is shaped to a large degree by the social milieu in which the individual grows up. Hüther (2006:331) explains that the elaboration and stabilization of higher brain-centres depend on:

1. how the brain is used;
2. the goals pursued;
3. the experiences gained in the course of an individual's life;
4. the models used for orientation; and
5. the values providing stability and eliciting a sense of commitment.

Hüther (2006) continues: *"The transmission and internalization of culture-specific abilities and of culture-specific values are achieved primarily during childhood by non-verbal communication (mirror neuron system, imitation learning) as well as by implicit and explicit experiences (reward system, avoidance and reinforcement learning). Therefore the structural and functional organization of the human brain is crucially determined by the social and cultural factors"*.

Modern imaging techniques show numerous differences on both structural and functional levels between the brains of differently encultured and socialized individuals, especially in the slowly developing higher cortical association areas (Hüther, 2006:332). Controllable stress (in the form of challenges or problems in the presence of the subjective feeling that the challenge can be met through his/her own efforts) is the factor implicated in stimulating brain growth. Controllable stress does this because it triggers a chain of events in the brain that stimulates adaptive modification. Absence of stress leads to little development, whereas uncontrollable stress (no adequate coping strategies are available leading to feelings of helplessness) is seen to be harmful to the brain because it destabilizes existing neuronal connections. That is why secure emotional relationships (as with parents, siblings and teachers) provide resilience: these relationships protect the brain against

overload and motivate and encourage the individual to learn from situations that could otherwise provide an inadequate stimulus (Hüther, 2006:332-338).

3.3.1.2.3 Neurons and learning

For educationalists, the emerging evidence that formation of neural connections is highly experience-dependent is of great importance. Hüther (2006) reflects on the discoveries in neurobiology and describes the discovery of the “*enormous experience-dependent plasticity of the human brain*” as one of the “*most significant findings*” in the field of neurobiology in the last decade. Perry (2002), Munakata, Casey and Diamond (2004: 122-129), Hüther (2006) are a few neuroscientists who describe the role of the growth of neurons as the result of experience or lack thereof.

The brain consists of 100 billion neurons and ten times as many glial (supporting) cells, connected by trillions of synapses. Despite being present at birth, most neurons have yet to organize into completely functional systems. Perry (2002) describes a number of activity-dependent processes that appear to be important in many neural processes related to learning, memory and development.

According to Perry (2002:2-5) processes that may result in loss of genetic potential as a result of lack of experience and/or exposure to adverse chemical and physical conditions before and after birth are:

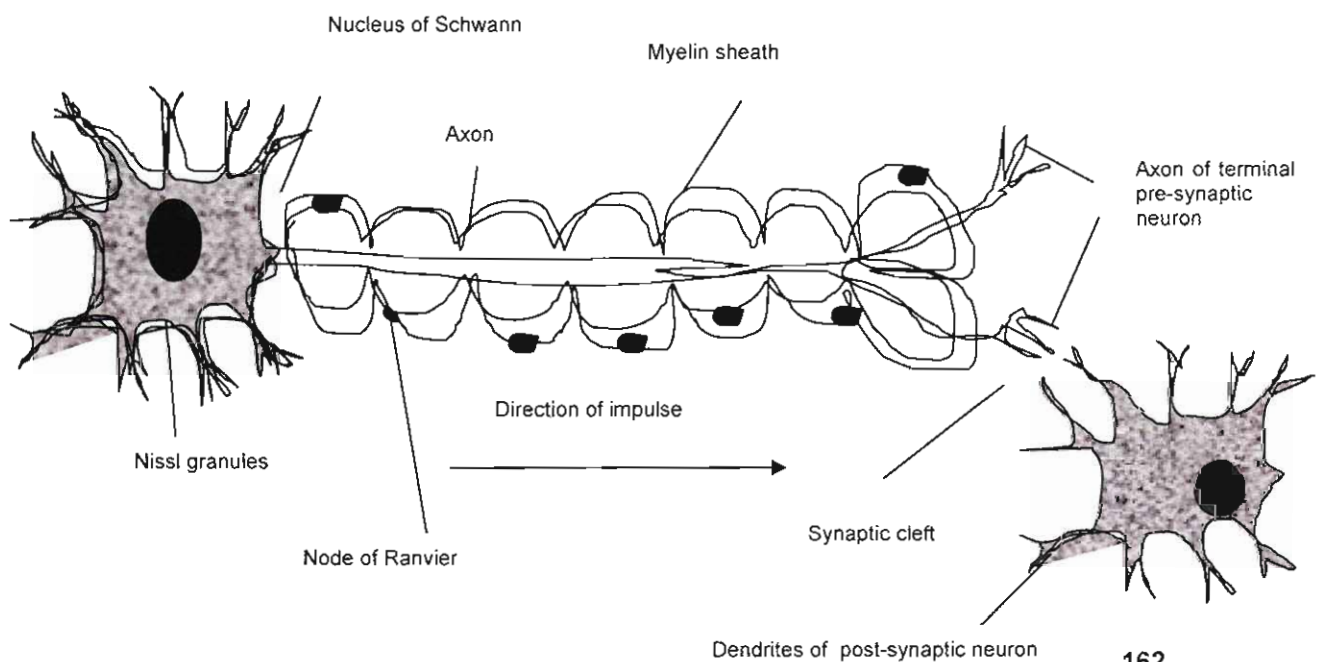
1. **Migration** of neurons and glial cells.
2. **Differentiation** of neurons to end up reacting to different neurotransmitters.
3. **Apoptosis** (programmed cell-death) of under-activated, unconnected or redundant neurons.
4. **Arborization** (tree-forming) that refers to an extremely experience-sensitive process, when dendrites are formed. Dendrites form receptive areas where the axon terminals of other neurons connect. The density of dendritic branches depends on the frequency and intensity of incoming signals (figure 3.1).
5. **Synaptogenesis** (the formation of synapses) where neuron-to-neuron communication takes place, is the **most** experience-sensitive feature of a neuron. A chemical (such as a neurotransmitter) is released from the “pre-synaptic” neuron into the extra-cellular space, called the synaptic cleft (a short distance between the dendrite and axon terminal). The neurotransmitter crosses the

synaptic cleft and binds to a specialized receptor protein in the membrane of the "post-synaptic" neuron. In order for the brain to function properly, neurons, during development, need to find and connect with the "right" neurons. During the differentiation process, neurons send fiber-like projections (growth cones) out to make physical contact with other neurons (figure 3.1 and 3.2).

6. **Synaptic sculpting** refers to the continual changing of the synapse in order to make it more efficient. With lack of activity, the synapse dissolves and the axon leading to it will disappear. This process appears to be the molecular basis of learning, memory and, therefore, at the centre of neurodevelopment (figure 3.2).
7. **Myelination.** Specialized glial cells wrap around axons (as electrical wires are covered in plastic) to ensure efficient and speedy electrochemical transduction down the neuron (figure 3.1).

Learning and memory are thought to occur through long-term potentiation (LTP) and its opposing process of long-term depression (LTD) (fig 3.2). This gives rise to synaptic plasticity and provides the foundation for a highly adaptable nervous system. **LTP** is the long-lasting strengthening (potentiation) of the connection between two nerve cells, whereas LTD is the long-term weakening of a synapse. LTP is a process in which synapses become increasingly sensitive, so that a steady level of pre-synaptic stimulation becomes converted into a larger post-synaptic output. Two types of LTP are distinguished, namely associative LTP (the molecular analog of associative learning) and non-associative LTP.

Figure 3.1: A Neuron and synapse



Associative LTP is the strengthening of the connection between two neurons that have been simultaneously active (at least two stimuli). Receptor calcium channels that are blocked by magnesium when the neuron is at rest are opened after strong post-synaptic depolarization. The calcium channel is also gated, so that it only opens when pre-synaptically-released glutamate binds the receptor. With the magnesium removed, the calcium floods the post-synaptic cells triggering the associative LTP-process (Mayer, Westbrook & Guthrie, 1984). Non-associative LTP is brought about by the repeated application of one stimulus. At non-associative synapses, persistent stimulation of the synapse is involved.

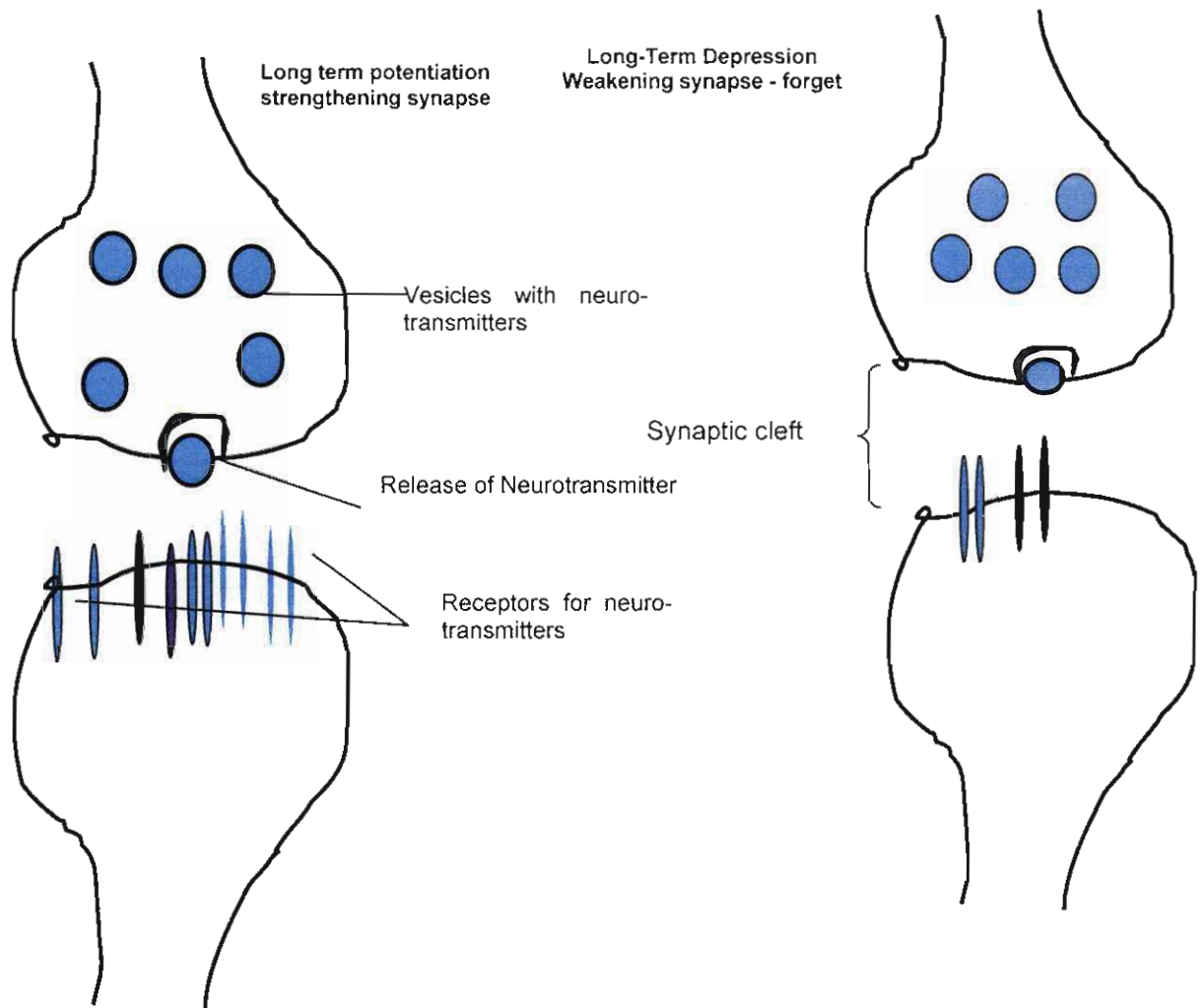
Studies by, among others, Artola and Singer (1987:649-652), Rioult-Pedotti (2000) and Huber and Kayser (2000) provide strong evidence that learning itself engages LTP in the cerebral cortex as a way to strengthen synaptic connections and that proteins secreted by synapses are implicated in facilitating long-term memory storage. The researchers found that changes in behaviour when new skills are acquired are accompanied by a change in the brain.

Hebb explains what happens in the brain during the thought process and attention:

"Any frequently repeated, particular stimulation will lead to the slow development of a 'cell-assembly', a diffuse structure comprising cells in the cortex" (TOP cf. figure 2.11) "and diencephalon (and also, perhaps, in the basal ganglia of the cerebrum), capable of acting briefly as a closed system, delivering facilitation to other such systems and usually having a specific motor facilitation. A series of such events constitutes a "phase sequence" - the thought process. Each assembly action may be aroused by a preceding assembly, by a sensory event, or - normally - by both. The central facilitation from one of these activities on the next is the prototype of 'attention.' " (in Klein, 1990.)

Hebb's predictions have since then been confirmed by research using improved microscopy and scanning techniques.

Figure 3.2: LTP and LTD: ways in which synapses may change during learning

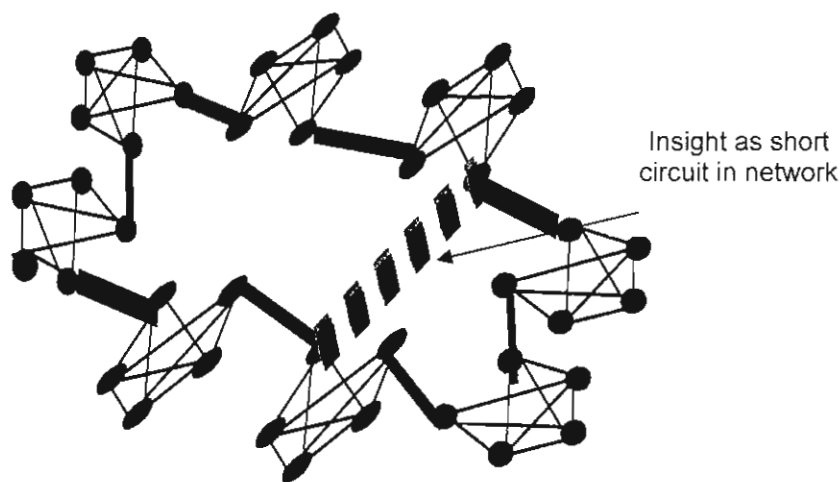


The nature of the connections in the brain shows certain properties: The work of researchers like Sejnowski and Laughlin (2003), Schilling (2005), Chialvo (2005), Chklovskii (2005) and Bitan, Booth, Mesulam, Choy, Burman and Gitelman (2005) shows that the structure of neural networks may have:

1. **Small-world-properties** (fig. 3.3) relating to technological, social and communication networks with *hubs and links* that relay information fast and effectively
2. **In-homogeneity** with many nodes with few connections and a very few nodes connected with many others

3. **Dynamic and continuously adapting abilities** to meet the demands of communication and computational needs. The brain region that performs the integration of information shifts, depending on the task their experimental subjects performed.
4. **Potential to be energy-efficient:** The more developed the brain network is, the less energy it uses. That implies that more and more associations can be made easier and faster.

Figure 3.3: Small-world network



From what was discussed above, learning can be linked to what happens to the neurons as the basic units of the nervous system. More complex processes happen as these neurons form networks as the result of experiences. Impulses should be strong and/or should be repeated to lead to permanent changes at the synapses. Insight (Aha) learning occurs, according to Schilling (2005), from an unexpected short-circuit, linking of two previously unrelated nodes in a network, creating a dramatic reduction in path-length in the whole network (figure 3.3). This may lead to a cascade of new associations. This may also be what happens during the inspiration phase of the creative process.

It seems as if the processes occurring in the nervous system during the process of learning may be looked at in a hierarchical manner.

1. **Level 1:** Simple neuron circuits are built, simple learning develops the basic units of the nervous system, involving a small number of neurons at a time, using the experience-dependent processes such as arborization, synaptogenesis and

synaptic sculpting (involving LTD and LTP). Myelination insulates neurons from one another and provides fast and efficient conduction of impulses. Knowledge and skills become automatic, making the brain more energy-efficient and freeing it for more sophisticated learning and thinking processes. This level of learning may be represented by stimulus-response reactions as proposed by behaviourists.

2. **Level 2:** Simple networks with few connections lead to more complex networks. The same neuron formation and sculpting processes are used as given on level one. As learning progresses and becomes more associative and integrative, more and more neurons are involved in networks, leading to highly complex behavioural patterns. It is not only the number of neurons and connections that increases; it is also the quality of connections. Some neurons can be trimmed out of the networks if that specific connection is not used, leading to more and more efficient networks. Learning on higher levels becomes less of a problem, since the brain's energy-efficiency increases.
3. **Level 3:** Insights form as short-circuits in networks. A mechanism that increases the efficiency of the network dramatically, bringing about a whole new perspective and new connections between existing information (as the Gestaltists describe it: transforming the perceptual field). New associations result from the newly formed proximity of the previously distant hubs. This is the moment or period of creative inspiration.
4. **Level 4:** The new perceptual field is explored as connections flood into the consciousness. The conscious discovery of the closeness of the hubs leads to new associations discovered and recognized.

If the learning processes on the first two levels did not occur properly, it is unlikely that creativity can result within a domain, since creativity becomes evident on levels 3 and 4. The short circuits come within existing networks. Levels one and two then correspond with what was seen to be the preparation phases of the creative process (*cf.* 2.3). This may explain why creative achievement is strongly linked to motivation and perseverance (*cf.* 2.2.3.2): levels one and two cannot be skipped. This, however, does not imply that learning must start with single items and not with whole situations. It is just that the individual will learn from the situation in steps, starting at level one and continually integrating, associating more and more of the units into networks. Exposure to the situation (chaos) and having to solve the problem or sort

out the situation may provide the needed challenge, the strong impulse that sustains the person through a series of insights and/or until the riddle is solved.

3.3.1.3 Information Processing views on learning

During the 20th century, the development of electronics and intelligent machines able to store and process vast amounts of information, changed people's views of the brain, of intelligence and of learning. The learning model proposed by Gagne and Driscoll (in Hamachek, 1998:196) is based on information processing as in computers. They propose that different internal and external conditions are necessary for different types of learning. To learn cognitive strategies, including creativity, one must have a chance to practise developing new solutions to problems (Gagne, 1985:148), to learn attitudes (Gagne, 1985:236-240), have a credible role model (Gagne, 1985:232-234; 238-239) and/or hear persuasive arguments (Gagne, 1985:241).

3.3.1.3.1 Basic assumptions of information processing

1. Learning takes place in a step-by-step way. These steps usually include:
 - 1.1 Sensory input
 - 1.2 Transforming input into a kind of mental image
 - 1.3 Comparing the image with information already stored in the memory
 - 1.4 Assigning meaning to the image
 - 1.5 Acting on the image
2. There are limits to how much information can be processed in each stage. New information must be acquired slowly and gradually.
3. The human information processing system is interactive. Learning occurs when there is an interaction between the environmental input and a learner who processes or transforms the information. What one already knows, influences and is influenced by what one perceives and attends to in the world around one.

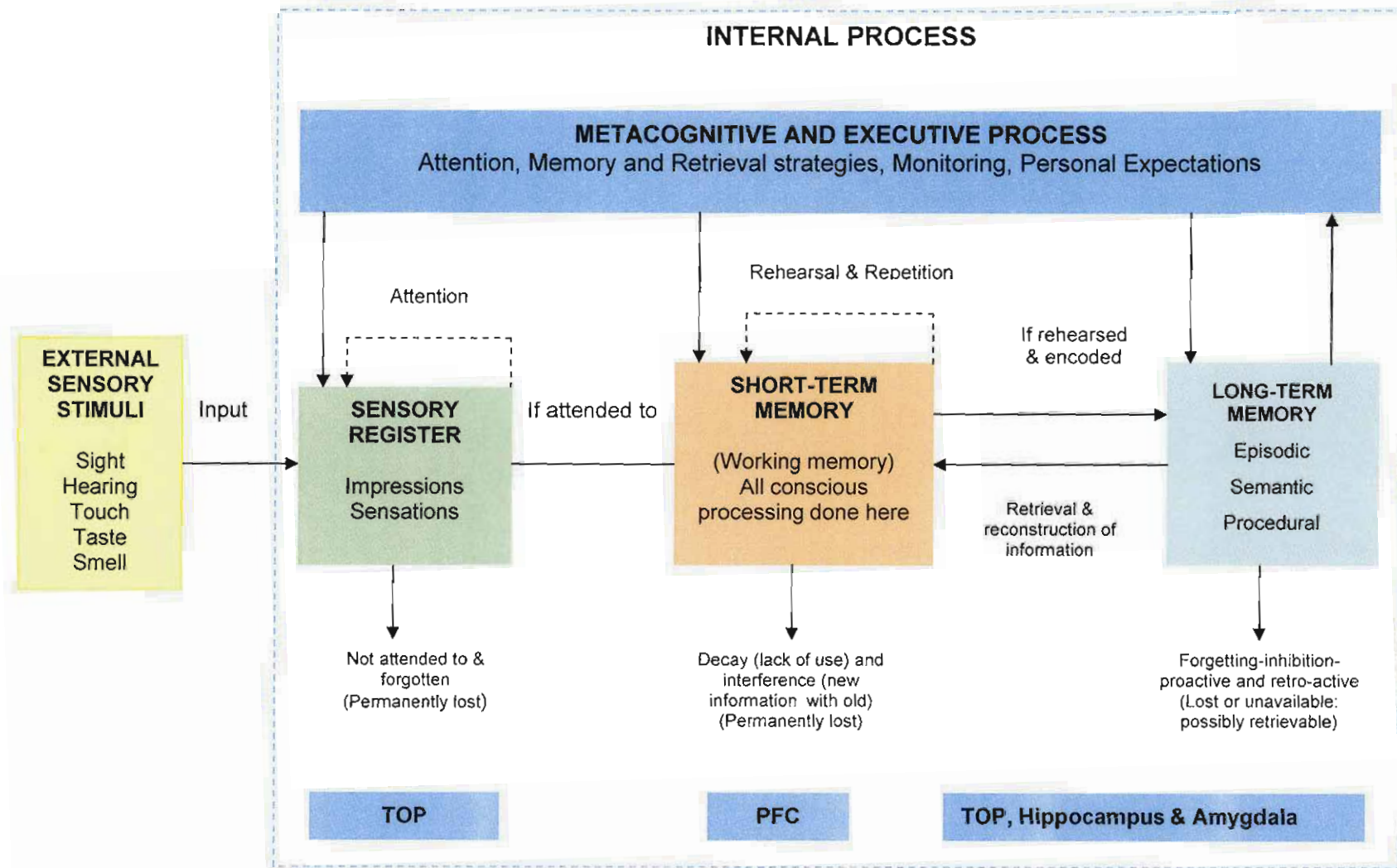
The processes in the information-processing model of learning and memory are given in figure 3.4. They include sensory input, the sensory register, working or short-term memory, long-term memory and metacognitive and executive processes. The

pre-frontal cortex (PFC) is identified as the place where meta-cognitive processes, executive control and conscious processing in the working memory take place (*cf.* 2.3.5.1 & 2.3.5.2). The Temporal, Occipital and Parietal lobes (TOP) represent the sensory association areas and memory stores. The hippocampus and amygdala are involved in formation and retrieval of long-term memories and feelings.

Stimulation of a sensory receptor produces a stirring of neural activity lasting for one to two seconds, during which input is held in the sensory memory or sensory register (Hamacheck, 1998:197). Paying attention to this sensory register for long enough to organize and give meaning to it, passes it on to the short-term memory. This is done selectively when we look for recognizable patterns. Selective attention is crucial so that overload is avoided, the limited capacity of attention is not exceeded and only relevant information is passed to the short-term memory. Lindsay & Norman assert that without attention, the information is lost and permanently forgotten (in Hamacheck, 1998:198). The mind immediately begins to work on stimuli received from the outside world. Perception refers to the meaning that we attach to the received information and is a mixture of objective reality and the way we organize our information. Perception is part of the sensory register and influences the meaning we attach to various sensory stimuli.

Gagne (1985:193-194) agrees with the conclusion made in section 3.3.1.3 when he explains that creativity results from an ordinary problem-solving activity after a tremendous amount of previously knowledge has been acquired (whether the knowledge is of the public sort (in science) or private sort (in arts)). The method of acquiring knowledge is similar to that used by all people. He is of the opinion that the deep immersion into the field makes a great store of intellectual skills and sets of rules, often from different disciplines, available to the creator. In the act of creation, these widely disparate systems of organized knowledge are combined.

Figure 3.4: Information processing model of learning & memory (based on Gagne & Driscoll (in Hamacheck, 1998:196)



3.3.1.3.2 Memory

Memory is one of the keys to creativity. Different models exist and it is a topic that is very controversial. Short-term memory (STM), Working memory (WM) and Long-term memory (LTM) will be discussed.

Short-term memory: Since short-term memory is a temporary potentiation of neural connections, new information that is put in it, is retained only briefly, probably only for about 30-45 seconds and is dumped when it is no longer needed. Short-term memory stores information only up to a limited capacity, about seven items or chunks at one time (Miller, 1956).

Working memory: WM is defined as a kind of memory maintained by the active firing of neurons (Lisman, 2006). The term working memory (WM) is often used to replace or include the term short-term memory. Newell (1990) explains that the capacity of the working memory must be far greater than the capacity of the traditional short-term memory. A proposal of a long-term working memory AND a short-term working memory is made by Ericsson and Kintsch (1995). The LT-WM for tasks in a given domain of activity is an integrated part of skilled performance. They explain that a skilled problem-solver possesses exceptional domain-specific memory skills obtained through extended practice. They conclude that domain-specific skills are used to expand the long-term working memory capacity so that information is stored in accessible forms (encoding methods and retrieval structures) in the LTM. In contrast to Ericsson and Kintsch (1995), Cowan (2005) sees working memory as part of the long-term memory.

A definition for working memory in terms of computer technology would be "the collection of structures and processes in the brain used for temporarily storing and manipulating information similar to the random access memory (RAM) in a computer". The working memory contains all that is in our immediate awareness: the raw materials for thinking. The working memory enables the brain to take in information and create planned responses using abstract thought. It therefore plays a crucial part in the development of higher mental abilities. Human behaviour would, without it, consist mostly of reflexive actions. The ability of humans to chunk information together as well as rehearsal, transformation into meaningful information and use of information improve the chances of retention of information (Hamacheck, 1998:202). More and more of the brain is involved in working memory as we mature: pre-adolescent children rely on prefrontal and parietal regions of the brain;

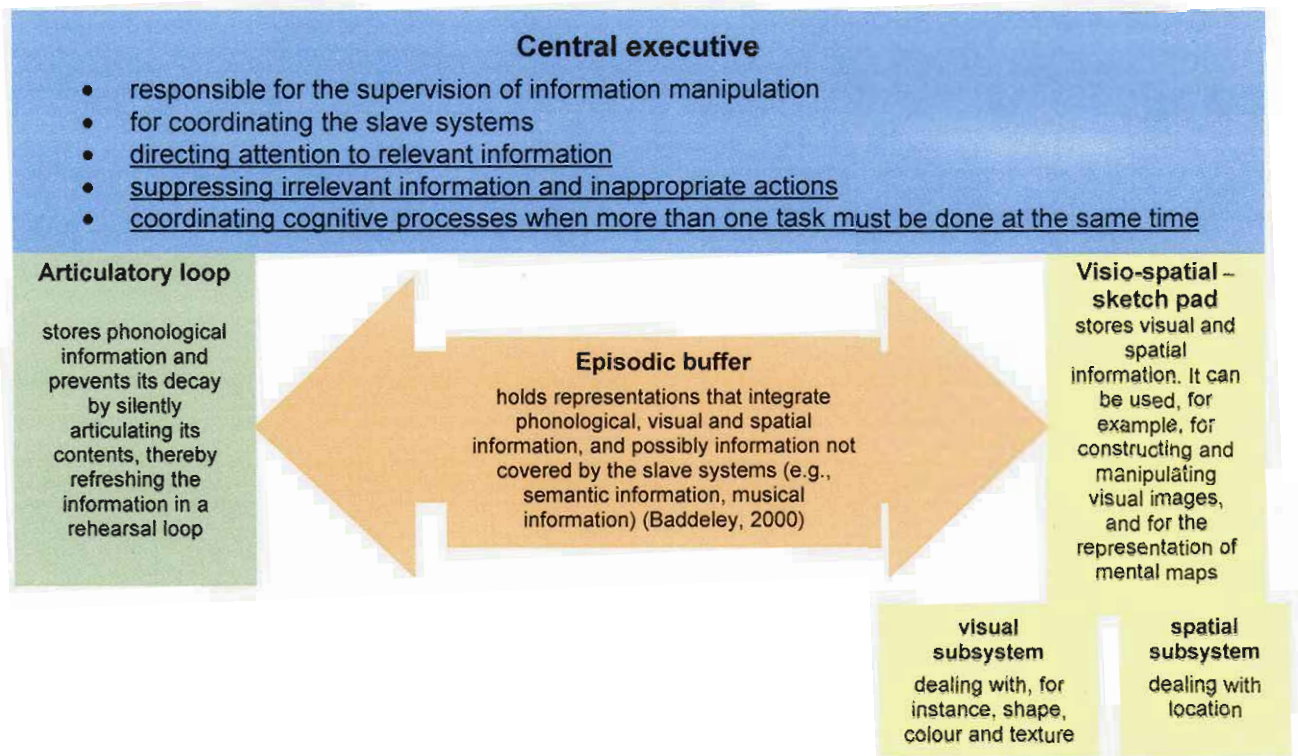
adolescents rely on prefrontal and parietal regions plus the anterior cingulate; adults use them all and more: prefrontal and parietal regions, anterior cingulate as well as the medial temporal lobe (Luna, 2004).

Baddeley and Hitch (1974) and Baddeley (2000) describe the working memory as consisting of four components, namely the central executive system and three slave systems, namely: the **articulatory loop** for phonological information, a **sketch pad** for visual and spatial information and an **episodic buffer** for integration of visual, spatial and phonological information. The central executive system is responsible for coordinating the three slave systems. A schematic summary of this model is given in figure 3.5.

Constantinidis (2004) notes that Spatial Working Memory, involved in maintaining a mental image in memory over a few seconds through persistent discharges of neurons in a distributed network, involves multiple brain areas including the prefrontal and parietal association areas.

Klingberg, Forssberg and Westerberg (2002) find that working memory can be improved by training. Working memory training brought about an increase in a range of cognitive abilities as well as an eight percent increase in IQ test scores. This supports the findings that working memory underlies general intelligence. Some researchers, such as Engle, Tuholski, Laughlin and Conway (1999), argue that working memory capacity reflects the efficiency of executive functions, most notably the ability to maintain a few task-relevant representations in the face of distracting irrelevant information.

Figure 3.5: Four component memory (Baddeley & Hitch (1974) & Baddeley (2000))



Long-term memory: When an experience or a fact is repeated enough or is associated in a meaningful way or elicits a powerful emotional response, shifting from short-to long-term memory occurs (Hayashi & Tonegawa, 2004). It moves from the hippocampus, in the innermost fold of the temporal lobe, to the brain's outermost region, the cortex, which controls higher functions such as abstract thought and speech. Different types of memory are stored in different regions of the brain. The proposed mechanism by which short-term memories move into LTM storage is via long-term potentiation (LTP), which leads to a physical change in the structure of neurons. Storing information in the LTM is a slow, passive and unconscious process. The information in the long-term memory is not easily accessible, is not easily disrupted, is retained indefinitely and the capacity of this memory is unlimited. Information is stored in large, interrelated networks or schemas. Related schemas are linked together and information that activates one schema also activates ones that are closely linked, so that relevant knowledge can be called up when information is presented.

LTM is typically divided into two major headings: **declarative memory** and **procedural memory**. Emotional memory is mentioned as a third type of memory. These three are briefly described below, according to Hamacheck (1998:204).

Declarative memories are memories that are consciously available. They are encoded by parts of the brain such as the hippocampus, but consolidated and stored elsewhere in the cortex. Different types are distinguished, such as:

- **Episodic memory** (that refers to memory for specific events in time places, has a strong visual aspect to it and is the place for storage of personal experiences)
- **Semantic memory** (that refers to knowledge about the external world such as general facts, principles and concepts, mentally organized in networks of connected ideas or relationships or schemata.)

Procedural memory that refer to the use of objects or movements of the body. It is encoded and probably stored by the cerebellum and the striatum. Skills are stored in the form of stimulus-response pairings.

Emotional memories are the memories for events that evoke a particularly strong emotion and are in many ways a combination of procedural and declarative memory. Emotional memories are consciously available, but elicit a powerful, unconscious physiological reaction. They also have a unique physiological pathway that involves strong connections from the amygdala into the prefrontal cortex, but much weaker connections running back from the prefrontal cortex to the amygdala.

Long-term memory stores knowledge about the world and affects perceptions of the world, strongly influences what information in the environment and what aspects of a situation one attends to, allows one to focus on relevant information and disregards what is not important (screening). Thereby it provides the framework for attachment of new knowledge.

The working memory of the creative person must be able to hold and process information in a way that makes associations possible. In domain-dependent creativity, information must be chunked together in the long-term memory in ways that make their appearance in the working memory meaningful. The openness typically associated with creativity is linked to the low levels of latent inhibition, an aspect that links up with the long-term memory's screening functions.

3.3.1.3.3 Metacognitive and executive processes

Metacognitive and executive processes are involved in assessing learning problems, determining learning strategies involved in assessing learning problems, determining learning strategies with which to approach the problem, evaluating the effectiveness

of the chosen strategy and making modifications where necessary. Metacognition is the study of how we think about our own thinking in order to develop strategies for learning. Sternberg (in Hamacheck, 1998:208) identifies nine groups of executive skills (or metacognitive skills), namely:

1. Identifying of problem
2. Selecting a problem-solving process
3. Selecting a strategy
4. Selecting a mode of representation (diagrams, charts, tables, outlines)
5. Allocating resources
6. Monitoring progress
7. Sensitivity to feedback
8. Incorporating of feedback into cognitive processes
9. Implementing selected strategies

Creativity may be partially the result of special or uniquely developed metacognitive and executive processes. It is these processes that may be responsible for either productive thinking or reproductive thinking.

The cognitive, emotional, social and physiological functioning depends on the mediating actions of neural systems that develop in childhood. When the genetic potential exists, but the necessary experiences are not provided at optimal times during a child's development, the development of these neural systems is inhibited. Creativity depends on ordinary mental processes and requires, in addition, mostly abilities like well-developed perceptual abilities, the ability to store and retrieve memories, a working memory with optimum capacity and a nimble prefrontal cortex. The optimal development of brain connectivity may be a key to creativity, since it depends on formation of new associations. Prerequisites for knowledge-dependent creativity are therefore the efficient storage and processing of information, fast and effective flow of information in the brain as well as the availability of needed information. The formation of Hebbian cell-assemblies (like cell-cities (*cf.* 3.3.1.2)) where information can be efficiently stored and processed, fast conducting myelinated neural fibres that act as high-ways between these cell-cities, as well as

mechanisms to retrieve the information from the different cell-cities when and as necessary are therefore needed. In a brain where information from the subconscious is readily available and where information can flow more easily and faster, the chances of making novel connections are increased.

3.3.1.4 Mastery learning

Mastery learning proposes that all children can learn when provided with the appropriate learning conditions such as time and quality instruction. Mastery learning (Funderstanding, 2001) rests on the ideas of Carroll, (1963), Block, (1971), Bloom, (1981). It points to the following:

1. Aptitude could predict a learner's learning rate. Outcomes must therefore be set and the criteria for their mastery should be clear to all.
2. The instructional variables are under an instructor's control, (such as the opportunity to learn and the quality of the instruction).
3. The instructor should be able to ensure that each learner can attain the specified objective.

It therefore focuses on process rather than content, regular feedback loops through correction of mistakes, diagnostic and formative tests. Independent learning is emphasized (Warren, 2003).

In the Japanese doctrine of Shuhari (*cf.* 2.3.2.2), mastery is seen as a prerequisite for creativity. At the starting point of the learning process, a person is unlikely to see the whole picture. Learning materials are seen as a means to teach mental and self-discipline, automatic retrieval of facts /movements and the establishment of good habits like concentration, task completion and routine. Creativity can thus come as a result of the fluid use of the elements, whether it is in martial arts, music, a language or mathematics. One may argue that proper mastery of a domain and deep knowledge of its elements are necessary in order to enable one to make meaningful changes in the domain and to combine its elements in new ways. Weisberg (1999:246) believes that knowledge and creativity are positively related. The other view, the so-called tension view of which Simonton (in Weisberg, 1999:229) is an advocate, is that too much knowledge (too deep entrenchment in a domain) inhibits creativity. By the time the student reaches the Ri phase, the habit of obedience is so strong, that few would be able to escape it. Habits of knowledge acquisition and

reuse for replication may then become a barrier to acquiring and reusing knowledge for innovation. Ng (2001:107) describes the *kiasi* (afraid to die) attitude of some Asian students. The student prepares for success to such an extent that he does not have any opportunity to learn from experience and, although he might be exam-smart, often has no real understanding of the topic. Since risk-taking is not encouraged and failure is seen as a disgrace, creativity may suffer in the quest for perfection.

3.3.2 Cognitive theories on learning

Cognitive theories focus on the learner as an active processor of information who is trying to make sense of information presented to him/her. The aims of cognitive approaches are to enhance the efficiency of the processor. Cognitive psychologists have a more holistic viewpoint than behaviourists, moving from the general to the specific aspects. They believe that general ways of thinking, the so-called cognitive structures, are learned. Learning is seen as a deductive process. They concern themselves with processes such as decision-making, information processing, understanding and insight (Hamacheck, 1998:229-230). The ideas of the Gestalt psychologists, constructivism and experientialism are discussed below.

3.3.2.1 Gestalt

Wertheimer, Koffka and Köhler concentrate on perception, awareness and insight in the Gestalt theory, a dynamic viewpoint opposing the simplistic, machine theory and atomistic view about life advocated by the behaviourists. A Gestalt is a concept describing *an extended event that distributes and/organizes itself as functional whole*. The term Gestalt, in this form can be applied to processes of learning, of striving, of thinking of, acting and so forth (Köhler, 1947:178-179). Gestaltists believe that analysis of separate and discrete parts can never provide an understanding of the whole. To understand the whole, it is necessary to analyse from the structure of the whole to the characteristics of the parts, not the other way around. In a true Gestalt, parts are so intermingled that they are impossible to separate. Factors affecting one, affects the whole (like in ecological models). In contrast to a Gestalt, an aggregate is easily separable and each part has a separate identity that does not depend on the whole (Linskie, 1977:136-137). Köhler (1947:345-352) describes insight as the “experienced determinations” in the emotional, motivational as well as in the intellectual fields or the “aha”—experience that occurs as a sudden solution after struggling with a problem. Before an organism arrives at an insight regarding a

particular problem, it cognitively formulates a number of hypotheses as to how the problem may be solved. Once it has decided which strategy should be used, the organism proceeds to act out its insight. This can happen in an instant or over time (Mwamwenda, 1995:227-234). Wertheimer (in Duminy *et al.*, 1990:246) distinguishes between two types of problem-solving, namely:

1. Mechanical application of past experience without understanding, leading to trial-and-error methods, blind solutions and using methods that were acceptable earlier, but that are inappropriate to solve a new problem.
2. Solutions involving originality and productive thinking: the learner understands the meaning and use of previous experience, as well as the essential structure of the problem itself.

Fostering productive thinking through creation of genuine understanding is, according to Wertheimer (in Duminy *et al.*, 1990:246), the aim of education. Wertheimer is of the opinion that rote-learning and mechanical memorization should be discouraged as much as possible and that self-activity, self-involvement and active participation will help learners to learn optimally. Wertheimer believes that pupils should be provided with the situation as a whole before attempting to find a solution to a problem. This should lead to understanding the relationships and to insight.

Gestaltists emphasize meaningful learning, global views and presentation of problems and opportunities for exploration, instead of only information discovered by others. The essence of learning is, according to the Gestalt psychologists, the perception of new relationships, namely insight. Insight is closely linked to creativity. During problem-solving, thinking takes the form of a perceptual re-organization (centring, focusing on the missing parts, filling the gaps, seeking better Gestalts) of the problem in hierarchical-related solutions that tend to become increasingly more specific. According to Duminy *et al.* (1990:245), the final solution of the problem tends to occur as a sudden transformation or reorganization of the elements in the perceptual field. Insight brings relative permanent learning, success in solving the same problem time and again, as well as transfer of insights to similar, related problems. Insight makes learning meaningful, makes monotonous repetition and exercise unnecessary.

3.3.2.2 Constructivism

Both Piaget and Bruner identify certain stages through which a human being's mental

development goes as he/she goes from infancy to adulthood. Piaget sees active interaction of the learner with the physical and social environment as the most important factor in the stimulation of mental growth and development (Linskie, 1977:148-156; Donald, Lazarus & Lolwana, 2002). Bruner's theory of discovery-learning proposes that students must be given a wide variety of examples of certain facts and information and they are then encouraged to discover the answer or the underlying rules or principles. The provision of a classroom atmosphere in which mistakes are seen as learning opportunities is seen as essential in this method. Generally students see the discovery method as a challenge and view it positively. They score better when they have to make judgments.

Bruner is serious about teaching learners to think creatively. They must be encouraged to take guesses and formulate hypotheses before doing a proper analysis. They must learn to trust their intuitive thinking (Duminy *et al.*, 1990: 270). Piaget and Bruner's main ideas are summarized in table 3.1.

Both these models see the learner as constantly interacting with his/her environment and gaining and rearranging internal representations of the world, using the newly acquired information. These models may be seen to describe the input and internal processing of knowledge.

Bloom's taxonomy of the cognitive domain, as reworked by Anderson and Krathwohl (2001) (table 3.2), also shows a sequence of progressive contextualization of information. Only when a person knows, understands, is able to apply and analyse, would he/she be able to synthesize and evaluate.

Table 3.1: Piaget and Bruner's main ideas

Piaget	Bruner
Developmental stages of cognitive growth: • Sensori-motor stage • Concrete operations • Formal operations Mental development is largely a process of continuous, active exploration of and adapting to the environment and of extending biological development.	Modes of representation: • <i>Enactive</i> (learning by doing) • <i>Iconic</i> (learning by forming images) • <i>Symbolic</i> (learning through language) A combination of the three modes of presentation in a learning experience should give better results, since people tend to use all three modes.
Four processes basic to intellectual organization and	Three integrated steps in the learning-process:

development: 1. <i>Schema</i> : a system of classification and grouping of things that belong together leading to concepts and generalizations. (There is no wrong categorizing; only classifying that is consistent with the thinker's own schema.) 2. <i>Assimilation</i>: when new information is fitted into existing schema. The schema grows in size and complexity. 3. <i>Accommodation</i>: the process that takes care of increased complexity that can cause some change in a schema. When confronted with new experience, the mind searches for an existing schema. If unable to find one, it creates a new one. When confronted with contradicting information, it adjusts, reshapes or modifies an existing schema, a process that may be seen as relating to the "creative process" (cf. 2.3). 4. <i>Equilibration</i>: Constant interaction between assimilation and accommodation in ever expanding cycles. Keeps the schemas organized in a kind of dynamic balance. An active process of establishing equilibrium in the person's whole map or cognitive structure. Cognitive conflict occurs when the individual is confronted with information that cannot be dealt with. This challenges the person to change the whole mapping structure in order to equilibrate and drives development.	1. <i>Acquisition</i> (obtaining new knowledge), 2. <i>Transformation</i> (information manipulation) 3. <i>Evaluation</i> (to check whether manipulation was done appropriately) (Duminy <i>et al.</i>, 1990: 268-270). Discovery learning: Learning: primarily a rearrangement of thought patterns and the perception of new relationships within the existing structure (Hamacheck, 1998: 232-233). Emphasis in discovery learning: 1. Learning by doing; learning is an active and unsystematic process. (Duminy <i>et al.</i>, 1990:280). 2. Intuitive thinking -spontaneous and unplanned 3. It leads to increased confidence and self – reliance. 4. A certain amount of structure, to make fundamentals of the subject more comprehensible, enhance retrieval, provide for adequate transfer of ideas, narrow the gap between elementary and advanced knowledge and make the integration and reintegration of existing and new knowledge easier.

Table 3.2: Bloom's taxonomy reworked by Anderson and Krathwohl (2001)

LEVEL	1	2	3	4	5	6
COMPETENCE	KNOW-LEDGE	COMPRE-HENSION	APPLI-CATION	ANALYSIS	EVALUATION	SYNTHESIS
SKILLS	observation and recall of information knowledge of dates, events, places knowledge of major ideas mastery of subject matter	understanding information grasping meaning translating knowledge into new context interpreting facts, comparing, contrasting ordering, grouping, inferring causes predicting consequences	use information use methods, concepts, theories in new situations solve problems using required skills or knowledge	seeing patterns organization of parts recognition of hidden meanings identification of components	compare and discriminate between ideas assess value of theories, presentations make choices based on reasoned argument verify value of evidence recognize subjectivity	use old ideas to create new ones generalize from given facts relate knowledge from several areas predict, draw conclusions

QUESTION CUES	list, define, tell, describe, identify, show, label, collect, examine, tabulate, quote, name, who, when, where	summarize, describe, interpret, contrast, predict, associate, distinguish, estimate, differentiate, discuss, extend	apply, demonstrate, calculate, complete, illustrate, show, solve, examine, modify, relate, change, classify, experiment, discover	analyse, separate, order, explain, connect, classify, arrange, divide, compare, select, explain, infer	assess, decide, rank, grade, test, measure, recommend, convince, select, judge, explain, discriminate, support, conclude, compare, summarize	combine, integrate, modify, rearrange, substitute, plan, create, design, invent, what if?, compose, formulate, prepare, generalize, rewrite

Ausubel's model of teaching and learning (Duminy *et al.*, 1990:274-281) as shown in figure 3.6, centres on the dimensions of learning. He integrates the different roles of the teacher and learner in a learning situation and shows that different modes of teaching and learning should be employed for optimal intake and integration of knowledge. Ausubel is of the opinion that the use of advance organizers can anchor learning. This involves giving broad outlines before details or detailed facts are given. Learners must solve problems actively, but in a systematic sequence and manner. He distinguishes between the following types of learning:

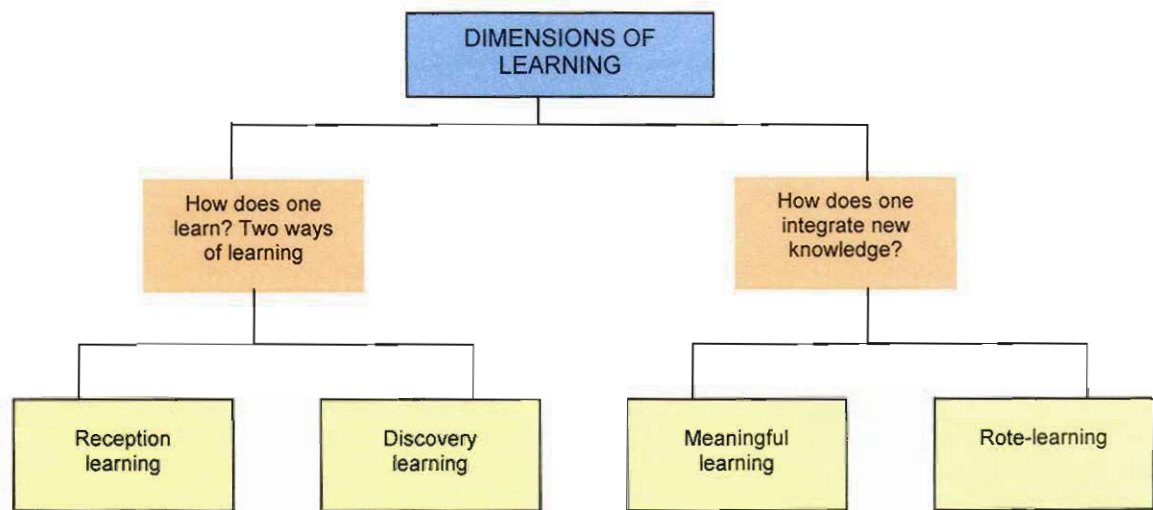
Reception learning: The materials are presented to the learner in a more or less final form such as when the teacher uses printed material and audio-visual means. Reception learning can be an active process and can be very meaningful.

Discovery learning: No materials are presented; a problem or assignment is given and learners must organize information themselves. This is seen as very appropriate for young children.

Meaningful learning: Learning is only meaningful to the extent that the learner finds it meaningful. In other words, to the extent that the learner can integrate it in his/her existing cognitive structures. Retention is improved if learning is meaningful.

Rote learning: When meaningless information is learnt or information is memorized *verbatim*, it is called rote-learning. Rehearsal and repetition are essential. (Duminy *et al.*, 1990:277).

Figure 3.6: Model of dimensions of learning (Ausubel in Duminy et al., 1990:277)



The models described by Piaget, Bruner, Bloom's taxonomy and Ausubel provide different perspectives on how one can acquire knowledge by interacting with the environment. Effective knowledge acquisition forms the foundation from which creative work resulting in changes in the domain can be done (cf. 2.4.2.).

Does a creative person form different, better, more or less schemas, assimilate and associate differently, better or more than less creative people? De Bono (2004:51) explains: *"the main purpose of the brain is to be brilliantly uncreative"*. It is the brain's very ability to form patterns in order to make sense of the world that sometimes prevents the formation of new patterns (cf. 2.3.4.4). It may be that creativity in an individual depends on the degree to which he/she can resist the fixation of schemas and stay open to look for and form new schemas on a continuous basis – a kind of mental plasticity. The difference may further lie in the nature and frequency of the equilibration process: the creative person may alternate between building and breaking schemas, continuously open to new information.

Creative contributions in a certain domain (specialist style of creativity) depend on proper learning. The processes described by Piaget and other cognitive theorists must function properly to form part of the foundation on which creative contributions in a certain domain can be made.

3.3.2.3 Experientialism

Experientialism is the viewpoint that personal experience is the only or the principal

basis of knowledge. Kolb (1983:38) defines learning in the following way: "*Learning is the process whereby knowledge is created through the transformation of experience.*" The experiential way of learning involves the application of the information received from the educator to the learner's experiences in real life; also outside the classroom. The student acquires new knowledge inside the class, but also outside, from teachers, but also from other sources. The student learns through this process of taking the new information derived in class and testing it against his / her accustomed real-life experiences. In the process, the learner transforms both the information and the experience into knowledge of some new or familiar subject or phenomenon.

Kolb's assumptions of learning centre around the following concepts:

Learning:

1. Learning is best conceived as a holistic continuous process of creating knowledge grounded in experience, and not conceived in terms of outcomes.
2. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world.
3. Learning involves transactions between the person and the environment.

Experiential learning emphasizes the role of the context in learning. As should be clear from section 2.4, the context is also crucial in the development of creative abilities.

3.3.3 Social Learning

The ideas of Bandura, the Activity Theory, Vygotsky and Feuerstein will be discussed as examples of theories that emphasize the role of the social environment and aspects thereof in learning and creativity development.

3.3.3.1 Modelling and observational learning

Bandura (1977:12-23) stresses the role of observing and modelling in human learning (*cf.* 2.4.3.4). He explains that all learning phenomena, resulting from direct experience, occur on a vicarious basis by observing other people's behaviour and its consequences for them. This way of learning facilitates acquisition of large chunks of integrated patterns of behaviour without having to form them gradually by trial-and-

error. It increases chances of survival by avoiding costly and fatal mistakes, is the way in which humans teach language, lifestyle and institutional practices of a culture to new members. The inexperienced members of society, therefore do not have to go through tedious selective reinforcement of fortuitous (chance) behaviours. This shortens the learning period. Cox (1997:51) emphasizes the role of teachers as role models in modelling (or not modelling) higher order thinking processes.

Unlike behaviourists who require changed behaviour as evidence of learning, Bandura, like the cognitivists, sees learning in terms of internal processes occurring in the "processor" that may or may not be demonstrated in future.

Bandura's (1977:23) model for observational learning describes four constituent processes that govern learning:

Attentional processes regulate exploration and perception of modelled activities. What is modeled, depends on factors such as cognitive skills of the observers (sensory capacities, arousal level, past reinforcement and perceptual set), the properties of the modelled activities (prevalence, functional value, affective valency, complexity and distinctiveness) and the structural arrangement of human interactions determining the types of models available for observation. Accurate perception, influenced by past experience and situational requirements, affects what is seen and how it is interpreted.

Retention processes are transitory experiences that are converted for long-memory representation into symbolic conceptions that serve as internal models for response. Two representational systems are involved: Imaginal (enduring retrievable images of modelled performances which can be summoned up later) and verbal (readily utilizable and carrying a great deal of information in an easily stored form) (Bandura, 1977 :26). Modelled behaviours, coded in symbolic form such as in words, concise labels, vivid imagery, are retained better than those that are simply observed. Mental rehearsal where people visualize themselves performing the appropriate behaviour increases proficiency and retention.

Production processes entail the selection and/organization of cognitive responses. The amount of learning depends partially on the availability of component skills. If some are lacking, behavioural reproduction will be faulty. Accurate matches are achieved after practice and are refined by informative feedback.

Motivation processes determine whether or not observationally acquired

competencies will be put to use. Factors such as external reinforcement, vicarious reinforcement and self-reinforcement play roles in motivating a person to use the observed modelled behaviour.

Bandura (1977:48) describes modelling of creative thinking and behaviour as follows: Innovative patterns can emerge through a modelling process. Through exposures to diverse models, the observers combine aspects of various models into new amalgams that differ from the original individual sources. Different observers adopt different combinations of characteristics. Within a family, the gradual imitative evolution of new patterns bearing little resemblance to those exhibited originally can occur. In homogenous cultures, where all models display similar styles of behaviour, behaviour may undergo little or no change throughout a series of successive models. It is diversity in modelling that fosters behavioural innovation. Modelling probably contributes most to creative development during the inception of new styles. Once initiated, experiences with new forms create further evolutionary changes. A partial departure from tradition thus eventually becomes a new direction. Innovators initially draw upon the contributions of others and build something new from their experiences.

While existing practices furnish some of the ingredients for the new forms, they also impede innovation. As long as familiar routines serve adequately, there is little incentive to consider alternatives. The unconventional is not only unexplored, but is usually negatively received when introduced by the more venturesome. Modelling influences can weaken conventional inclinations by exemplifying novel responses to common situations. People exposed to divergently thinking models are more innovative than those exposed to models who behave in a stereotyped conventional fashion (Harris & Evans, 1973).

Bandura warns that although innovative modelling generally enhances creative ideas in others, there are some limits to this influence. When models are unusually productive and the observers possess limited skills, their creative efforts may be self-devaluated by the unfavourable comparison. Prolific creative modelling can thus dissuade the less talented (*cf.* 2.4.3.4).

Bandura therefore points to both negative and positive aspects of modelling creative behaviour. Diversity is important to avoid imitation (that would inhibit originality) and prolific creative modelling should also be avoided. The models, the type of interaction with the models and the characteristics and readiness of the observer are other

factors that need to be considered when planning to use modelling as a strategy.

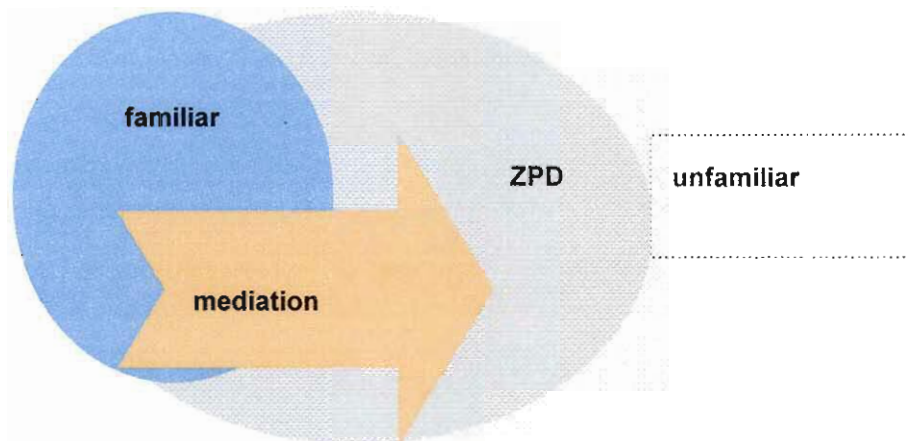
3.3.3.2 Mediation

Creativity is seen as a higher order thinking ability (Bloom *et al.*, 1956; Anderson & Krathwohl, 2001). Both Vygotsky and Feuerstein see the role of mediation as crucial in the development of especially higher cognitive abilities. This distinguishes lower functioning from higher functioning. Where Pavlov explains that conditioned and unconditioned reflexes occur and the cerebral cortex acts as central station through which conditioned reflexes are relayed, Vygotsky (1978: 52- 57) sees the mediator as an operator that plugs in the line and so connects the cortex and the social environment. Besides other humans, language, culture and artifacts are all viewed as tools that can mediate an individual's development.

Vygotsky (1978:84-91) sees language and mediation as the engines that drive development. Mediation takes place in the Zone of Proximal Development (ZPD) and represents the area just beyond present understanding (figure 3.7). This ZPD varies from student to student. During mediation, the process of interaction must connect in the ZPD. If the process challenges the student to develop new ways of thinking, the effect can lift him/her to a higher level of understanding. The implication is that the mediator (parents, peers, teachers) must not only give information, but also provide challenge.

According to Feuerstein (in Kozulin & Presseisen 1995:67-68), there must be an intentional effort (Intentional Engagement) in order to help students organize and understand information in progressively more effective ways. The mediator "*selects, changes and amplifies objects and processes... explains meaning and stimulates generalization*" for the learner. This process of mediation is seen as necessary in humans because of the meaning given to objects within social contexts. A transistor will be just a strange three-legged object without any meaning till the mediator, someone (a human) or something (a cultural artifact), helps the person to make a connection between the object, its name and its function in a system.

Figure 3.7: Vygotsky's Zone of Proximal development



Feuerstein (in Kozulin, Feuerstein & Feuerstein, 2001:2) reiterates that the individual learns through both direct experience and through mediated learning experience (MLE). In cases where the opportunities for direct experience are diminished either by internal factors (like disability) or through external factors (like cultural deprivation), the mediator's role becomes even more important (Falik, 2006). The mediator is not only instrumental in the construction of shared meaning, he/she/it is also involved in changing the way in which a person perceives, thinks and learns and what he/she perceives, thinks and learns. Cox (1997: 51) points out: *"Culture, in the form of scientific instruction, qualitatively changes the reasoning processes."* Feuerstein (in Cox, 1997:51) recognizes that people coming from *"radically different cultural contexts were missing a set of procedures as well as information about the world seen through the matrix of the new culture, including information about how questions are asked and answered, what counts as evidence, and how to evaluate the evidence and solve problems in the new culture"*.

The relationship between learner and mediator, as described by Feuerstein, may be seen as a dyad: the simplest form of a network described by Bronfenbrenner (cf. 2.4.3.6). MLE is described as the *proximal* determinant of cognitive development with organismic and environmental determinants as *distal*. In MLE, a mediator (an initiate) interposes him/herself between the environmental stimuli and the learner. MLE intentionally sensitizes an individual for learning through direct experience, making it meaningful and transcendent (Kozulin & Presseisen 1995:69-70).

Kozulin and Presseisen (1995) combine the ideas of Vygotsky and Feuerstein. They differentiate between two processes instrumental in helping a person to acquire

higher order thinking abilities, namely MLE (from Feuerstein) and Higher Order Psychological Tools (HOPT -*researcher's abbreviation*) (from Vygotsky). Kozulin and Presseisen (1995) describe four scenarios with different combinations of these two processes, namely:

- A, where a person receives both sufficient MLE and HOPT.
- B, is characteristic of culturally different individuals where sufficient MLE is received, but there is no exposure or provision to HOPT (as would happen in children who were well-mediated in their own traditional pre-literate culture). This individual has the prerequisites for learning. HOPT (such as writing, numerical and other abstract notational systems) will not be necessary, because it will not be expected of the individual in this context as other well-articulated means of transmission are present in this culture (such as oral tradition).

A and B need no remediation.

- C, where an individual receives adequate, but deficient MLE that does not support HOPT to which he/she is exposed at school. The new set of HOPT *acquired at school* remains unmediated. The individuals' *"everyday life is attuned to the norms of pre-literate, traditional society"* and HOPT-tools are used *"in a narrow sense, but fail to affect the whole of an individual's cognition"*. The argument is based on Tulviste's conclusion (in Kozulin & Presseisen, 1995:71) that certain forms of reasoning appear only as the result of specific educational practices and cannot emerge spontaneously. He bases his conclusion on the observation that native children had greater success with syllogistic tasks involving hypothetical situations based on scientific and unknown situations than on familiar everyday-life events. This situation also relates to the concept of frame switching (Hong, Morris, Chiu & Benet-Martinez, 2000:710) (*cf.* 2.4.3.10).
- D, where individuals receive deficient MLE due to disruption (through factors such as war, famine or other major social upheavals) and HOPT are unavailable. These individuals often find themselves at the margins of industrial society (Kozulin & Presseisen, 1995:71).

C and D need remediation to perform optimally.

Kozulin and Presseisen (1995) stress that this matrix is in no way exhaustive and does not describe all possible situations.

3.3.3.3 Scaffolding

Scaffolding is a term first defined by Wood, Bruner and Ross in 1976 (in Puntambekar, 2005) to describe the interactions between a child and a parent or between a tutor and student. It is a metaphor for the process during which temporary supporting structures are used to help the inexperienced individual to gain expertise. The scaffold provides the inexperienced individual with an opportunity to "*concentrate and complete only those elements of the task that are within his range of competence*". The term is currently used to describe supporting structures in a variety of learning environments as in web-based learning, cooperative learning environments and whole-class discussions.

The idea of scaffolding is linked to Vygotsky's beliefs that social interpersonal learning precedes personal intrapersonal learning and that this learning takes place in the inexperienced person's zone of proximal development.

In the original description of Wood *et al.* (in Puntambekar, 2005), six types of support were envisaged in scaffolding: recruiting attention, reducing freedom by simplifying the task, maintaining direction, highlighting the critical task features, controlling frustration and demonstrating ideal solution paths. This leads to motivation by providing just enough support to enable the learner to reach the goal, as in providing modelling, clear shared understandings of the goal of the task and hints and questions that might help the learner to reflect.

Scaffolding may include ways of helping students such as: clear step-by-step instructions, clarification of the purpose of the activity, ways of focusing the attention of the students like assessment rubrics and outcomes that clarify expectations and demarcation of resources that could be used to restrict students from wandering off too far.

3.3.4 Integrated models

Two models, namely that of objectivism complementary to constructivism (Cronje 2000) and a proposed model will be discussed.

3.3.4.1 Objectivism complementary to Constructivism

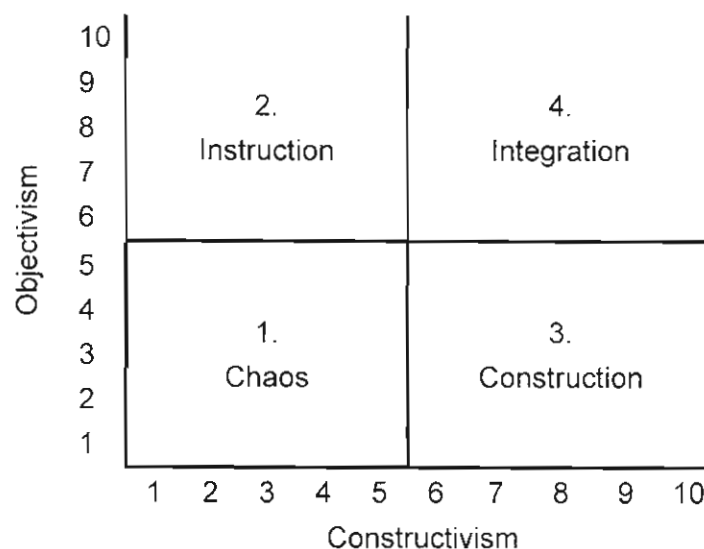
Cronje (2000) explains the conditions for learning to occur, using four quadrants. In contrast to popular opinion, he sees *objectivism* (behaviouristic approaches) and *constructivism* not as lying on opposite sides of a straight line, but as complementary

to one another. Plotting them at right angles produces four quadrants of conditions of learning. He goes on to describe learning in each of these four quadrants. His descriptions will be summarized below and in figure 3.8.

1. **Chaos:** Most learning takes place in the chaos quadrant: It is the domain of serendipitous immersion and incidental learning. Learning occurs through experience rather than studying or training. Positive feedback is encouraging and the behaviour is reinforced. Learning in the chaos quadrant is low in objectivist elements. It is further:

- not determined by outside entities nor placed in any given, pre-determined sequence;
- opportunistic;
- low in constructivist elements;
- lacking clear evidence of support and cognitive scaffolding; and
- lacking conscious effort to place it in real-world context.

Figure 3.8: Four quadrants of teaching and learning (Cronje, 2000)



2. **Instruction:** Learning in this quadrant:

- is high in instructivist elements and in pre-planned extrinsically determined learning practice.
- is programmed (it is the domain of learning, tutorials, lectures and drill-and-

practice).

- has “automaticity” as the principal outcome of instruction (Bloom in Cronje, 2000).
- has as its principal advantages efficiency and focus, but may be monotonous; and
- is typically the domain of military instruction.

3. **Construction:** This is designed to give learners the opportunity to construct their own meaning intrinsically by building on previous knowledge.

- Its principal outcome is individual understanding;
- Its principal advantages are effectiveness and transfer;
- It is typically the domain of teachers supporting the 'new paradigm';
- Corresponds closely with what is traditionally written about constructivism, constructionism, and cognitivism; and
- May lack support and structure for learners that would flourish in instruction paradigms.

4. **Integration:** This is the combination of instruction and construction in appropriate conditions.

- It is the domain of the instructional designer.
- The following steps can be distinguished:
 - goal analysis (determines the essential learning outcome);
 - analyses (to determine the skills and sub-skills required for the outcome to be reached);
 - selection (of both behavioural / instructionist and constructivist/cognitive learning events to achieve the desired outcome); and
 - evaluation of learning (ranges from de-contextualized testing of rote learning through authentic testing to portfolio assessment, depending on the performance criteria specified during the goal analysis). In the

integration quadrant, the strengths of the other quadrants can be emphasized and the weaknesses minimized.

3.3.4.2 Proposed model of teaching, learning and creativity

To summarize what the researcher learnt from the literature study about the different learning theories, a model is proposed which is represented in figures 3.9 and 3.10. This model proposes different ways in which creativity may be incorporated in a learning environment. It incorporates Gagne's explanation of creativity (*cf.* 3.3.1.3), Piaget's processes (*cf.* 3.3.2), Ausubel's dimensions of learning theory (*cf.* 3.3.2.2), Cronje's integrated theory (*cf.* 3.3.4.1), as well as social learning models (*cf.* 3.3.3) and De Solla Price's network theory (*cf.* 2.4.3.6). The basic idea of this model is that different learners may need different contexts and different degrees of support, scaffolding and time frames to enable them to come to a creative outcome.

Is it possible to be creative in a domain without the basic knowledge and skills? Is it perhaps a trap, based on Bloom's cognitive hierarchy into which we are conditioned to believe that basic knowledge, skills and understanding are essential for creativity? May it not be possible that if a problem or idea is presented, the necessary skills and knowledge will be acquired while solving the problem or realizing the idea? The researcher believes it is possible to have creative ideas without deep knowledge. Deep knowledge may even inhibit creative ideas. The generation of the idea, however, also depends on having the terminology and language in terms of which it could be expressed. To gain acceptance for one's creative ideas needs deep knowledge since your ideas must be explained to the gate-keepers of the domain in their terms. Creativity without deep knowledge may therefore come to nothing, since it would not be presented in acceptable terms and according to the rules of the domain (*cf.* 2.4.2.2 & 3.3.1.3) and would therefore usually not be accepted. It could further unnecessarily duplicate work already done (like re-inventing the wheel) and could ignore crucial features, due to lack of understanding (like machines for perpetual motion ignoring the law of conservation of energy). Solutions, without understanding of the intricacies of the domain, will be unsophisticated. Without knowledge transfer, little progress will be made, even over generations, since the same problems will be solved over and over. Reception and rote-learning, although usually reproductive, are therefore needed to develop basic skills, knowledge and understanding. Without these basic skills and domain-specific knowledge, higher cognitive functioning may be impossible. Both these ways of learning may further help in co-evolution (*cf.* 2.4.3.5, 2.5.2.1) by developing the chunking ability of the

brain, as well as enlarging the capacity and nimbleness of the working memory and long-term memory (*cf.* 2.3.5).

Besides rote and reception learning, guided discovery and mediated creativity are processes that may be most successful in most classroom situations. In guided discovery (figure 3.10), knowledge may be reproductive, as learners rediscover principles and knowledge through experimentation and through interaction with other sources such as a parent/teacher/lecturer/peer, artifacts such as tools, models, written and audiovisual sources, etcetera. Guided discovery may be scaffolded and systematic. The learner is guided and mentored (figure 3.10). Existing knowledge, skills, values and attitudes are transferred. The role of the facilitator is to guide the discovery of, for the learner, new knowledge and skills and to scaffold where needed. In mediated creativity, the use of cognitive skills is modelled and mediated. Meanings are shared between facilitator and learner, and between learners. The learner is the newcomer in a creative network (*cf.* 2.4.3.6). The parent/teacher/ lecturer and /or more experienced peers may be the incumbents. This may include learning the manual and cognitive skills and knowledge of the domain in a protected environment through interaction with other people, but with the aim of solving a problem or producing something new. Ideally, people should go through more than one of these processes before being left to work in the fourth mode, namely independently. The independent mode can be seen to be equivalent to Bruner's discovery learning. On the other hand it is also the learning outside the classroom where what was learnt in the other three modes, is tested in real life situations as described by Lewin and Kolb's experiential learning (Shields, Aaron & Wall, 2001) (*cf.* 2.2.2.2.4 & 3.3.2.3). In figure 3.9, the advantages and disadvantages of starting *without* reception and rote-learning, guided discovery and /or mediated creativity are compared with a situation where a person had exposure to these processes.

Cronje points out that most learning takes place in chaos (figures 3.8 and 3.9). Although the other intentional interventions, rote / reception learning, guided discovery and mediated creativity, attempt to manage, guide and accelerate learning, the teacher and learner cannot and should not try to avoid independent learning. It is here that integration, and contextualization of knowledge reach their peak and where the learner takes possession of knowledge and skills. Guiding the learner towards independent learning could be seen as the goal of mediated and guided learning. It is during this mode where what was learnt can be applied, criticized and changed. If, however, the education experience does not expose the learner to the other three

modes, there is no sense in being exposed to formal education. Then, in Feuerstein's terms, the learner will be "unmediated" and only potential will exist, but no optimal realization of potential. No higher order psychological tools will be modelled and little knowledge would be transferred. Learning could then be a long struggle with trial-and-error learning directly from the environment or slavish imitation of others. It is through the mediating and scaffolding actions of human mediators that technological progress can be made, as one generation can build on the progress and lessons learnt by previous generations.

Therefore it is unlikely that a person would be creative in a domain-dependent area unless the learning process is successful. It is unlikely that the learning of complex knowledge and higher order skills will be successful if it is not mediated and modelled. Creativity is a unique combination of ideas. If no ideas have been stored meaningfully in the long-term memory, it is unlikely that any conflicts will arise and new combinations would materialize. If the necessary cognitive skills are not developed to compare, contrast, analyse and evaluate information, it is unlikely that a person would be able to synthesize common, let alone novel combinations between them.

Not all people will tend to be highly creative even under ideal conditions. Not all situations where proper learning takes place will lead to creativity. Highly structured instructional methods that are very effective in teaching specific knowledge and skills may discourage creativity if it is over-emphasized and leaves little room for error (*cf.* 2.4.3.10). Instructional methods where little structure and few rules exist (as in independent mode in figures 3.9 and 3.10), may encourage creativity in some people, but may lead to chaos (and lack of proper knowledge acquisition) in many other cases. Some people (such as Edison) may be able to function well and persist until order emerges from chaos. For the majority of learners this may, however, be a nightmare because they need the structure to feel safe and operate optimally. They need the scaffolds to strengthen their understanding and guide them through the sea of possibilities.

Figure 3.9: Learning processes and the advantages and disadvantages of different starting points in facilitating creative learning outcomes

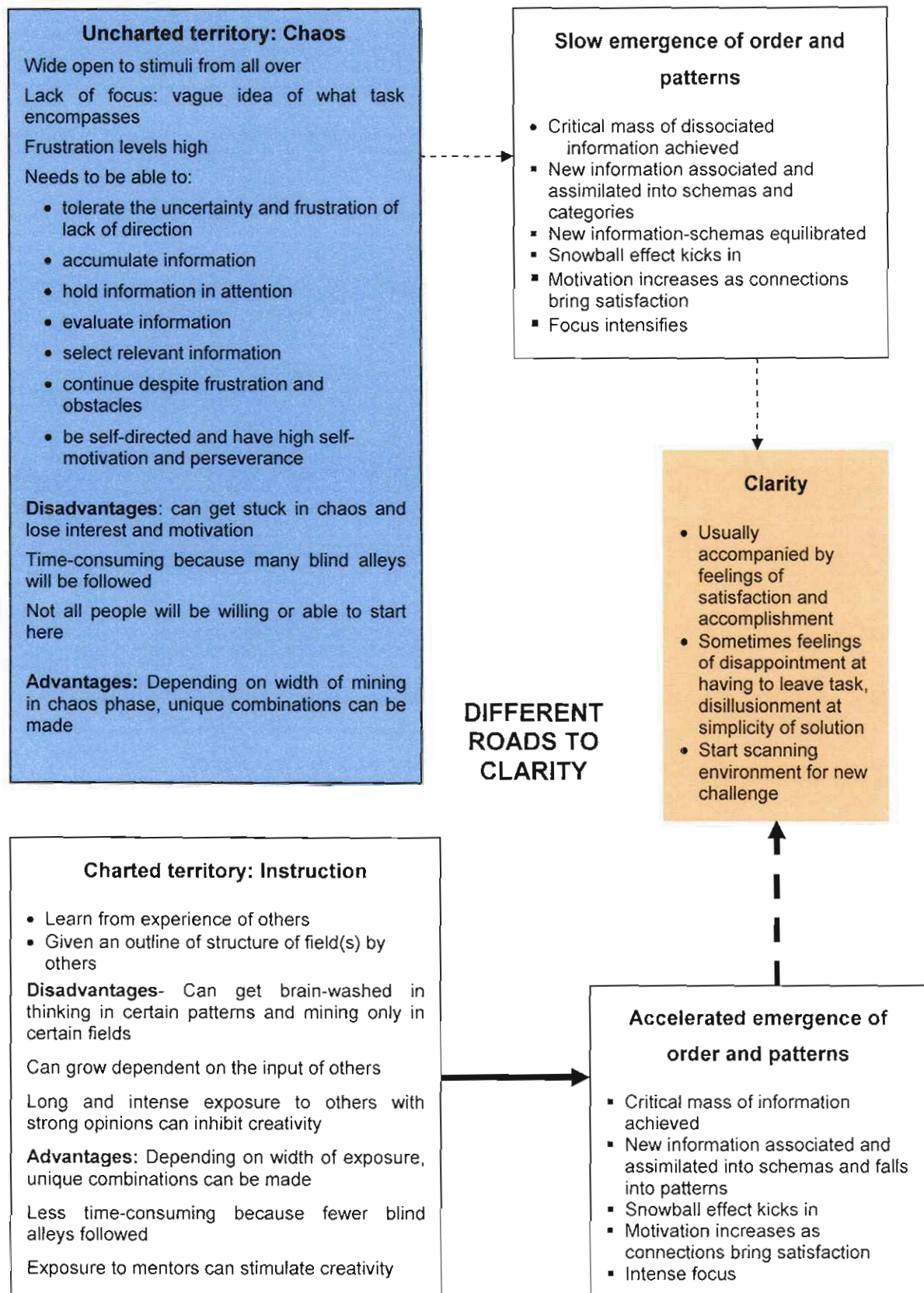
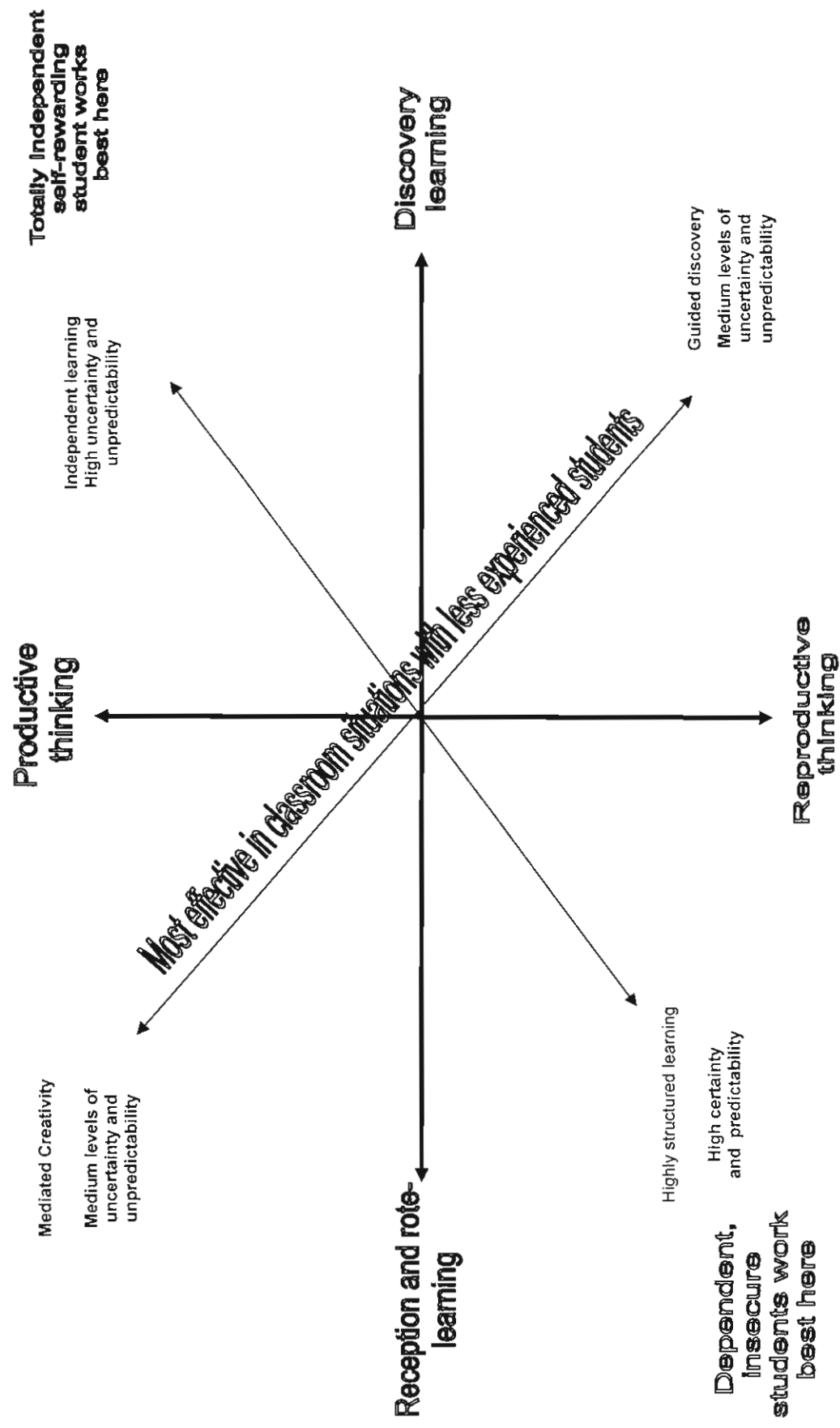


Figure 3.10: Proposed model of learning to facilitate creativity in learners with different needs



3.4 THE ROLE OF COGNITIVE CONFLICT IN LEARNING

Conflict is seen as an instigator and motivator of learning and/or creativity in various cognitive and social theories. Ausubel (1978) advocates the creation (simulation) of conflict when he explains that advance organizers should be used to create expectation. Lewin (in Smith, 2001), Vygotsky (1986,1997), the Activity Theory, Fritz (1994) and Kolb (1983) all point out that learning (and/or creativity) is the result of conflict resolution: the conflict may exist between reality and the inner world or mental schema of the individual (Vygotsky and Piaget) or between reality and visualized goals (Fritz (1994) and Activity Theory (1996), according to Lewin, between immediate concrete experience (reality) and detached analysis within the individual (in Shields, Aaron & Wall, 2001) or between the learnt knowledge (theory) and the experience in the real world (Kolb,1983).

This conflict between classroom practice and real-life experience and the constant adjustment resulting from resolving conflicts between these two worlds are well illustrated by the theory of experientialism. The viewpoint is that personal experience is the only or the principal basis of knowledge. It involves the application of the information received in the classroom and from other sources to the learner's experiences in real life, also outside the classroom. Through this continuous testing of knowledge against accustomed real-life experiences, knowledge becomes grounded in experience. Kolb (in Shields *et al.*, 2001) assumes that learning results from the "*resolution of conflicts between dialectically opposed modes of adaptation to the world*".

3.5 LEARNING CREATIVITY

A number of lessons regarding how creativity can be learnt are found in literature. They are discussed below.

3.5.1 Creativity enhancement should be done in a balanced way

Sternberg warned in 1986 "*that theory, assessment, and instruction in the field of human abilities have tended to emphasize intelligence at the expense of wisdom and creativity*". Since research has shown that these three abilities are distinguishable and different, a balance should be struck between educating for each. Sternberg (1986 & 2001), Perkins (2001) and Stanovich (2001) emphasize the need to look at the goals and beliefs of the learner, thinking dispositions, values, morality, cognitive

styles and the evaluation of cognition in terms of normative criteria. One must remember the amplifying effect seen in the chaos theory. Just enhancing creativity for creativity's sake or creativity at the expense of the other human abilities could potentially breed large-scale problems in future. Awareness of ethical aspects (Nickerson, 1999:396) and, as Halpern (2001) describes it a *"value system that balances concern for oneself with concern for others and extra-personal concerns such as concern for the environment"* should be a concern in a creativity enhancement programme.

3.5.2 Different types and styles of creativity exist and each has a rightful place

All humans may be viewed as creative. Humans are not creative on the same level or in the same way (cf. 2.1.3). Very high levels of personal creativity are rare. It results from a chance confluence of certain genetic traits and environmental conditions and is linked to a creative personality. The genetic predisposition may include factors such as fairly high general intelligence, access to the right side of the brain and a familial tendency towards psychopathological conditions such as schizophrenia and Bipolar Affective Disorder (cf. 2.2.3.1.2). Environmental factors that cause certain genes to be expressed may include marginalizing and circumstances leading to independence during childhood (cf. 2.4.3.2). The person may develop self-rewarding coping mechanisms, techniques and meta-cognitive control mechanisms to sustain high intrinsic motivation. The process used by these people may even be related to a chemical dependency on certain neuro-chemicals such as the brain's own reward substance, namely dopamine (cf. 2.2.2.3 & 2.2.3).

Personal creativity or Csikzentmihali's "creativity with a small c" is the creative way in which ordinary people lead their daily lives and solve their daily problems (cf. 2.1.3). Although most people will not change domains or discover laws of nature, this is an attitude towards life and a way of thinking that may have far-reaching effects in the community and in the human population, if encouraged. This is the type of creativity that may be expected of the majority of teachers. This is an attitude and an awareness that may assist teachers to help unlock the creative potentials of learners in their care. Enhancing creativity in the classroom depends on the willingness of educators. Simplicio (2000) determined that *"If educators are willing to incorporate changes within their daily teaching styles they can be taught to be more creative in the process"*.

3.5.3 Using Technology Education to enhance learning of creativity

Knowledge and skill acquisition is the basis of creative work within a domain (*cf.* 2.2.5.1, 3.3.1.3). The wide and open nature of Technology Education and freedom in the choice of context makes it ideal for the acquisition of a wide variety of knowledge, cognitive skills and contextual learning catering for specific interests of students.

3.5.3.1 Paying attention to basic skills and knowledge

Since creativity depends on the use of ordinary mental processes (*cf.* 2.4.3.7; 3.3.1.3), they must be in place. Bloom's taxonomy (table 3.2) may be used as guideline. Nickerson (1999:409) explains Feldhausen's three-levelled conceptual model with basic language, mathematical skills and use of imagination on level one, learning various structured approaches to creative problem-solving on level two and the performance of independent self-directed projects on level three. Bloom's taxonomy (table 3.2) also assumes that knowledge and basic cognitive skills form the basis of creativity.

3.5.3.2 Exposure to a variety of knowledge

A positive link between creativity and exposure to diverse information (*cf.* 3.5.3.3) was indicated by in pre-test-post-test design research by Clapham (2001:247). Students should therefore be exposed to a wide range of knowledge (for ideas) and should also go deeper in their area of application. In Technology Education in South Africa, the NCS prescribes that the topics of Structures, Processing and Systems and Control must be taught as main fields. Cross-field areas that must be integrated in the main content areas include the technological process, communication, safety, energy, materials, indigenous knowledge, bias and the impact of technology on the natural and social environments.

3.5.3.3 Paying attention to creative process skills

The skill and ability to alternate appropriately between divergent and convergent thinking may be developed by allowing for brainstorming sessions on different levels (individual, group, class) during which judgment is withheld, alternating with evaluation sessions during which optimum answers are selected. This may lead to an attitude of openness to alternatives and different perspectives, an active effort to find and eliminate causes and factors leading to the situation in appropriate ways, rather than just looking for superficial and existing solutions. An increasingly clarified aim

and focus may help students to stay motivated.

3.5.3.4 Paying attention to information storage

An ability to learn and store information in such a way that it can be retrieved in chunked form seems to be necessary for creativity. Mental maps (Boden,1995) or schemata (Piaget (cf. 3.3.2.2) may be seen as the result of different levels and stages of chunking.

If knowledge such as $2 + 2 = 4$ can be automatically retrieved as 4 or d-o-g as a image of a dog, its barking and shape, etcetera., the knowledge contained in it is chunked in the brain. This chunk $2 + 2 = 4$ can enter the working memory as one piece of information instead of a number of distinct pieces. The working memory has a limited capacity and can hold up to only about seven single bits or seven chunks of information (cf. 3.3.1.3.2). People without the basic knowledge in chunked form in Hebbian connections, will have difficulty in solving complex problems or seeing Gestalts when chunks simultaneously enter the working memory to be associated and/or when short-circuits form in already established networks (Schilling, 2005; cf. 3.3.1.2). Bits of knowledge will stay separated and unrelated from one another and the connections made may tend to be simple, unoriginal and of a "low order".

Boden (1995), uses Mozart as example to explain the interrelatedness of chunked information (or cognitive maps) and creative output. She mentions that a *"crucial difference, probably the crucial difference-between Mozart and the rest of us is that his cognitive maps of musical space were very much richer, deeper, and more detailed than ours. In addition, he presumably had available many more domain-specific processes for negotiating them"*. She explains further that mental maps enable us to explore and transform our conceptual spaces in imaginative ways.

In Technology Education, attention is given for chunking information by making mental maps in the form of mind-maps for situation analysis, flow-charts, comprehensive working drawings and production schedules. Mental and physical models, expected in Technology Education can further aid in this process.

3.5.3.5 Paying attention to learning within a context

Technology Education is taught within context. Specific needs and interests of learners can therefore be addressed. Knowledge about situations may be obtained from real-life scenarios and problems, individuals, groups, artifacts, the domain of

knowledge and human mediators.

3.6 CRITICAL EVALUATION

Different pictures regarding learning emerged from the literature search. Everyone has something to tell about how learning takes place and how it specifically occurs in humans. Behaviourists concentrate on the basic unit of behaviour modification (the stimulus and response). Behaviourists explain how a rewarded response tends to be repeated and a punished response avoided. This may be a mechanism in which creativity is culturally inhibited or encouraged. The connectionists and neuroscientists concentrate on the basic unit of the nervous system (the neuron), how it is changed to store information and how different neurons become connected into integrated networks. In this way, neuroscientists and connectionists explain that learning results from changes on cellular and inter-cellular level. These changes are experience-dependent: "use it or lose it" is their message. Experiences (challenges, problems) serve as stressors, which are, when controllable, the stimuli for adaptive modification of the brain. Brains of individuals, socialized and encultured differently, differ on both functional and structural levels.

Neuroscientists further explain the importance of the chunking ability of the brain in creativity, as well as the roles of a nimble pre-frontal cortex and a well-developed working memory in facilitating creativity. The formation of networks of neurons is explained as a mechanism for the storage of memories. A proposed mechanism for insight forming a short-circuit in such a neural network with small-world properties is described (Schilling, 2005). Information processing models explain the functioning of the human nervous system in computer and system terms with input, process and output (Gagne & Driscoll in Hamachek, 1988:196). Baddeley and Hitch's (1974) model of human memory is explained.

Where neuroscientists use cell assemblies and networks to describe what the neurons do to store information, cognitive scientists use schemas to describe the way in which the brain structures knowledge. In these schemas, new information is accommodated and assimilated and the schemas are equilibrated during dynamic processes (Piaget). Cognitive scientists themselves, in the style of Watson and Crick, make use of schemas to explain the processes necessary for learning (Ausubel) and the hierarchy in acquiring and processing knowledge (Bloom & Bruner). Gestalt psychologists describe the phenomenon of insight and seeing the whole as a "*sudden transformation of the elements in the perceptual field*" (Schilling's short-

circuit in a network of cells that triggers a cascade of associations).

Social cognitive theories see culture (language and higher order psychological tools) as a product of technology. Culture needs to be mediated. Modelling (Bandura) and mediating (Vygotsky & Feuerstein) in the zone of proximal development and scaffolding processes (Wood & Bruner) are described as ways in which higher order psychological tools may be transferred. Kozulin and Presseisen (1995) use the work of Vygotsky and Feuerstein to describe different situations where cultural transfer may be hampered and where remedial work may be useful. One of these, applying to the situation in this research, is where learners are first encultured in a pre-literate culture and are then expected to function in a literate culture (*cf* 2.4.2.1).

Cronje (2000) and the researcher propose integrated models (figure 3.10), incorporating concepts from behaviourist, cognitive and social-cognitive learning theory. The role and importance of rote-learning, reception learning, guided discovery, mediated creativity and independent work within a supportive, but challenging context, to develop the different cognitive levels described by Bloom, Anderson and Krathwohl, are pointed out.

Aspects of creativity can be learnt. Providing creative role-models, encouragement for creative efforts, a proper knowledge base and a context for the development of creative networks that can act as support and scaffolds are a few of the controllable components that could be made part of a classroom environment that should enhance creativity.

Technology Education has a unique nature and problem-solving, project-based approach to learning. Its methodology makes provision for mediated learning, for acquiring basic knowledge and skills and applying this knowledge and skills in ethical and responsible ways to solve real-life problems in creative ways. Learning may initially be scaffolded, mediated and guided. As the student gains more and more confidence and competence, the scaffolds may be removed and independent learning results. The contextual knowledge and procedural knowledge of Technology Education may be used to mediate higher order thinking, effective problem-solving strategies and attitudes towards problem-solving.

3.7 SUMMARY

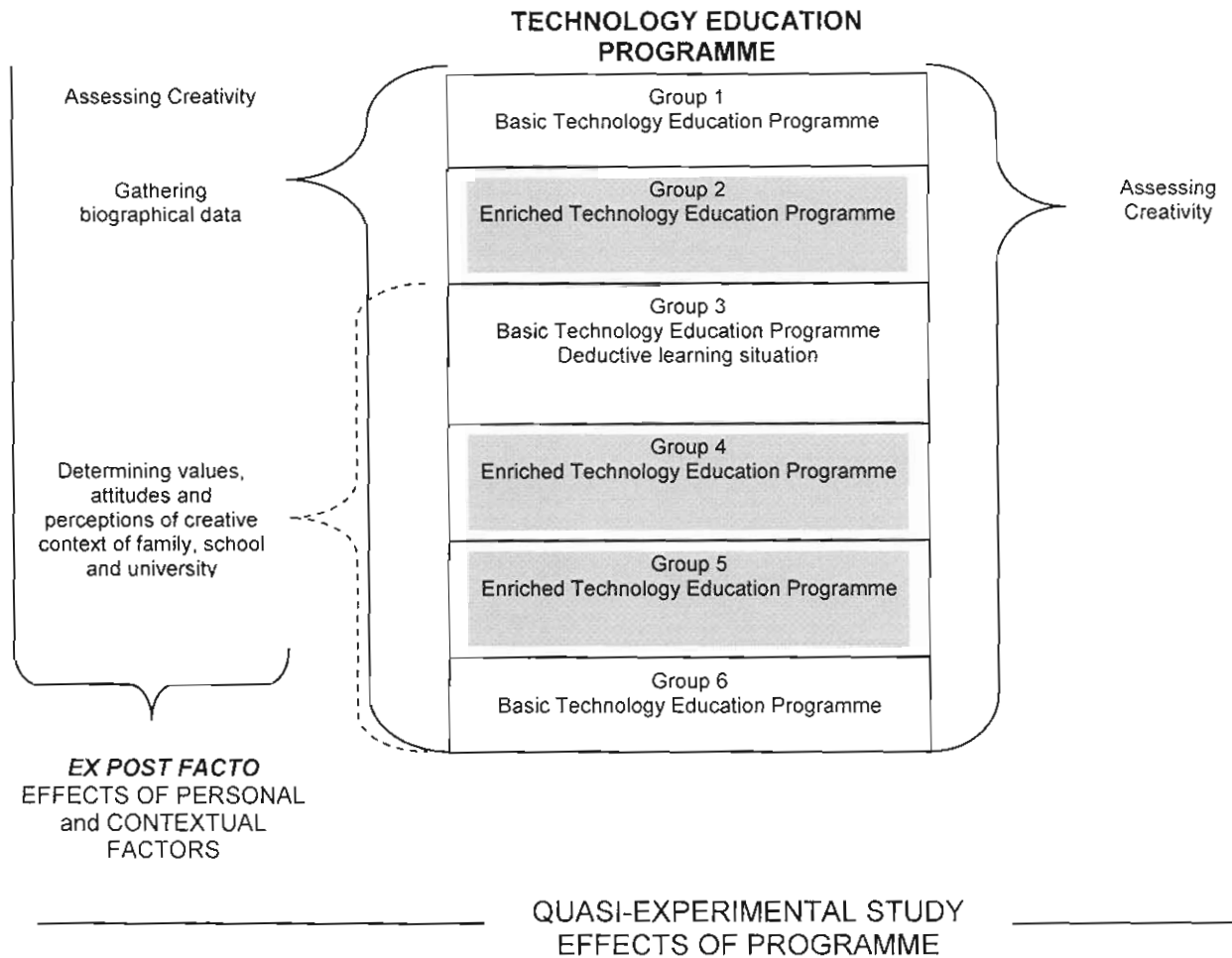
This chapter focused on the different theories, attempting to explain how learning occurs. Attention was given to objectivist theories (such as behaviourist, neuroscientific, information-processing and mastery-learning theories) and cognitive theories (like Gestalt, Constructivism and Experientialism). Social cognitive theories, namely modelling, mediation and scaffolding were discussed. In conclusion, integrated models used in an attempt to reconcile the learning theories and specifically aimed at the learning of creativity. The learning theories were applied in a discussion of the role that Technology Education could play in the learning of creativity.

In chapter four, the empirical design and statistical methods that will be used in this study will be discussed.

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about earning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER FOUR

EMPIRICAL RESEARCH DESIGN



4.1 INTRODUCTION

This chapter describes the aims and methods of the research as well as the tools used to determine creativity indicators and to capture biographical data and perceptions of culture, families, schools and university. It further discusses the statistical methods used in the analysis of the data. The reasons why the research and instruments could be viewed as valid and reliable are discussed in every case.

It was assumed that a variety of modes and styles of creative expression are available. Further it is acknowledged that all people have strengths in certain modes (cf. 2.2.2.1). For the purpose of this current study, creativity will be assessed only

through modes of writing and drawing and by using the framework given by Guilford about divergent thinking (cf. 2.2.2.1) that also relates to Sternberg's concept of experiential intelligence. The study therefore does not attempt or pretend to give a full picture of the creativity of the participants. It is only limited to these specific skills that the researcher thought are most relevant and appropriate in an academic milieu and for which a reliable standardized assessment instrument was available.

4.2 THE AIMS OF THE RESEARCH

It was observed that students at the Vaal Triangle Campus of the North-West University opting for teaching as a career often struggle to utilize the opportunities for creative work that are provided in a learning area such as Technology Education. This was also noticed and identified as a problem by other observers regarding in-service teachers, as was mentioned in reports reflecting on the first few years after implementation of OBE in South Africa (Taylor & Vinjevold, 1999:104-130). Students taught by the researcher over a number of years often commented that they find the learning area Technology Education initially unsettling in the sense that they are unsure about what is expected of them since it is so "open". They complain that they do not know what to learn. They take a while before adapting to new "ways of thinking". Some seem to have great difficulties finding their feet. These examples have led to an interest in finding out why students initially struggle with this "open" learning area. Firstly, the researcher wanted to determine the *status quo* regarding creativity indexes of the students when they start the Technology Education programme. Factors in their family, schools and cultures that could contribute to this *status quo* were a further topic of interest. The researcher was also interested in finding out whether the Technology Education programmes that are offered at the local university or slight variations of these programmes contribute to or inhibit the creativity indexes of the students. Lastly the researcher wanted to determine whether the factors like family, culture and school had any influence on the capacity to change.

The overall aim of this research was to optimize the learning environment for creative work for pre-service teachers in Technology Education.

This aim was operationalized as follows:

1. The creativity indexes and creative abilities of the pre-service teachers in Technology Education were determined.

2. The factors that impact on the creativity indexes and creative abilities of pre-service teachers in Technology Education were investigated.
3. Ways of how the creativity of pre-service teachers in Technology Education could be improved were explored.
4. A programme for enhancing the creative thinking abilities of pre-service teachers in Technology Education was designed and implemented.

4.3 HYPOTHESES

The following null and alternative hypotheses were formulated for the study, based on three assumptions.

Assumption 1: Personal factors (such as age, position in family, academic achievement and gender), **process-related factors** (such as ability to generate many ideas (fluency), new ideas (originality), different ideas (flexibility) and adding detail to ideas (elaboration), **contextual factors** (such as culture, socio-economic factors and acculturation of parents, family factors, role models and school model attended) and **perceptions of whether contexts** (such as culture, family and school) and **model creative behaviour as desirable behaviour** might be responsible for the inability of students to seize opportunities for creative work.

Null hypotheses:

- H_0^1 Personal factors have no significant influence on the creativity index of participants in this study.
- H_0^2 There are no differences in the strength of the relationships between creativity index and the different creative abilities used in the creative process in the participants in this study.
- H_0^3 There are no relationships (direct or indirect) between contextual factors and creativity index in the participants in this study.
- H_0^4 There are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity in the participants in this study.

Person	Process	Context	Perception	Creativity
X				X
	X			X
		X		X
		X	X	

H_0^5 There are no relationships (direct or indirect) between perceptions about the context and the creativity in the participants in this study.

			X	X

The researcher also posed the following alternative hypotheses:

Alternative Hypotheses:

- H_a^1 Personal factors have a significant influence on the creativity index of participants in this study.
- H_a^2 Some creative abilities, influencing the creative processes, are more of a problem for the participants in this study than others.
- H_a^3 There are direct and/or indirect relationships between the contextual factors and creativity indexes.
- H_a^4 There are direct and/or indirect relationships between contextual factors and the perception that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres).
- H_a^5 There are direct and/or indirect relationships between the perceptions that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres) and their creativity.
- H_a^6 There are direct relationships between the personal, process and contextual factors, whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres) and direct and indirect relationships between the contextual factors and the creativity of participants.

Person	Process	Context	Perception	Creativity
X				X
	X			X
		X		X
		X	X	
			X	X
X	X	X	X	X

Assumption 2: A Technology Education programme including exposure to creative-role models, modelling creative behaviour as acceptable, combined with exposure to creative processes (enriched programme) should have a more positive effect on creativity indexes of students than a programme focusing just on exposure to creative processes (basic programme).

The following null hypotheses are posed:

- H_0^6 : The difference in Technology Education programmes followed will have no significant effect on participants' **creativity indexes**.
- H_0^7 : The difference in Technology Education programmes followed will have no significant different effect on participants' **creative process skills** (creative abilities).

The researcher also poses the following alternative hypotheses:

- H_a^7 : Hypothesis: Explicit training of pre-service teachers to view creative behaviour positively might have an effect on participants' creative indexes.
- H_a^8 : Hypothesis: Explicit training of pre-service teachers to view creative behaviour positively will have **a definite effect** on participants' creative indexes.
- H_a^9 : Hypothesis: Exposure to the different Technology Education programmes will have **different effects** on participants' creative indexes.

Assumption 3 states that the context from which a student comes and the perceptions about these contexts regarding modelling creativity as desirable behaviour will determine the effect that a programme aimed at enhancing creativity may have on his/her creativity.

The following null hypotheses were posed:

- H_0^8 : The possible effects of the different Technology Education programmes on the **creativity indexes** of the participants will not be influenced by contextual factors and /or perceptual factors.
- H_0^9 : The possible effects of the different programmes on the **creative abilities** of the participants will not be influenced by contextual factors and /or perceptual factors.
- H_0^{10} : Cultural factors have no effect on the "modifiability" of participants regarding creativity.

The following alternative hypotheses are formulated:

- H_a^{10} : The possible effects of the different Technology Education programmes on

the **creativity indexes** of the participants will be influenced significantly by contextual factors and/or perceptual factors.

- H_a^{11} : The possible effects of the different programmes on the **creative abilities** of the participants will be influenced by contextual factors and perceptual factors.
- H_a^{12} : Cultural factors have an effect on the “modifiability” of participants regarding creativity.

Therefore, in the case of this study:

- If the null hypothesis H_0^1 is true, the **creative index scores** would not depend on the **personal factors** of the participants in this study.
- If the null hypothesis H_0^2 is true, there would be no **creative abilities** that will stand out as **problem areas** in the participants in this study.
- If the null hypothesis H_0^3 is true, the **creativity scores** of students would not depend on their **contexts**.
- If the null hypothesis H_0^4 is true, the **perceptions** of their contexts as enhancing creative behaviour would not depend on the **context** from which they come.
- If the null hypothesis H_0^5 is true, the **creativity scores** of participants would not depend on their **perceptions** of their contexts as enhancing creative behaviour.
- If the null hypothesis H_0^6 is true, the **creative abilities** scores in the post -test would be independent of the **programme** that was followed.
- If the null hypothesis H_0^7 is true, the **creative index scores** in the post -test would be independent of the **programme** that was followed.
- If the null hypothesis H_0^8 is true, a **change in creative index** scores from pre to post-programme test would not depend on the **contexts** from which participants come.
- If the null hypothesis H_0^9 is true, a **change in creative ability** scores from pre-to post-programme test would not depend on the **contexts** from which participants come.
- If the null hypothesis H_0^{10} is true, **cultural backgrounds** would have no effects

on how the students respond to the differences in the programmes.

4.4 VARIABLES

4.4.1 Independent (exogenous, upstream) variables

Measured variables or indicators may reflect *latent* variables or form (cause) emergent variables (both unobserved) (Chin, 2000:36). The following represents a list of measured independent variables. Most of them are reflective rather than formative (*cf.* 4.7.3.1) and could be measured with little error.

- Personal variables: Age, position in family, gender, academic achievement
- Contextual variables: Family factors such as family trauma, family status and number of children in family.
- Domain variables: Culture.

Exogenous latent variables are not influenced by any other variables and are indicated by the symbol ξ (Ksi) (Gefen, Straub & Bourdreau, 2000:22). Covariance may, however, exist among the exogenous latent variables.

4.4.2 Intermediate (endogenous, downstream) variables

Intermediate variables are endogenous variables dependent on the exogenous variables or other endogenous variables and affect dependent variables. Endogenous latent variables are influenced by any other variables and are indicated by the symbol η (Eta) (Gefen, Straub & Bourdreau, 2000:22).

- Contextual variables: parental education, socio-economic factors, school model attended, people chosen as role models
- The perceptions of students about their culture, family, school and the university as factors that promote or inhibit the development of creativity
- Personal views such as that about ideal education, locus of control, the nature of technology and problem-solving also fall in this group.
- People chosen as role models are assumed to depend on contextual and personal factors.

4.4.3 Experimental variables

- Exposure versus non-exposure to an enriched learning environment
- Exposure to different types of enrichment in the learning environment

4.4.4 The dependent (endogenous, downstream) variables

These variables are influenced directly or indirectly by exogenous variables and also by the other endogenous variables.

- Creative indexes, level of creativity and creative abilities such as fluency, originality, flexibility and elaboration
- Field variables: academic achievement (possibly co-varying with the levels of creativity)
- Perceptions of ideal education

4.5 RESEARCH METHODOLOGY

A quantitative method was utilized in both the studies.

4.5.1 The quantitative research method

The quantitative research method was utilized to collect numerical data regarding the creativity indexes, abilities and styles of the research participants. Independent variables such as age, sex, cultural group, number of children per family, position of the student in the family, the parental education and family situation that could possibly affect the dependent variable, namely creativity indexes, were investigated. Factors in the past, in an experiment of nature, could possibly influence what is observed. At this point there was no direct manipulation of the independent variables (table 4.1). This design can therefore be seen as *ex post facto* (Leedy & Ormrod, 2004 :235).

Table 4.1: The ex post facto design

Group										Time
Prior event's										Investigation period
Exp _A	Exp _B	Exp _C	Exp _D	Exp _E	Exp _F	Exp _G	Exp _H	Exp _I	Etc.	Obs
1	1	1	2	1	1	1	2	2		Obs
2	2	2	2	1	1	2	2	1		Obs
1	2	1	2	2	1	2	1	2		Obs
2	1	2	1	1	1	1	2	1		Obs
2	1	1	1	2	2	1	2	1		Obs

The participants who studied over the three years were different regarding their prior experiences in areas such as personal variables (such as age (Exp_A), academic achievement (Exp_B), gender (Exp_C) and position in their families (Exp_D)), contextual and domain variables (such as cultural experiences(Exp_E), family situations(Exp_F), school situations Exp_G, parental schooling(Exp_I), beliefs (Exp_J) and perceptions(Exp_F)). The design is illustrated in table 4.1. With the use of PLS-path-modelling, these groups need not be restricted to students in one class group only. All participants in the data matrix coming from Non-African cultures in both the Afrikaans and English medium of instruction groups over the three years of the study could, for example, be compared with all those coming from African cultures. Similarly, trends regarding any of the variables could be modelled, using all participants or specific selected groups of participants.

Although confounding variables need to be considered when interpreting the possible correlations between the different exogenous and endogenous variables and firm conclusions cannot be drawn about the precise effects of every variable on the dependent variables, Leedy and Ormrod (2004:232) describe the method as *"legitimate research that pursues truth and seeks the solution of a problem through the analysis of data"*.

Furthermore, a **quasi-experimental design** with a non-randomized control group pre-test-post-test design was used to determine the effects of the programmes. It was not possible to control all variables and it is thus not possible to rule out alternative explanations for the result obtained (Leedy & Ormrod, 2004: 227). The practical arrangement of the classes in the compulsory Technology Education

modules in the first year of study at the university is based on language of instruction. Two groups are formed yearly: a homogeneous Afrikaans Medium of Instruction group (AMI) and a heterogeneous English Medium of Instruction (EMI) group. Randomness could not be achieved on a yearly basis due to this practical class situation (table 4.2(a)). Randomness could also not be achieved over the whole study due to unequal class sizes and the unequal number of years that the study was running. In the first two years of the study, the EMI groups were exposed to the enriched programme (with emphasis on making “creative behaviour” acceptable) and the AMI to the basic programme. During the third year of the study, the situation was reversed: the AMI-group was now exposed to the enriched programme and the EMI to the basic programme. The overall study therefore gave two non-equivalent groups: a mixture of AMI and EMI (groups 1, 3 and 6) (Tx_a) that were not exposed to the programme and a mixture of AMI and EMI (groups 2, 3 and 5) (Tx_b) that were exposed to the programme. The overall study further gave groups of both EMI (mainly African and Western cultures) and AMI (all Western culture), that were respectively exposed to Technology Education programmes with different approaches that could be compared (for example: AMI (group 1,3) exposed to the basic programme and AMI (Group 5) exposed to the enriched programme. EMI (Group 6) was exposed to the basic programme and EMI (Group 2, 4) was exposed to the enriched programme.

Table 4.2(a): Experimental design involving 6 groups over a three-year period

Table 4.2 (a)

Year	Group		Investigation Period		
2004	1	AMI	Obs	Tx _a	Obs
	2	EMI	Obs	Tx _b	Obs
2005	3	AMI	Obs	Tx _a	Obs
	4	EMI	Obs	Tx _b	Obs
2006	5	AMI	Obs	Tx _b	Obs
	6	EMI	Obs	Tx _a	Obs

Table 4.2(b)

Group	Investigation Period	
1,3,6	Tx _a	Obs
2,4,5	Tx _b	Obs

Tx_a represents the basic Technology Education programme and Tx_b the enriched programme. In Table 4.2(b) the groups are clustered to show how data were collected during the study as a whole.

4.5.2 Validity of the research method

Leedy and Ormrod (2004:97) explain that to determine the internal and external

validity of a study, we need to answer two questions, namely: "Are there sufficient controls to ensure that the conclusions that are drawn are warranted by the data?" and "Can we use the data to make generalizations about the world beyond that specific situation?"

The use of non-equivalent groups threatens validity of a study since any effects could be due to the selection process (Garson, 2006d). Other threats to validity that apply in the second part of this current study and the interpretation of the results are maturation, regression towards the mean and test experience.

4.5.2.1 Internal validity of the research method

Leedy and Ormrod (2004:99) specify unobtrusiveness, double-blind experimentation and triangulation as strategies to ensure that accurate conclusions could be drawn regarding the cause and effect and other relationships within a study. History, maturation, testing, instrumentation, selection and mortality are described as extraneous factors that influence internal validity (Zikmund, 1997:308). This study should have internal validity because:

1. The measures that were used were unobtrusive in the sense that the testing was done in minimum time without making a fuss about it and although the students gave their consent, it was presented as part of their Technology Education course.
2. Different teaching methods were compared during the intervention. The participants had no idea what the hypotheses were. All students had to reach the same basic outcomes and the same lecturer presented both modified and basic courses. The students were unaware of the differences between the exposure of the two groups since the differences were not emphasized and they wrote the same tests and examinations. Attention was not specifically drawn to creative processes and terminology, and whatever Technology Education could offer in this regard was used as is (*cf.* Chapter 5).
3. Although the history of the students in this study differs, it is accounted for and is used as variables. They all fall in the same age group, mainly between 18 to 22 years, with the English Medium of Instruction (EMI) group slightly older than the Afrikaans Medium of Instruction (AMI) group. Similar levels of maturation may be expected, looking purely at the age of the students. Since the prior experience (studied in the first part of the study, the ***ex post facto*** design) of the students

differs, the predominantly Western culture of the university system may have a general stimulatory effect regarding creativity, especially in the EMI. In the AMI the university may either represent a continuation of their predominantly Western cultural experience or may broaden their perspectives as they are exposed to other cultures and attitudes.

4. The testing conditions were identical and the same instruments were used.
5. Multiple sources of data such as the biographical, perceptions and creativity tests were collected in the hope that all would converge to support the hypotheses-leading to triangulation.
6. The use of the newer SEM (structural equation modelling) models in the data analysis eliminates the problems with covariance in non-equivalent groups to a large degree since these programmes make provision for covariance within and between classes (Saretsalo, 1998:2). With the six groups taken over the three years, comparisons could be made between different cultural groups exposed to basic and enriched programmes (*cf.* table 4.2(b)).

4.5.2.2 External validity of the research method

Can we use the data to make generalizations about the world beyond that specific situation? Leedy and Ormrod (2004:99-100) explain that external validity depends on whether the study is done in a real-life setting, whether a representative sample was used and whether the study could be replicated in another context.

The experimental study was done in a class situation. The class situation in both the enriched programme and the basic programme was natural and sustainable – students were not aware of any differences and the outcomes reached in terms of the curriculum were identical.

A quasi-experimental design is not the ideal for statistical analysis. In this case it was the only option and represents a valid method if the data is handled and interpreted correctly. Trochim (2006a:1) recommends removal of pre-test measurement error that “leads to the attenuation or ‘flattening’ of the slopes in the regression lines” (as will be explained in section 4.7.2). He explains that this attenuation effect is also present in randomized designs, but only causes bias in non-equivalent groups. To avoid getting pseudo effects, it was decided to follow Trochim’s advice.

This study was done on a specific population, namely first year education students at

a university with a unique student population in terms of cultural composition and social situation. The results may be used to speculate about students enrolled in teaching courses at other universities with similar entrance requirements, but it may not be generalizable to the population as a whole. The study may, however, be replicated in a different context (such as at another university or with a group of students studying in a different direction, or randomly selected groups) and may yield similar results and/or results that can be compared to the results of this study.

4.6 DATA COLLECTION INSTRUMENTS

4.6.1 Measuring Creativity: The ATTA

The creativity measuring instrument, namely the Abbreviated Torrance Tests for Adults (ATTA) was used to determine the creativity indexes and creative abilities at the beginning of the course and again after the programme (*cf.* Appendix A).

Background: Torrance based the Torrance Tests of Creative Thinking on Guilford's dimensional intelligence ideas (*cf.* 2.2.2.1.2).

Goff and Torrance published the ATTA in 2002. It is a shortened version of previous tests, namely the TTTC that was published in the mid-sixties and the D-TTCT (Demonstration Form of the Torrance Tests) and the BD-TTCT (Brief Demonstrator of the Torrance Tests of Creative Thinking). The problem with the TTCT is that it takes a lot of time to administer: 44 minutes for the verbal and 30 minutes for the figural parts. The D-TTCT is much shorter, but still consists "of activities utilizing the same rationale as activities in the original TTCT" (Goff & Torrance, 2002:1). In 2000, Goff and Torrance published the BD-TTCT –Training /Teacher Manual with Norm Technical Data. From this test, the ATTA, that takes only 9 minutes to administer, was developed.

Technical Detail: The Torrance test consists of several simple verbal and figural tasks that involve divergent thinking plus other problem-solving skills. The test can be scored for **creative abilities**, namely **fluency** (number of relevant responses), **flexibility** (number of different categories of relevant responses), **originality** (statistical rarity of the responses) and **elaboration** (amount of detail in responses). The records of all adults who completed the BD-TTCT prior to 2000 were used to convert raw scores for the creative abilities to scaled scores on a scale from 11 to 19

so that they can be compared as shown in table 4.3. The means, standard deviation (sigma) and selected percentile points are given in table 4.4. The mean of the scaled scores of the four abilities is approximately 14, with standard deviations of about 2 for each of them (Goff & Torrance, 2002:31).

Table 4.3: Converting Ability Raw Scores to Normalized Standard Scores (Scaled Scores) (Goff & Torrance, 2002:30)

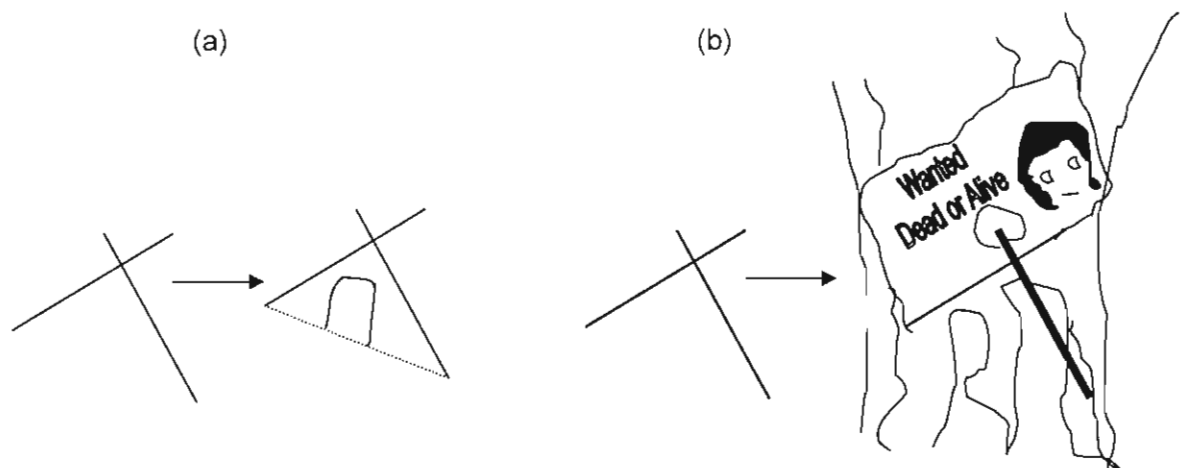
CREATIVE ABILITY	TOTAL SCORE	Scaled scores								
		11	12	13	14	15	16	17	18	19
		Corresponding Raw Scores								
FLUENCY		1-6	7	8-9	10	11-12	13-14	14-16	17	18+
ORIGINALITY		1	2	3	4	4	6	7-8	9-10	11+
ELABORATION		1-3	4-4	6-8	9-11	12-14	14-18	19-23	24-27	28+
FLEXIBILITY		-	1	-	2	3	-	4	4	6+

Table 4.4: Scaled Score Means, Standard Deviations (Sigma) and Selected Percentile Points for the Creative Abilities (Goff & Torrance, 2002 :31)

CREATIVE ABILITY	MEAN	SIGMA	Selected percentile points								
			.04	.16	.24	.40	.40	.60	.74	.84	.94
Fluency	14.011	1.90	11.6	12.9	13.6	14.6	14.2	14.7	16.4	17.0	18.1
Originality	14.149	2.14	11.4	12.7	13.4	14.6	14.3	16.0	16.8	17.4	18.6
Elaboration	14.116	1.94	11.7	13.1	13.7	14.6	14.1	14.7	16.6	17.2	18.4
Flexibility	14.247	1.86	11.8	13.3	14.0	14.6	14.0	14.8	17.0	17.4	18.3

A **creativity index (CI)** is compiled by adding the sum of the scaled scores to the scores of 14 verbal and figural **creativity indicators** (verbal and figural, like openness: resisting premature closure (figure 4.1), unusual visualization and different perspectives, richness and/ or colourfulness of imagery, movement and/or sound, abstractness of titles, context, combination, internal visual perspective, feeling, emotions and fantasy) that reflect approximately 13% to 14% of the creativity index.

Figure 4.1: The response (a) in activity 2 of the ATTA is an example of premature closure. The first idea that comes into most people's mind. The more creative individual resists the urge for premature closure and closes later or never (as seen in b).



The CI is finally converted to creativity levels on a scale from 1 to 7 as indicated in table 4.5. Goff and Torrance (2002:29) explain: "A score of 6 can be interpreted as being among the top 16% (4% +12%), a scaled score of 4 as being among the top 36%, and a scaled score of 2 as being among the bottom 16%, and so on."

Table 4.5: Conversion of Creativity Index to Scaled Score and related Interpretive Information (Goff & Torrance, 2002 :33)

CREATIVITY INDEX	1-50	51-59	60-67	68-73	74-77	78-84	84+
CREATIVITY LEVEL	1	2	3	4	5	6	7
VERBAL ASSESSMENT	MINIMAL	LOW	BELOW AVERAGE	AVERAGE	ABOVE AVERAGE	HIGH	SUB-STANTIAL
% ADULTS IN LEVEL	4%	12%	20%	26%	20%	12%	4%

Reliability Information for the ATTA: Reliability is the measure of the stability of a test and whether the test measures what it is supposed to measure. Reliability for the ATTA is evidenced by the Kuder-Richardson reliability coefficient (KR21) (Goff & Torrance 2002:33). The KR 21-score indicates reliability when values are between 0 and +1 and is dependent on factors such as the length and content of the test and guessability of questions in the test. This formula *"effectively averages out the*

correlations that would be obtained between all possible item-splits across two sub-tests" (NFER).

Another factor, related to reliability, is the Standard Error of Measurement (SEM): the lower the reliability, the larger the SEM. Sigma, known as the standard deviation, is the square root of the variance which is obtained by subtracting the average from each data item and then getting the square of each deviation.

The authors of the ATTA give different sets of data to illustrate the reliability of the ATTA:

- **Reliability information of the ATTA composite raw scores:** The Mean, Sigma, KR21 and SEM for total abilities (34.30, 11.43, 0.84 and 4.63) and total abilities plus indicators (44.14, 14.78, 0.90 and 4.76) are given. As can be seen, the KR21 values are 0.84 for total abilities and 0.90 for total abilities plus the scores for the creativity indicators (Creativity Index (CI)). This indicates high reliability.
- **Mean, Sigma and Standard error of Measurement (SEM) for derived Composite Scores:** The mean for the total scaled score is 49.49, the sigma (standard deviation) 7.87 and the SEM is 4.63. The corresponding scores for creativity index are 69.43, 10.98 and 4.76.
- **KR21 Reliability coefficients for the separate creative ability scores:** The KR21 scores range from 0.38 for flexibility and originality to 0.84 for elaboration. All these values are between 0 and +1, indicating high reliability. The KR21 for the total abilities plus indicators raw score is .90.
- **Standard Error of Measurement (SEM) for the separate Ability Derived Scores:** The SEM-scores range from 0.78 for elaboration to 1.69 for originality with a total of 8.23 for total creativity indicators.
- **Inter-rater reliability coefficient of correlation:** The inter-rater reliability for the ATTA ranges from 0.94 to 0.99 (Goff & Torrance, 2002:34). Two raters were used over the three-year-period. One rater was used in the first year of the study and another one for both the second and third year of the study. Both were trained from the manual by the researcher herself and adhered closely to the instructions in the manual.

Validity of the ATTA: Several hundred validity studies were done on the precursor

of the ATTA, the TTCT. The authors describe the most powerful evidence of its validity as two longitudinal studies, namely one initiated in 1949 on high school students and one started in 1948 on elementary school children. These studies, with real-life criteria, offer the strongest link to test behaviour of creative achievement (Goff & Torrance, 2002:36).

Recognition for and criticism of the ATTA: The ATTA and the TTCT, from which it was developed, have been used very widely in research. Some criticize the paper-and-pencil tests as trivial and inadequate measures of creativity (*cf.* 2.5.3). Amabile (in Sternberg & Lubart, 1999: 7) suggests that a panel of judges must rather evaluate creative products. The results of research done by Lin, Lien and Jen (2004) showed that scores of divergent thinking tests predicted neither the creativity in hypothesis generation nor the success rate of solving a task involving inductive reasoning that should result in insight. Dietrich (2004:12) predicts that research may show that the Torrance test may be more useful in measuring the spreading activation through the knowledge-based network in the temporal, occipital and parietal (TOP) lobes of the cortex and less useful in measuring the processing that takes place in the dorso-lateral prefrontal cortex of the frontal lobe (the working memory)(*cf.* 2.3.5).

Cooper (1991), in her critique of six measures for assessing creativity, concludes that the Torrance tests, as well as the other four that she assessed “*only partially measure divergent and productive thinking*”. Lubart (1999:340) comments that the Torrance tests provide evidence of a “*product-oriented, originality-based definition*” of creativity corresponding to the Western definition of creativity. Although no other references could be found in the literature, doubting the reliability of the ATTA in cross- cultural studies, the abilities that are tested by the ATTA (fluency, originality, elaboration and flexibility, verbal and figural abilities) and the mode of testing (writing and drawing) may perhaps not adequately demonstrate creativity in all individuals. People, for example, those with natural creative talents in oral and musical modes and the use of colour, may not be in their comfort zone with the restrictions imposed on them.

The objections above to the Torrance tests are acknowledged and despite these objections, these tests were chosen in this current research. The reasons why they were chosen are:

- They measure attributes, like verbal and figural fluency, elaboration, flexibility and originality, that are in demand in the development of learning programmes and

experiences as demanded from teachers and also in idea generation and elaboration occasions that are plentiful during design and planning processes in Technology Education.

- They are the best-researched tests available.
- Evidence of researchers like McCracken (1997) and Wechsler (2006:24) who found a good correlation between the results of these tests and creative output in real life.
- In the ATTA, the tasks are either without domain or in a domain outside the experience and knowledge of all the students. Research by Runco, Dow and Smith (2006:274), using bi-variate and canonical correlations and regressions on information, experience and divergent thinking, concluded that *"it should be easy to avoid experiential bias in testing divergent thinking"* if the given tasks *"represent domains with which they (the participants) are unfamiliar"* as is the case with the ATTA.
- The versatility of the ATTA: Besides the overall creativity index score, the activities are scored for four abilities, giving a break-down of specific creative abilities (fluency, originality, elaboration and flexibility) that an individual may possess. These abilities are further used to identify specific creative roles, namely collaborator, contributor and accelerator (that was not even reported in this current study). Lastly, creativity levels that can be compared with the spread in a standard adult population can be deduced.
- The user-friendliness of the ATTA. It was clear that these "knowledge-free" tests, that remind of childhood play, are enjoyable. Some participants showed obvious delight at their own thoughts. Although it is scored for many different abilities that make the scoring procedure time-consuming, it takes only 9 minutes to administer. This makes it a non –intrusive and convenient instrument to use in a class situation.
- McCann (2005:127) points out that the ATTA result analysis showed that the test does not discriminate in terms of sex, socio-economic status or cultural differences. Kim (2006:10) refers to the work of Cramond and Torrance, that found the TTCT (from which the ATTA is derived) to be fair in terms of race, culture and socio-economic status. Wechsler (2006:24) compared the results of the TTCT with real-life creative achievements in Brazil. He found that the TTCT

"shows remarkable predictive validity" .."not only within the United States, but also within Brazil".

The researcher is aware of the controversy about using a test, designed in a Western country as is, to test the abilities of groups of people in a different context and specifically on people from a non-Western cultural group. What is tested by the test is creative thinking as expressed through writing and drawing modes. It is a very simple test, assesses the abilities that are needed in an academic milieu and uses the modes prevalent at schools and universities (which is the concern of this research). In this sense it may be biased against individuals of all cultures whose preferred mode of creative expression is through oral, melodic, rhythmic or social and other innovations, and improvisations and not through writing and drawing (*cf.* 2.2.2.2). No research showing cultural bias or bias of the mode of testing could be found so far. It is further also true that in the school milieu, in which teachers will perform, creative ideas are usually recorded through the modes of writing and drawing, for example in the preparation of lessons, lesson units, programmes and assessments. If one lacks the ability to express one's ideas through these modes, it may pose a problem in this milieu.

4.6.2 Self-constructed questionnaires

Two questionnaires were used for obtaining quantitative data about the background of the students and to determine perceptions that the student may have about the different spheres to which he/she was exposed during his/her lifetime. Table 6.6 provides information on the content of the questionnaires.

Questionnaires may be used to gather data about aspects such as gender, age and first language, directly and with little error. Gefen and Straub (2005:91-92) explain how a questionnaire may also be used to measure subjective abstractions such as perceptions. Because they "cannot easily be measured through direct means, agreed-upon practice dictates that they be measured indirectly through several items in a research instrument."

The aims and structures of these three questionnaires are discussed below.

4.6.2.1 Questionnaire One

This questionnaire was used on group one and two in the first year of the study. The biographical data were used to compile the data matrix that was used in the SEM analysis where the total group of 207 participants are indicated. The value part of the questionnaire was used as an exploration and helped to compile the perception questionnaire two that was administered in the second and third year of the study. Questionnaire one aimed at determining the following:

1. **Biographical data:** The upstream exogenous variables included the age, home language (from which the ethnic group was taken), number of children in the family, position of participant in family, trauma (such as divorce or death) in family, parental education, socio-economic index and role model. The inclusion of parental education and language group was motivated by the diverse cultural and educational spectrum that is currently available for research at the universities in South Africa and the work of researchers like Vygotsky, Feuerstein, Kozulin and Presseisen (*cf.* 3.3.3.2) on mediation and cross-cultural aspects. The inclusion of the role model in the questionnaire was inspired by the role of modelling in the development of creativity as described by Bronfenbrenner (1979:6), Bandura (1986:48-40), Amabile (1996:179-202) and Simonton (1988:413)(*cf.* 3.3.3).
2. **Values:** The value system was investigated by giving choices about how they perceive an ideal person: traditional, competitive, team-worker and so forth. The list of characteristics was compiled, using Sternberg's intellectual styles as described in his three-facet model of creativity (1988:137-146).

4.6.2.2 Questionnaire Two

This questionnaire is a follow-up that was developed as an improvement on questionnaire one. This questionnaire was administered to groups three, four, five and six.

Aims

1. **Biographical data:** It gathered the same data as questionnaire one.
2. **Socio-economic deprivation:** The students also completed a socio-economic deprivation checklist (Human Sciences Research Council, 1991). The checklist included questions about parents' occupation, possession of household items, rooms in the house and so forth. This checklist scored out of 10 with zero

equalling no deprivation and 10 the highest level of deprivation measured with this instrument. The scores were inverted during the preparation of data so that a score of ten became the least deprived and the zero score the most deprived. This was done to ensure that all the observed variables informing the socio-economic status of the family would have the same direction. The education of the father and the mother, for example, are measured from low to high and the assumption was made that low educational levels and low socio-economic index co-vary.

3. **Values and attitudes and perception of contexts:** A questionnaire consisting of 79 questions aimed at determining how students perceive their family, school and university environments and how these environments compare, in the students' minds, regarding fostering creativity. This questionnaire was based on Bronfenbrenner's (1979:4-6) ecological model where perceptions of proximal interactions, namely micro-, meso-, exo- and macro-systems are identified as factors influencing behaviour. It was further influenced by descriptions by Gauvain (2001) and Sternberg (1988) of conditions, values and perceptions that could influence creativity. It was only used during the second and third year of the study, since the first questionnaire, used in the first year, was an exploratory attempt and did not measure the same constructs. The perception questionnaire was used as a pre-programme instrument only.

Structure

The questionnaire consisted of questions referring to family, culture, school, university, problem-solving, attitude towards Technology and ideal education. The questions were arranged in a random fashion. The questions attempted to determine one thing, namely whether students experience the respective atmospheres and beliefs as conducive or inhibiting to creativity in the light of what was learnt from the literature study (*cf.* 2.4.3).

An **Ordinal Scale**, a four point **Likert scale**, using a forced choice method, was used. The choices were:

- 4-Strongly agree
- 3-Agree
- 2-Disagree

- 1-Strongly disagree

Reliability

Questionnaire two was piloted with a group of 34 students. The results are given in table 4.6.

Table 4.6: Statistical data of the trial run of the perception questionnaire

Valid Number:	Mean	Standard Deviation	Cronbach's Alpha	Standardized Alpha	Average inter-item correlation
34	220.843	14.6166	0.848946	0.861376	0.076494

The Cronbach-Alpha is a coefficient of reliability, indicating how well a set of items (or variables) measures a single uni-dimensional latent construct (in this case contextual stimulation of creativity). Since a Cronbach-Alpha of between 0.7 and 1.0 is considered as a good measure of internal reliability of a questionnaire, this questionnaire (Cronbach-Alpha 0.84) was used in this form as it complied with reliability criteria. Construct reliability was determined using Visual-PLS and is discussed in section 4.8.6). Four measures were used, namely Cronbach-Alpha, Average Variance Explained (AVE), Composite Reliability and Factorial Loadings.

Since the questions were asked in such a way that some tried to probe for creativity inhibiting factors while others probed for creativity stimulating factors, some of the responses to the items were inverted during data preparation so that all data pointed in the same direction. The responses to a questionnaire item which, according to literature could inhibit creativity, was inverted so that the responses to all items pointed eventually in the direction of what is assumed to stimulate creativity. (Example: "*In my culture children are discouraged from fantasizing*". A response of 4 (strongly agree) was changed to 1 (strongly disagree) and 3 (agree) to 2 (disagree). It was therefore assumed that the latter would have been the response if the question had been asked: "*In my culture children are encouraged to fantasize*").

Validity

Validity, the extent to which a measuring instrument is measuring what it is supposed to measure, depends among others on face, content, criterion and construct validity (Leedy & Ormrod, 2004:92):

Face validity: It is easy to see that this questionnaire wanted to determine particular characteristics of creativity, namely whether openness and independence or rigid, custom-bound responses were encouraged in the different milieus.

Content validity: The questionnaire attempted to address different life systems encountered by a typical student up to his/her first year at university. This measuring instrument measures the domain of creativity in appropriate proportions.

Criterion validity: The responses of the students in the pilot study corresponded well with what one could expect from the milieu from which they came, as given by the biographical questionnaire.

Construct validity: The constructs measured with this questionnaire were perceptions of cultural beliefs, perceptions of atmosphere in different systems and attitudes. The researcher, her supervisor and two other experts in the field of education scrutinized the questions to ascertain their validity for measuring the characteristics in question. The conclusion was that the questionnaire measured the desired characteristics conducive to or inhibiting creativity. The Cronbach-Alpha, however, showed that some of these constructs did not show good convergent validity because of values lower than the recommended 0.7 (Oosthuizen, 2007). Some items were therefore removed from the questionnaire to increase its convergent construct validity. Discriminant validity was determined, using an Average Variance Explained (AVE) as is available in Visual-PLS (*cf.* 4.8.6).

4.7 THE POPULATION AND SAMPLE

4.7.1 The population

All students enrolled at the Vaal Triangle campus of the North-West University for a B.Ed degree over a three-year period were part of the population (N=207). They are all aspiring to teach in the Intermediate, Senior and Further Education and Training school phases, and Technology Education is a compulsory eight credit module for them in their first year. The second part of the Technology Education curriculum is followed in their third year of study.

4.7.2 The sample and handling of missing data

By means of convenience sampling (Leedy & Ormrod, 2004: 206) all first year B.Ed students formed part of the sample. All these students were readily available for the

research as the researcher taught them all. The sampling design chosen for this study was non-probability sampling (Leedy & Ormrod, 2004:206) as some members of the population had little or no chance of being sampled. The only first year senior and intermediate phase BEd-students who were excluded from the study were those with incomplete data regarding the creativity tests. Some students started late with the courses, some discontinued and others were absent on one or both of the test days and were excluded from the study. List-wise deletion was therefore used to clean up the data because all data were removed in cases where the data about the ATTA-tests were incomplete. Imputation of means was used in the few cases where students left out single items or data.

For the quasi-experimental study on creativity, the data of all participants (groups 1 to 6) were used (N=207). For the effects of perceptions as determined by questionnaire two, the data of groups three to six were used (N=162). Groups one and two did not complete questionnaire two. In model 4 (*cf.* figures 4.7, 6.10), investigating the effect of different contextual factors (including role models) on creativity index and creative abilities, the 81 participants who chose their father, teacher, celebrities or public leaders as role models were used.

4.8 DATA ANALYSIS AND INTERPRETATION

In order to address the research questions adequately, this study used a number of data analysis methods. The quantitative data were analysed by the statistical services of the North-West University, using t-tests, f-tests and Cohen's d-value, as well as by the researcher, using the PLS path-modelling SEM programme Visual-PLS 1.4 (Fu, 2006). Descriptive and inferential statistics were used. Component-based structural equation modelling (SEM), specifically Visual-PLS-1.4 software (Fu, 2006), was used, since it makes it possible to compare a number of regression coefficients, means and variances simultaneously. It allows the examination of complex relationships and models, as was foreseen in this current study.

The first part of this study attempted to reflect on possible contextual, personal and perceptual reasons for differences in creativity indexes between different individual students. It is therefore an *ex post facto* study reflecting back on possible causes for the current state of affairs, as a result of what happened during the previous and present life phases of the participant and the perceptions that were formed as a result of these occurrences.

The assumption is made that creativity results from the interaction of a large variety of variables, some personal (*cf.* section 2.2), some conceptual (perceptions impacting on procedures) (*cf.* section 2.3) and others contextual (*cf.* section 2.4). Within the contextual category, for example, different values and cultures act as strange attractors, every one with a different pull and push on the individual's thinking and motivation. Besides that, the perceptions of an individual about factors such as his/her culture and circumstances and him/herself and others are also involved (*cf.* 2.4.2.2, 2.4.3, 3.3.1.3, 3.3.3.1). To describe the topography of the basins surrounding these strange attractors is therefore a complex matter. It was considered appropriate to make use of a statistical procedure that attempts to reflect the holistic, multi-faceted and integrated nature of the forces acting on the individual. It is conceivable that some of the independent variables and creativity may be non-linearly related. For the purpose of this study, it was assumed that the relationship between creative behaviour and certain personal and contextual factors could be linear.

Non-linear relationships between creativity and some personal factors are reported in literature. Examples of reported and or suggested non-linear relationships include:

- a curvilinear or inverted U-shaped relationship between educational level and creativity, suggested by Simonton (in Weisberg, 1999:229);
- the relationship between intelligence and creativity (*cf.* 2.2.2.1); and
- "*peaks and slumps as a function of age*" in children (Sak & Maker, 2006).

It is argued that these aspects do not apply in this current study. All the participants had the same level of education, namely Grade 12, so that the level of education was not used as a variable. Intelligence *per se* was also not used as a variable. Academic performance, however, was. In the analysis of the relationship between academic achievement and creativity, the general trend will be given and the specific data will be analysed further to establish possible non-linear trends. Age was used as a variable. All the participants were eighteen years and above, well above the "*early grades*" affecting creativity, according to Sak and Maker (2006). The statistical methods chosen were therefore all based on the use of linear regression.

4.8.1 Descriptive Statistics

In descriptive statistics, numbers are used to describe information or data or the

techniques used to calculate these numbers. In this study, the maximum, minimum, range (the difference between the highest and the lowest score in a set of scores), median (the number occurring most often in a group of numbers), population means (μ = simple average formed by dividing the sum of the numbers by the number of numbers in the group), sample means ($\bar{x}$), median (the mid-point in a set of ranked numbers), standard deviation (σ = a measure of the deviation of individual numbers from the mean of the group of numbers) and mode (the number which occurs most often in a group of numbers) of data sets were used, as appropriate, to describe the point of central tendency of the data regarding pre-and post-programme results for the ATTA for the different groups and the whole group.

- Frequencies were used to describe the creativity indexes, levels and creative abilities obtained from the ATTA.
- Cronbach-Alpha coefficients were used to determine how well the items (or variables) of the perception questionnaire measured the constructs. (Adapted from SAS Class Notes, with permission from UCLA Academic Technology Services).
- Cohen's d , (the difference between the means, $M_1 - M_2$, divided by the standard deviation (s)) was used to compare the statistical significance of any effects of the Technology Education programmes. D-values of 0.6 and larger (indicating an overlap of 38.2% and larger between the two groups) are seen as large and indicate a large effect in practice, values of 0.4-0.6 (indicating an overlap of 33.0%) are moderate and indicate a moderate effect in practice. Values smaller than 0.4 are small to insignificant (indicating an insignificant effect in practice).

4.8.2 Inferential Statistics

Inferential statistics are procedures used to estimate population-characteristics from sample-characteristics. P-values, T-tests, F-tests, correlations (a quantifiable relationship between two variables) and regressions (prediction of levels of a variable when another is held constant) are examples of inferential statistics. Simple linear regression is able to predict the value of a variable from the value of one other variable. With multiple-regression one may predict the value of a variable from the values of more than one variable.

Since the study used a **quasi-experimental** design with non-randomized groups, special care was taken with the data analysis. Trochim's (2006a) advice for analysing

data from non-equivalent groups was taken and the pre-test creativity index and level scores were adjusted accordingly (cf. 4.5.2.2).

The p- and t- values of the pre-and post-test ATTA results were calculated: Correlation or co-variation is the degree to which two variables vary together. A significant correlation is indicated by a probability (*p*)-value *smaller than 0.05*, that indicates a confidence interval of 95%. P-values indicate the probability of getting something more extreme than your result, without an effect in the population. It means that if the correlation is bigger, the probability of getting something more extreme is smaller and the result more significant. A small p-value therefore allows one to reject the idea that the correlation is a coincidence (the null-hypothesis).

The t-test is a statistic for evaluating whether the difference between two means is statistically significant. T-tests are therefore used to compare the average performance between two groups. T-values are calculated using a formula. Taking the degrees of freedom, $((N_1 + N_2) - 2)$ into consideration, this value's significance is then looked up on a t-table of significance. For both the 207 participants in groups 1 to 6 and the 162 students in groups 3 to 6, the number where the t-test can be seen as significant with a p-value of 0.05 is between **1.65** and **1.69** (see table 4.7). If the p-value of 0.1 is acceptable (as in one-tailed t-test), a t-value of between **1.28** and **1.31** would show significance, The t-tests were used in this study to determine whether the difference between the means of the creativity tests for the groups exposed to the different programmes and for the pre-and post-creativity tests, taking the differences in group variation and group size of the groups into account, were statistically significant (Leeper, 2006).

Table 4.7: Student t-statistic table

df/p	0.40	0.25	0.10	0.05	0.025	0.01	0.005	0.0005
30	0.255605	0.682756	1.310415	1.697261	2.04227	2.45726	2.75000	3.6460
inf	0.253347	0.674490	1.281552	1.644854	1.95996	2.32635	2.57583	3.2905

One-sample t-test compares a single sample with a population value, such as when one compares the average level of creativity within a group of students with a value that was known to represent the average for a population as from the test manual.

Independent-samples t-test is usually used to compare two independent groups'

scores on the same variable, for example the creative indexes of a group that was exposed to the basic programme with that of the group that was exposed to the enriched programme. The participants should be from non-overlapping groups, randomly drawn from normally distributed and independent populations, if one wants to compare two groups using the *t*-test. The “randomly drawn” requirement was not met in this study. Trochim (2006b) explains that non-equivalent groups and pre-test measurement error “leads to the attenuation or ‘flattening’ of the slopes in the regression lines”, giving a biased pseudo-effect. He recommends that since the bias is caused by a pre-test error, the error should be removed by squeezing the pretest distribution in using the formula given in figure 4.2.

Figure 4.2: Formula used to adapt the pre-test creativity index to make provision for the non-randomized samples

	X_{adj}	$\bar{X}$	X	r
	Adjusted score	Mean of pre-test	Original score	reliability

$$X_{adj} = \bar{X} + r(X - \bar{X})$$

Cronbach's-Alpha is recommended to calculate the reliability coefficient (*r*). In the ATTA-manual, the Kuder Richardson 21 for reliability is given and it was therefore used in this study to adjust the pretest creativity index scores.

Paired-samples *t*-test is used to compare observations from two measurement occasions for the same group or the means of two variables, for example, average creativity indexes before and after the programme.

An F-test is used to answer the questions:

- Are the standard deviations of the populations from which the two samples come equal?
- Does the applied programme reduce the variability?

An F-test compares the standard deviations. A two-tailed test or a one-tailed **F-test** is used to test if the standard deviations of two populations are equal. An F-test, testing only in one direction, is known as a one-tailed version test (the standard deviation

from the first population is either greater than or less than (but not both) than the standard deviation of the second population). The two-tailed F-test tests against the alternative that the standard deviations are not equal (Anon, 2006).

If the standard deviations are equal for the two populations, the null hypothesis is true. If the standard deviation of population one is unequal to that of population two in a two-tailed F-test, the null hypothesis may be rejected. If the standard deviation of the population one is larger (in upper one-tailed test) or smaller (for lower one-tailed test) than that of population two, the null hypothesis may be rejected. The F-test statistic cumulative distribution function (cdf) value is expressing the critical value. The null hypothesis is rejected when the test statistic *is greater than the tabled critical value in a one-sided test* (Anon, 2006).

Cronbach-Alpha (to determine the probability that, according to the null hypothesis this is a false-positive error: affirming a non-null pattern by chance) was used to determine whether the effect of the programme was significant. It was also used to determine construct validity of the questionnaire items.

Data for both the descriptive and inferential statistical analysis are presented by means of tables, graphs and path analysis models.

4.8.3 Structural Equation Model (SEM)

Structural Equation Modelling (SEM) is a relatively new and dynamic field that has been around for less than fifty years. The variety of different techniques evolved over the past years to address the growing demand for multivariate statistical techniques. Garson (2006c) describes this holistic approach as a *"powerful way which takes into account the modelling of interactions, nonlinearities, correlated independents, measurement error, correlated error terms, multiple latent independents each measured by multiple indicators, and one or more latent dependents also each with multiple indicators"*.

It is a technique used to *"examine direct and indirect relationships between one or more independent variables and one or more dependent variables"* (Statistics Solutions, 1996-2006:1).

Although SEM represents a family of useful statistical techniques, it still only gives an approximation of the forces involved and the relationships between them. Statsoft (1984-2003) explains the reasons why it is *"unreasonable to expect a structural*

model to fit perfectly”:

- It is unlikely that most of the true relationships between the variables are linear. Many of them may be non-linear. The linear model is therefore only an approximation.
- Some “*statistical assumptions are somewhat questionable*”.
- The purpose of the model is to give a reasonable explanation of the trends of the data to provide a *useful approximation to reality*, rather than to get a perfect model.

Different models may fit the data equally well. A model that fits the data does not mean that the model is true.

The information used in the description of SEM comes from a variety of sources such as: Statsoft (1984 to 2003); Statistics Solutions (1996-2006); Garson (1998-2006); Chin, (2000); Gefen, Straub and Bourdreau (2000); Howie (2002) ; Gefen and Straub (2005) and Garson (2006a-d).

4.8.3.1 Properties of SEM

Chin (2000:6) describes SEM as second-generation statistics, whereas ANOVA, ANCOVA, multiple regression and principal component analysis are seen as first generation statistics. SEM may be used to analyse complex systems quantitatively in such a way that the relationships between independent and dependent variables that cannot easily be measured directly may be determined.

A path diagram (a model similar to a flow-diagram) is used to show which variables affect other variables. The variables may be related by causal (indicated with uni-directional arrows pointing from the cause to the effect) or covariance and correlations relationships (indicated with bi- directional arrows) (Garson, 2006c).

The simple linear equation below is used to explain path diagrams:

$$Y = aX + e$$

All variables in the equation system ($Y = X + e$) are placed in either boxes or ovals in the path diagram. Boxes are used to represent indicators (observed, directly measurable or manifest variables). Ovals or circles are used to indicate latent or

(unobserved) variables (see figure 4.3). They are not measured directly, but are inferred by the relationships or correlations among measured variables such as shared variance in the analysis. Between all independent variables ($X + e$), arrows are pointing to the dependent variables (Y). Regressions are done for each variable in the model. The weighting coefficients (α) are placed above the arrows (Statsoft, 1984-2003). Residuals or error variances (e) are always unobserved.

A measurement model (outer model) specifies the relationships between manifest variables and latent variables. **A structural model (inner model)** defines hypothesized relationships between all the latent variables (see figure 4.3). In model 3 (figure 4.5), family size (*FamSize*), trauma in family (*FamTrau*) and family status (*FamStat*) are measurable and are therefore manifest variables. These measurable factors, in turn, infer the construct, namely “Family factors” (*FamFact*) that is seen as an exogenous latent variable indicated by the symbol ξ . Together “Family factors” and its manifest variables represent part of the outer model. “Family factors” is hypothesized to influence creativity directly, but also indirectly through perception of family as stimulator of creativity (*PerFam*). These inner relationships represent the structural model. Endogenous or downstream latent variables (indicated by the symbol η (Eta)) are dependent or mediating variables caused by exogenous or other endogenous variables (such as *PerFam*). (The abbreviated names are necessitated by the restriction of the modelling programme on the number of letters, namely eight, that may be used to name constructs).

The symbol γ (Gamma) identifies the paths between exogenous and endogenous variables and the symbol β (Beta) indicates the paths among endogenous variables (Gefen, Straub & Bourdreau, 2000:21).

Reflective or outward mode variables are manifest variables that are regressed on latent variables (indicated by arrows pointing from the latent variable to the manifest variable). They are latent variables that are indirectly observable by a set of manifest variables (x_{jh}) (Chatelin, Vinzi & Tenenhaus, 2002:5). The relationship between manifest variables (χ) and latent variables (ξ) is described by the regression formula:

$$\chi_{jh} = \pi_{jh0} + \pi_{jh}\xi_j + \varepsilon_{jh}$$

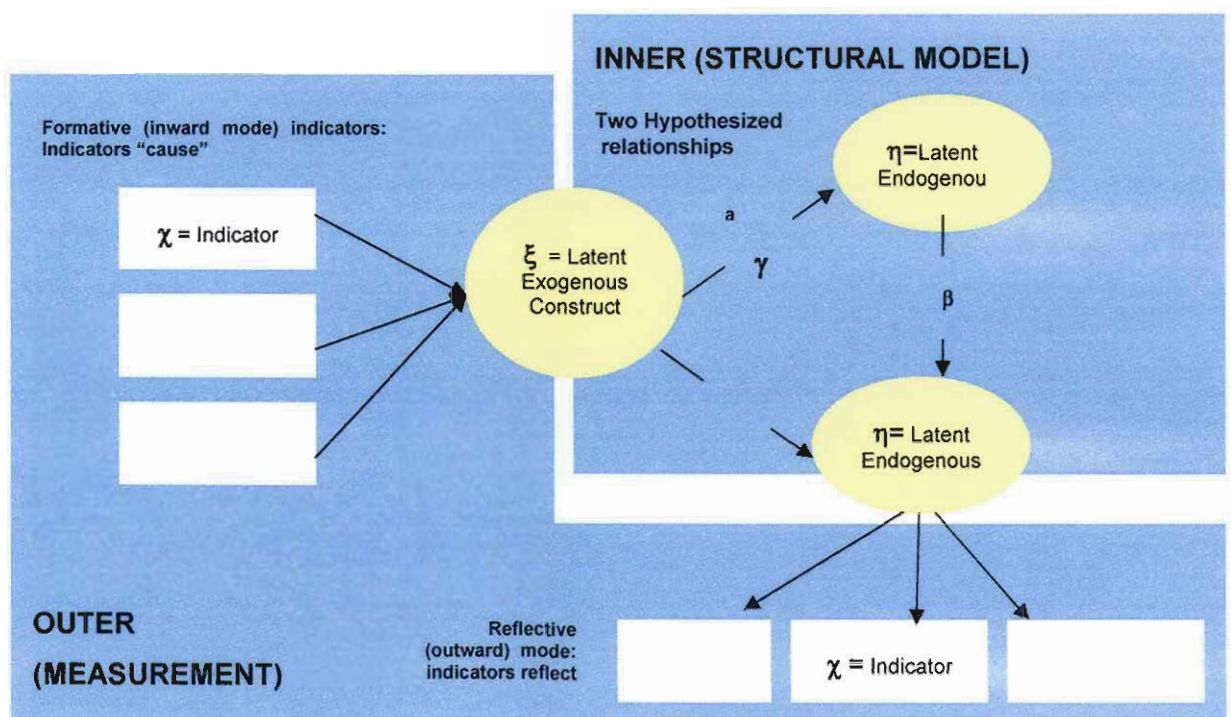
Chin (2000:36) explains that reflective measures should covary. In the current study,

the questionnaire items may be modelled as reflective. Since perceptions cannot be measured directly, they are measured indirectly through the items of the questionnaire.

Formative, inward mode variables are latent variables regressed on manifest variables (indicated by arrows pointing from the manifest variables to the emergent latent variables). They “cause” the latent variable. Chatelin *et al.* (2002:5) describe formative latent variables (ξ) as “generated by manifest variables” (χ) using the formula

$$\xi_j = \sum_h \omega_{jh} \chi_{jh} + \delta_j$$

Figure 4.3: The measurement (outer) and structural models (inner) in a SEM model



According to Chin (2000:36), formative measures need not covary. In the current study, the items of the biographical data may be seen as formative. Family factors (*FamFact*) are, for example, generated by the different observed items such as parental education (*Trauma*, *Family status* and *Number of children*). In this case the measures may covary.

Unities or unique factors relate to only one, a “single” manifest variable (such as

gender relating to sex), while common factors relate to more than one variable (such as errors in measurement)(Garson, 1998 –2006:2-3).

4.8.3.2 Types of SEM

Chin (1998:vii) and Hsu, Chen and Hsieh (2006:346-348) distinguish two main types of SEM, namely *component-based techniques* and *covariance-based techniques*.

4.8.3.2.1 Component-based SEM

One type of SEM is component-based SEM, PLS path-modelling is an example of component-based SEM and is considered as **soft modelling**. PLS path-modelling is based on the nonlinear iterative **partial least squares** (NIPALS) algorithm, developed by Wold (1985,1987) and Lohmöller (in Statsoft, 1984-2003), assuming "*that the x and y variables have been transformed to have means of zero*" and for the SIMPLS algorithm developed by De Jong (in Statsoft, 1984-2003). Lohmöller (in Kroonenberg, 1990) explains that the cornerstones of PLS path-modelling are "*conditional (linear) expectation and predictor specification*".

Different PLS path-modelling software packages are available (Temme, Kreis and Hildebrandt, 2006: 1-27). Early DOS supported packages include LVPLS (Lohmöller) and PLSpath (Sellin). More recent and user-friendly Windows-supported packages with graphic interfaces include PLSGraph (Chin), PLSGUI (Li), SmartPLS (Ringle & Hansmann), Visual-PLS (Fu) and SPADPLS (Test&Go) (in Temme *et al.*, 2006). Based on the Temme *et al.*'s analysis of different software packages, SPADPLS seems to be the most advanced package (in December 2006) addressing collinearity, using PLS-regression in both the formative (outer) and reflective (inner) models. In this analysis, it was, however, shown that the other recent programmes, all using OLS regression, get similar results. Wold (1985:204-205) developed the Fixed Point (FP) algorithm to remove bias from OLS regressions for unobserved variables.

These software programmes can handle many independent variables, even when they display multi-co-linearity. They indicate causal relationships between latent variables and reflect the relative strength of the unobserved (latent) constructs as defined by the observed (manifest) variables (Valente, 1999:4). PLS is, however, low in power to filter out variables of minor causal importance (Tobias, 1997: 1).

A second type of component-based SEM is the so-called Artificial Neural Network

(ANN)-based SEM programmes. They are suitable for modelling non-linear relations since they use different activity functions, connections (called weights) and layers of hidden nodes (or Processing Units (PE's)). A subset of nodes act as input nodes and another subset act as output nodes (Hsu *et al.*, 2006:349).

It is important to repeat that although the assumption of linearity is made by PLS path-modelling and is used in this study as such, the models proposed in this study give an **approximation** and do NOT pretend to give a perfect model of the reality.

4.8.3.2.2 Covariance-based SEM (SEM-ML)

Covariance-based SEM or SEM-ML techniques include EQS (Bentler), AMOS (Analysis of Moment Structures) (Arbuckle), MPlus (Muthen & Muthen) and LISREL (Linear Structural RELations) (Jöreskog & Sörbom in Garson, 2006c).

Covariance-based models are primarily for theory testing in situations where prior theory is strong. They follow a strictly confirmatory approach, an alternative models approach or mostly a model development approach. In Confirmatory Factor Analysis (CFA) meaningful constraints are placed on the factor model, such as setting the effect of one latent variable to equal zero on a subset of the observed variables. In exploratory factor analysis (EFA), no substantive constraints are imposed on the data and it is assumed that each common factor affects every observed variable. Common factors are either all correlated or uncorrelated (Albright, 2006). In AMOS, for example, one may first work on a measurement model and thereafter confirm this in a structural model by adding (model building) or taking away (model trimming) certain causal relations or covariances.

4.8.3.2.3 Component-based versus covariance-based SEM methods

Component-based SEM methods such as PLS path-modelling use Partial Least Squares Analysis while covariance-based SEM methods (SEM-ML) uses the Maximum Likelihood Estimation method. SEM-ML is parameter-oriented and aims for high accuracy in the estimation of parameters, while PLS path-modelling is prediction-oriented, aiming at high accuracy in prediction of paths (which is what is desired in this study). With SEM-ML, the number of inner variables is limited, whereas PLS is more suitable for larger complex models (Howie, 2002:90). AMOS, uses Analysis of Moment Structures (analysis of mean and covariance structures) that gives a researcher advantages like providing a unifying framework for work with numerous linear models.

Although all SEM techniques can identify negative path coefficients, covariance-based models are more accurate in this regard. The component-based SEM techniques have smaller deviations than the covariance models and are more consistent when the number of manifest variables (MV's) increases. Covariance-based SEM techniques cannot report latent variable (LV) scores. The difference in LV scores between PLS and ANN is small for exogenous, but larger for endogenous variables. The covariance-based models are found to be more accurate to estimate path coefficients than the component-based models. They do, however, sometimes give an improper result. The ANN and PLS techniques do not suffer from this problem (Hsu *et al.*, 2006:368-369).

In conclusion, some researchers, like Petrina (2001, Chapter 1:9), combine component-based and covariance-based SEM techniques to make use of the respective strengths.

4.8.3.3 Choosing suitable SEM technique (s)

Gefen, Straub and Bourdreau (2000), Howie (2002), Zeegers (2004), Hsu *et al.* (2006) agree that SEM-ML and PLS path-modelling should be seen as complimentary techniques and that each fits a certain scenario better.

The current study explores relationships between contextual factors and creativity. Although many contextual and personal factors are pointed out in literature, the researcher could not find studies that attempt to describe the whole complex web of causal factors affecting creativity in a holistic way. Component-based SEM, namely PLS path-modelling, seemed to be the most appropriate statistical method in the modelling of these factors. A number of the situations that are present in this current study affecting the choice are listed below:

- PLS path-modelling allows for the exploratory nature of the study and the lack of strong theory. It was therefore assumed that PLS path-modelling would be appropriate to identify patterns, and in doing so, find variables that had significant paths to the students' creativity indexes. Component-based techniques are used for predictive analysis in situations of high complexity and low theoretical information. It means that PLS-path-modelling is suited for situations where theory is weak or non-existent and needs to be explored. PLS-path-modelling is therefore better "*in the investigation of causal –predictive analysis rather than confirmatory analysis*" (Zeegers, 2004). He further explains that it is a rapid,

technically simple programme that allows for trimming of the model through the deletion of paths that do not contribute to the hypothetical model.

- The aim of PLS path-modelling is to show high R^2 -values and significant t-values and, in doing so, reject the null hypothesis, the same as in regression. SEM-ML tries to show the null hypothesis to be insignificant (Gefen, *et al.*, 2000: 24). PLS path-modelling uses an iterative sequence of Ordinary Least Squares (OLS) and analyses one construct at a time. SEM-ML uses techniques like maximum likelihood estimation, weighted, unweighted and generalized least squares (Gefen, *et al.*, 2000:28).
- Component-based techniques like PLS are better for large models with many variables, as in the current study (Lohmöller in Fornell & Bookstein, 1982:450).
- PLS path-modelling is less sensitive to sample size than SEM-ML. The latter requires at least 100 to 200 cases while the former requires 10 times the number of items in the most complex construct (Gefen *et al.*, 2000: 9). Although the sample size *per sé* was not a problem (maximum of 207 participants with usable biographical data and 162 participants' questionnaire responses) in this study, it could be considered as borderline for SEM-ML.
- PLS-path-modelling gives better results than SEM-ML if the data is non-parametric. Gefen *et al.* (2000: 9) describe PLS-path-modelling as relatively robust to deviations from a multivariate distribution.
- Both reflective and formative variables may be used in PLS-path-modelling whereas SEM-ML uses only reflective variables (Gefen *et al.*, 2000:10).
- PLS-path-modelling avoids specification issues that would need to be addressed in covariance-based SEM. Howie (2002) explains: "*Least Squares estimation in PLS is free of assumptions about the distribution of the variables except for the prediction specification and is devoid of assumptions regarding the independence of observations.*"
- PLS path-modelling is easier to use than programmes such as LISREL, and is based on a set of algorithms that are reasonably robust and relatively inexpensive (McNaughton, 1990:387; Byrne, 1998:44-86).

4.8.3.4 Finding path-modelling software

Having decided on the component-based SEM, finding suitable PLS path-modelling software was another issue. An article by Temme *et al.* (2006) was useful in this regard. It was decided to opt for a Windows-supported software package giving user-friendliness, both text and graphical path diagram output, handling of missing data by both imputation of means or pair-wise deletion, using a variety of resampling methods (blindfolding, jackknifing and bootstrapping) and cross-validation through both CV-redundancy and CV-communality. Visual-PLS 1.04, PLS-Graph 3.00, SMARTPLS and SPAD-PLS all meet these requirements. The first three were available as freeware, making them attractive options from an economic viewpoint. PLS-graph has already been applied in a number of studies, providing one with a frame of reference about its applications. Chin, the developer of PLS-graph, could unfortunately not be reached and the researcher was unable to activate SMARTPLS, that uses a Java platform, due to technical problems.

Visual-PLS was freely available under the GNU-general public licence and presented no technical problems. It is Green Software that does not need to be installed and does not copy garbage files to your computer. Visual-PLS1.04b, developed by Fu from the National Kaohsiung University of Applied Science in Taiwan, uses the original LVPLS 1.8-programme of Lohmöller, but Fu provided it with a Graphic User Interface (GUI) that is supported by a Windows operating system. The forum of Visual-PLS provides questions and answers and useful tips on problems encountered by other researchers when they used the programme. The only real challenges in the beginning were to figure out how the data must be prepared (from Excel it must be converted to tab-delimited text and saved as a text or data file). Another problem was to get past the "*is not a valid floating point value*" that appeared as soon as the command to "run" the model was given. The latter problem was solved by using the settings from a non-South African country like the Netherlands that uses a period (.) rather than a comma (,) in the decimal numbers. The text qualifier (") under "data" was removed and replaced with (**none**). Data need to be complete and must not contain punctuation marks, question marks or asterisks. The few cases of missing data were rectified by imputation of means.

4.8.3.5 Information generated by Visual PLS and its interpretation

Visual-PLS 1.04b automatically generates Cronbach-Alpha, composite reliability, average variance extracted (AVE) and factor structure matrix of loadings and cross-

loadings to help the researcher to check the convergent and discriminant validity of constructs.

To determine the significance of the data and confidence intervals, Bootstrap and Jackknife procedures may be performed once the model has been specified and the computation of path coefficients and R-square values has been done. Bootstrapping is a re-sampling technique with replacement of the sample. P-values should be calculated as permutation tests as if the null hypothesis is true (Moore & McCabe, 2003:48).

To interpret the results of a Visual-PLS-1.04b analysis, Falk and Tonkin's (2001:1-4) explanation of Lohmöller's LVPLS, forming the basis Visual-PLS-1.04b, is relevant to this study. They explain that three important pieces of information need to be considered:

- 1 The correlation matrix
- 2 The path coefficients (indicating size and direction of directly comparable relationships between predictor and predicted constructs)
- 3 The R-square values (the product of correlation coefficient and path coefficient giving the total amount of variance in the predicted construct).

Falk and Tonkin (2001:1-4) recommend that, generally, principal paths component loadings of 0.55 or above are desirable. Guidelines given by Cohen (in Howie, 2002: 99) are the following: Path coefficients of 0.10 and 0.25 are considered weak, those between 0.25 and 0.40 are considered medium strength and any above 0.40 are considered strong. Sellin and Keeses (in Howie, 2002: 98) consider a loading of 0.30 or greater as significant. Howie (2002:99), however, retained paths with values as low as 0.07, due to the large size of her sample (8000). Falk and Tonkin (2001:1-4) propose that constructs with R-square values of less than 0.015 (1.5% of variance explained by predictor constructs) should be removed. Under some circumstances, these variables could remain in the model, as when they are a focus of the research or when they are interesting or useful in comparison.

Bootstrapping is used to indicate significance and confidence intervals. It creates an entire sample estimate, means of sub-samples, standard error and a t-statistic for both the outer measurement model (both loadings and weights) and the inner structural models.

4.8.3.6 Assumptions of PLS path-modelling

Garson (2006b) and Statistics Solutions (1996-2006:25) give the following assumptions of PLS path-modelling.

1. **Linear relationships:** Linear relationships between indicator and latent variables and between latent variables are assumed by all SEM. Exponential, logarithmic or other non-linear transformations may, however, be added to the original model.
2. **Additivity:** No interaction effects exist, although interaction cross-product terms may exist.
3. **Interval level data** are used for all variables. The use of continuous scales like the Likert scale is allowed and in cases such as with gender, ordinal variables can be changed to interval variables by, for example, changing them to "male =1" and "female=2". Dummy variables may be used for categorical variables and are represented by blocks. Arrows must be drawn to all dummies if it is drawn to one in a set. Arrows may not be drawn between dummy variables in the same set as it would violate the recursivity assumption.
4. **Unmeasured (Residual) variables are only correlated** with the variables in the model that they cause and not with any other variables.
5. **Disturbance terms are uncorrelated with endogenous variables.** A critical assumption in path analysis is that, for any endogenous variable, its disturbance term is uncorrelated with any other endogenous variable in the model. Violation of this assumption is caused by:
 - measurement error in measuring an endogenous variable;
 - reverse causation when an endogenous variable causes a variable given as the cause; and
 - spurious causation when an absent variable is a cause of an endogenous variable.
6. **Low multi-collinearity** (high multi-collinearity will give large standard errors of the b coefficients that are used to remove the common variance in the

partial correlation analysis).

7. **Not theoretically under-identified or just identified.** Over-identification models give the best results because of the positive number of degrees of freedom that provides the researcher with a test of hypotheses. It allows the model to be falsified with the chi-square test. When the model fits well, it is considered as an adequate fit for the data (Garson, 1998-2006: 23). **Over-identified models** have more than one possible solution (but one best or optimal solution) for each parameter estimate. The number of knowns (observed variable variances and co-variances) is greater than the number of unknowns (parameters to be estimated) (Statistics Solutions, 1996:23). **Just-identified models** have only one possible solution for each parameter estimate. Goodness of fit cannot be computed without using up all the degrees of freedom: χ^2 will be incomputable, chi square will be 0 and degrees of freedom 0. (Garson, 1998-2006: 22). **Under-identified models** have an infinite number of possible parameter estimate values. There are more parameters to be estimated than there are elements in the covariance matrix. No unique solution could be reached (Statistics Solutions, 1996-2006: 22). In under-identified models there are too few structural equations to solve for the unknowns (Garson, 2006b).
8. **Recursivity:** All arrows must flow one-way, and no feedback looping occurs. Residual error for the endogenous variables must be uncorrelated.
9. **Proper specification** of the model is necessary for interpretation of path coefficients. When a significant causal variable is left out of the model, *specification error* (the so-called Heywood case) occurs and shared covariance is reflected, which makes it difficult to interpret accurately in terms of direct and indirect effects of unmeasured variables. The coefficients may, however, still be interpreted if the same specification errors are made in two models that are compared.
10. **Appropriate correlation input.** Pearsonian correlation is usually used for two interval variables when a correlation matrix is used as input. Polychoric correlation is used for two ordinals, tetrachoric for two dichotomies, polyserial for an interval and an ordinal, and biserial for an interval and a dichotomy (Garson 2006b).

11. Adequate sample size is required to assess significance. Kline (in Garson, 2006b) recommends 10 to 20 times as many cases as parameters. Kline is of the opinion that 5 (or less) times are insufficient to test for the significance of the model effects.

12. The same sample is required for all regressions used to calculate the path-model. To ensure that there is no missing data for any of the variables, list-wise deletion (deleting an entire case's record in cases with one or more missing data points) or appropriate data imputation (missing values are estimated) may be used.

4.8.3.7 The steps followed when using PLS path-modelling

- 1. Contextual framework:** The literature review pointed to a multitude of factors coinciding in the life of creative individuals.
- 2. Model:** Models were specified. The models attempted to explore the direct and indirect relationships that could possibly exist between creativity indexes and personal, creative process skills, contextual factors, perceptions and beliefs (figure 4.4).
- 3. Measuring constructs:** To measure the constructs, a standardized creativity test (the ATTA), a questionnaire (about perceptions of the inhibiting and encouraging contextual factors and understanding) and a biographical data collection sheet were used. The questions from the questionnaire that showed low convergent and discriminant validity (*cf.* 4.7.3.9) were removed.
- 4. Data collection:** The data were collected over three years. A matrix with all the data collected for the different groups was compiled. This matrix was converted to text, using the "text to columns" function under "data" in Excel and the document was then "saved" as a text file. This text file was imported into Visual-PLS and the models were built, using the easy-to-use icons.

4.8.3.8 Validity of PLS path-modelling

Factorial validity (construct validity) is an important issue in statistics (also in PLS). In PLS, two aspects of factorial validity are important: convergent and discriminant validity. **Convergent validity** refers to how well the items correlate with its assumed theoretical construct. In Exploratory Factor Analysis (EFA), this is ideally indicated by a factor loading of 0.60 or larger, as is desired within constructs. PLS performs a Confirmatory Factor Analysis (CFA) to determine factorial validity. Convergent validity is determined, using t-tests. *"Each item must load with a significant t-value on its latent construct...the p-value of this t-value should be significant at least at the 0.05 alpha protection level."* (Gefen & Straub, 2005:93.) Pearson correlations (for interval data and/ or normal data distribution) or Spearman correlations (for ordinal data and/ or non-parametric data) may be used (Gefen & Straub, 2005:102).

Discriminant validity refers to how weakly the items from one construct relate to that of another construct. In Exploratory Factor Analysis (EFA), a factor loading of 0.40 or lower indicates low correlation, as is desired between constructs. Gefen and Straub (2005) explain that discriminant validity in Confirmatory Factor Analysis (CFA) in PLS is determined by inspecting the item loadings and through Average Variance Extracted (AVE) analysis (2005:94). Discriminant Validity is shown when *"all the loadings of the measurement items on their assigned latent variable"* are of *"an order of magnitude larger than any other loading"* (2005:93). An AVE analysis determines whether the square root of the AVE for each latent construct is *"much larger than any correlation among any pair of latent constructs"*. In Visual-PLS (Fu,2006), the t-values of the loadings (equivalent to least square regressions (Gefen & Straub, 2005:97)) are determined, using the bootstrap technique (Gefen & Straub, 2005:92-97).

4.8.3.9 The PLS path-model

The hypothetical model developed in this study resulted from the conceptual model for the study, the literature study and the researcher's knowledge of the local context. It was assumed that creativity is partially the result of personal and contextual factors, resulting in certain perceptions that encourage or inhibit creative behaviour in the individual. It was further assumed that creativity might be enhanced by classroom activities, specifically in creating an understanding that creative behaviour is not only

allowed, but also seen as desirable. The literature dealt mostly with contexts outside South Africa, with people of other cultures. The researcher could not find any studies investigating the effects of the context on creativity in such an integrated way as was proposed for this study. The theory was therefore considered to be weak and it was decided that an exploratory factor analysis would be appropriate. The models in figures 4.4 to 4.10 therefore formed the starting point for a PLS path-modelling.

The Visual-PLS-1.04b (Fu, 2006) programme was used to analyse the data. The programme uses linear equations (similar to regression equations) to specify which variables must be included in the model. For instance, creative index may be influenced by age, socio-economic factors and trauma. The equation for this would be:

$$\text{PrCIAd}_{a5} = \beta_0 + \beta_1(\text{Age})_{a5} + \beta_2(\text{SocioAcc})_{a5} + \beta_3(\text{Trauma})_{a5} + R_{a5}$$

where:

PrCIAd_{a5} = the outcome variable (the adjusted pre-programme creative index) for student a group 5.

β_0 = the intercept (the point at which the regression line crosses/intercepts (the expected value of the dependent variables when the value of the independent variable is zero) (Vogt in Howie, 2002).

β_1 = the regression slope associated with age (*Age*);

β_2 = the regression slope associated with socio-economic and acculturation factors (*SocioAcc*);

β_3 = the regression slope associated with exposure to trauma (*Trauma*); and

R_{a5} = the random error (random variation or unreliability).

Initially, the model may be unconstrained, assuming that every common factor affects every observed variable and that common factors are either all correlated or uncorrelated (Garson, 2006c). The principles of **parsimony** (choosing the simplest model) and **coherence** (considering theory) are advised (Tuijnman & Keeves in Howie, 2002:97). For this purpose, the hypothesized paths that are redundant should be removed through trimming and the model is refined in the process. This means deleting one path at a time, following the guidelines given by Falk and Tonkin

(2001:1-4). Trimming should be done in such a way that it is consistent with theory and face validity. In effect, this may lead to the removal of latent and manifest variables without significant paths to the dependent variable.

The primary research question addressed by these models 1 to 5 (figures 4.4 to 4.8) is: "what factors have (direct and/or indirect) effects on creativity in first year pre-service teaching students at the North-West University in South Africa?"

Model 6 to 7 (figures 4.9 to 4.10) investigated aspects of the effect of the Technology Education programmes that the participants were subjected to.

Maximally, the data collected could be used to model nine exogenous factors directly and/ or indirectly influence students' creative indexes (C1), namely:

4.8.3.9.1 Personal factors

1. Age of student (*Age*);
2. Gender of student (*sex*)(male =1 or female =2);
3. Position in family (*PosFam*), indicating whether the student is a firstborn, second-born and so forth up to five and further; and
4. Academic Achievement (*AcaAch*) of student in Technology Education examination.

4.8.3.9.2 Process factors

Process factors that were modelled included the four different creative abilities (or process skills) as were determined by the ATTA namely fluency, originality, elaboration and flexibility. They were not numbered since they were used in only two separate models, namely model 2 (figure 4.5) and model 4 (figure 4.7).

4.8.3.9.3 Contextual factors and perception factors

Models 3 and 5 explores the relationships between contextual factors and adjusted pre-programme creativity levels.

5. Culture (*Culture*) was simplified from the collected data that included the different cultural groups such as Nguni, Sotho and so forth, to African and non-African. This was done since it was impossible to establish a direction

with a large number of different language groups and since some groups consisted of only a small number of individuals;

6. Socio-economic position and acculturation (*SocioAcc*) with manifest variables, parental education (*FaEd*, *MoEd*) and Socio-economic indicator (*SEI*);
7. Family factors (*FamFact*) with the number of children in a family (*FamSize*), trauma (*Trau*) (No trauma was again indicated as (1) death of parent or divorce with 2) and family status (*FamStat*) with a household with two parents living together indicated with a one (1), divorced parents as (2), parental death as (3). The variables in this construct were modelled *formatively*. In other words, it was assumed that the manifest variables caused the latent variable;
8. Model of school attended (*SchoMod*) with manifest variables: (1) ex- model C-schools (with teachers mainly from Western cultural groups) and (2) township-schools (with teachers from mainly African cultural groups; and
9. Role model chosen (*RoleMod*), refers to the person chosen by the participant as a role model. They were given a free choice and choices were grouped as self or no-one (0), mother or female relative (1), father or male relative (2), teacher (3), celebrity like actor or artist (4), political leader or religious leader (5). The sequence was therefore from the most intimate (self) to the least intimate relationships.

The questionnaire items could be modelled as endogenous reflective constructs. The responses to negatively directed questions (directed towards inhibiting factors) were turned around so that a strong negative response was reversed to a strong positive response. All responses therefore pointed towards stimulating circumstances and perceptions. The five constructs that were modelled are discussed below:

10. Perception of culture (*PerCult*), using items in the questionnaire referring to factors generally seen as individualistic (encouraging) or communalistic (inhibiting) creativity;
11. Perception of family (*PerFam*), using items of the questionnaire referring to factors generally seen in literature as encouraging or inhibiting creativity;
12. Perception of school (*PerScho*), using items of the questionnaire referring to

factors generally seen in literature as encouraging or inhibiting creativity (teachers and peers contributed to this perception);

13. Perception of university (*PerUni*), using items of the questionnaire referring to factors generally seen in literature as encouraging or inhibiting creativity; and

14. Perception of the outcome of ideal education, using items of questionnaire two referring to:

14.1 A productive thinker (*ProdTh*);

14.2 A person with internal locus of control (*InLoCo*); and

14.3 An innovative view of problem-solving (*InnoTh*).

(Due to lack of convergent validity, the last two constructs had to be dropped from the models).

It was hypothesized in H_a^4 that contextual factors might have direct effects on creativity. It was further hypothesized (H_a^4 , H_a^5 and H_a^6) that certain exogenous factors have, besides their direct effects, also indirect effects on creativity through intermediate endogenous variables. These are summarized in table 4.8. **Culture** (exogenous variable) may influence the **role model** (endogenous variable) chosen. The role model chosen may, in turn, influence the perception that the student has regarding productive thinking as an outcome of education (*ProdTh*). This perception may influence the dependent variable, namely **creativity index**. These intermediate factors are influenced by the exogenous factors and influence, in turn, the dependent variable, namely creativity. In other words: a dependent variable in one equation is used as an independent variable in another equation.

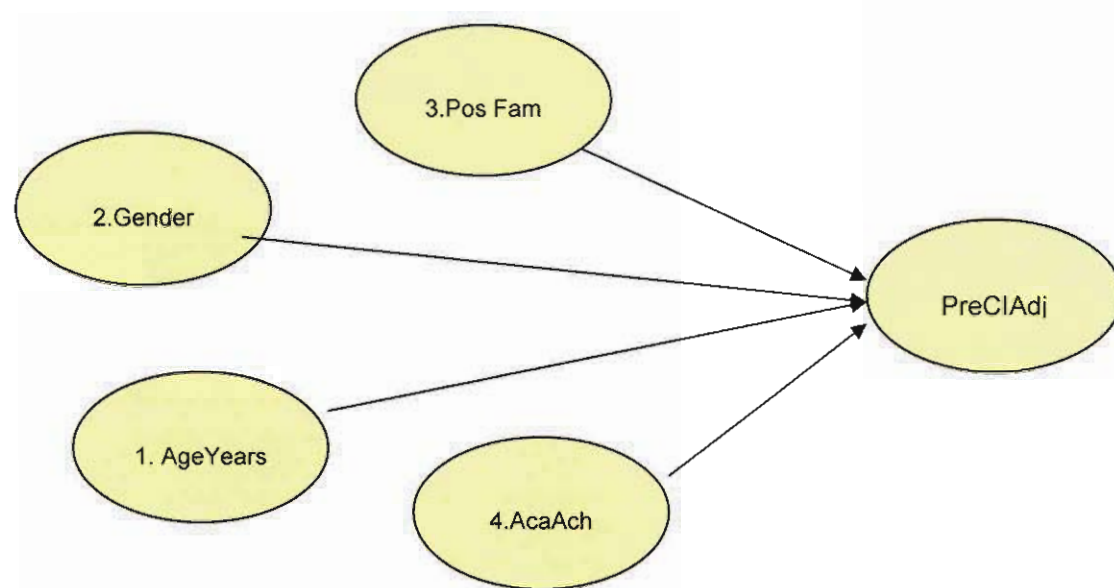
Table 4.8: Exogenous variables affecting endogenous intermediate variables and through them, the dependent variable creativity

Exogenous variables	Gender	Culture	Family status	School model	Age
Intermediate endogenous variables	Role models	Perceptions of culture, university, ideal person Role model	Perceptions of family Perceptions of productive thinking as ideal outcome of education	Perceptions of school, university	Perceptions of university

Some of the assumptions were tested using PLS-path-modelling. The path-models used in these cases are given below.

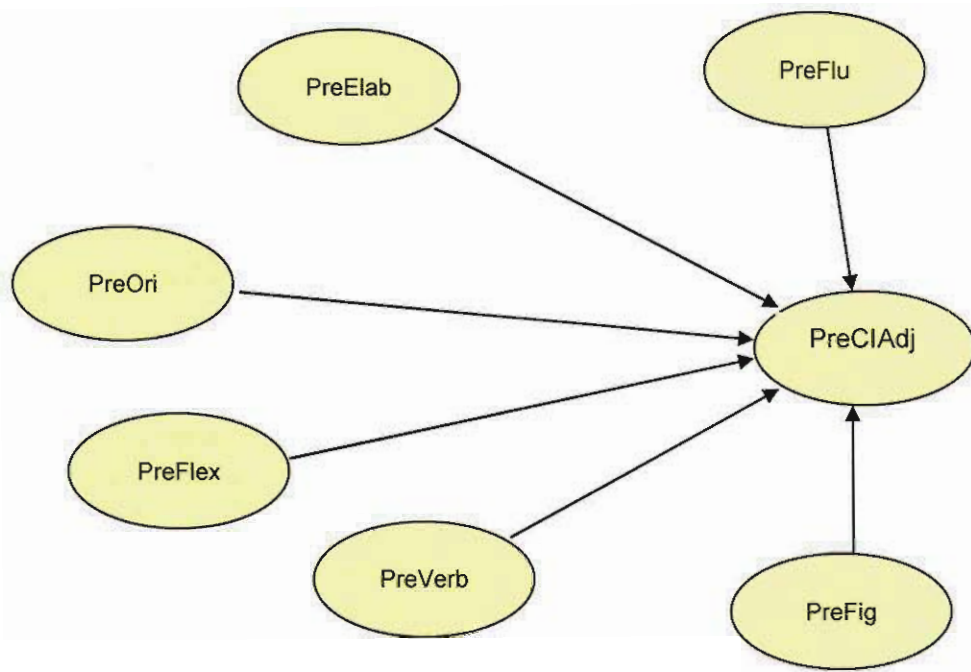
To test the H_0^1 , namely, that personal factors have no significant influence on the creativity of participants in this study, the simple model, using only unities and given in figure 4.4, was used. The relative strengths of paths between the first four factors (namely age (*AgeYears*), academic achievement (*AcaAch*), Sex (*Gender*) and position in the family (*FamPos*)) and the pre-programme creativity index were simply compared. No interactions between these factors were investigated.

Figure 4.4: Model 1: Exploring relationships between personal factors and creativity index (CI)



To test hypothesis H_0^2 , namely that there is no difference in the strength of the relationships between creativity index and the different creative abilities used in the creative process of the participants in this study, model 2 (given in figure 4.5) was used.

Figure 4.5: Model 2: Exploring relationships between process factors and creativity index (CI)



As with model 1, model 2 was very simple and tried to determine which of the creative abilities contributed more to the difference in creativity indexes and which ones were contributing less to these differences.

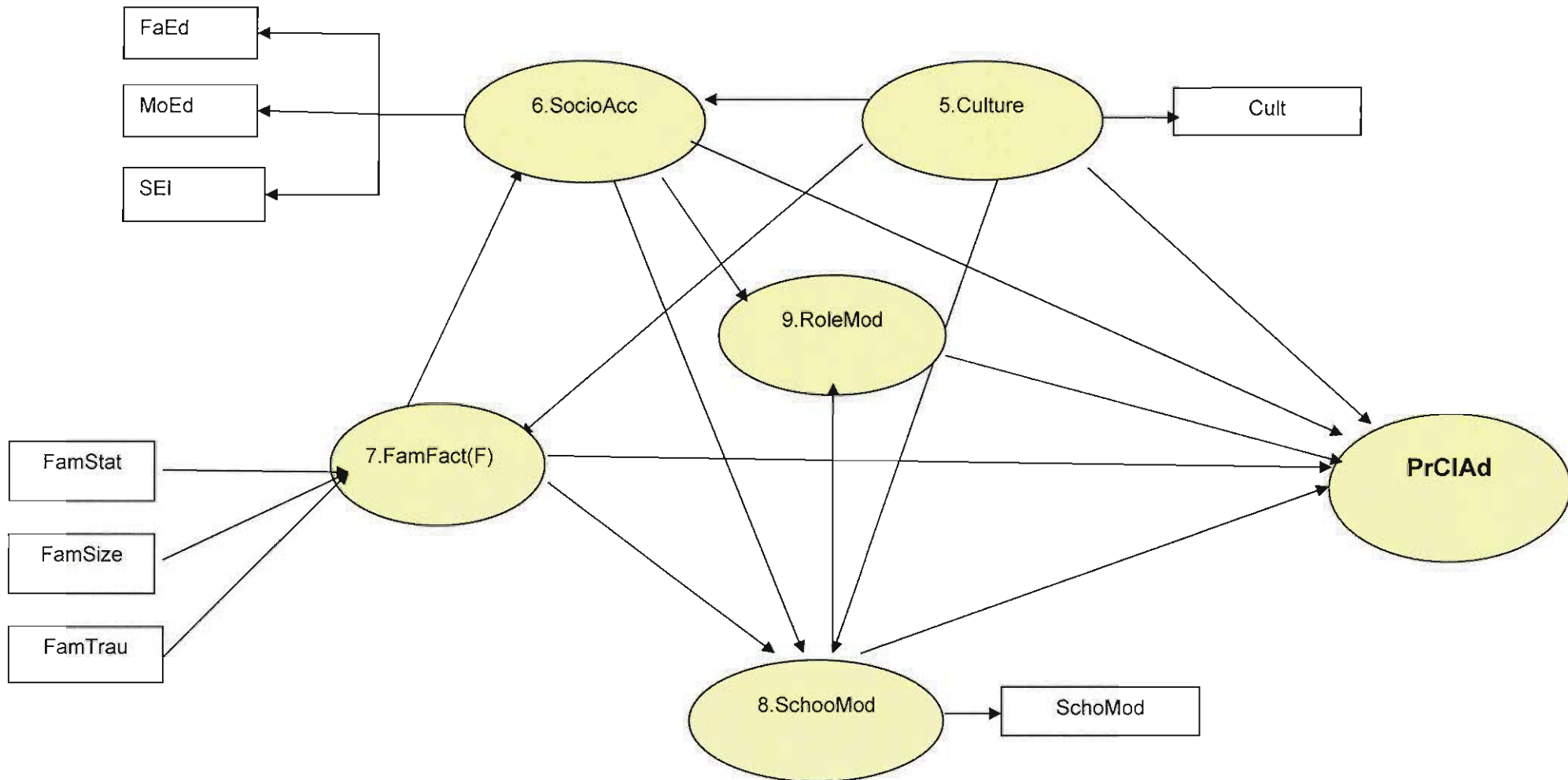
To test hypothesis H_0^3 , namely that there are no relationships (direct or indirect) between contextual factors and levels of creativity in the participants in this study, model 3 (figure 4.6) was used.

All relationships that were foreseen based on logic and the literature study were indicated in the original model. It was envisaged that some of these relationships might be very weak (with path coefficients of below 0.1) and that they would have to be trimmed at a later stage. All available measured contextual factors were included. It was foreseen that some of these factors might have R Squares of below 0.015. This value would indicate that it should be removed from the model. It was also foreseen that some constructs might “steal” from others due to multi-collinearity and that this may lead to the removal of some constructs from the models.

Some of the latent factors were unities with single measured variables and others had a number of measured variables. Visual PLS can let latent constructs regress in different directions (in formative and reflective modes), but it cannot turn the direction within a latent construct around. Care should therefore be taken in this model to

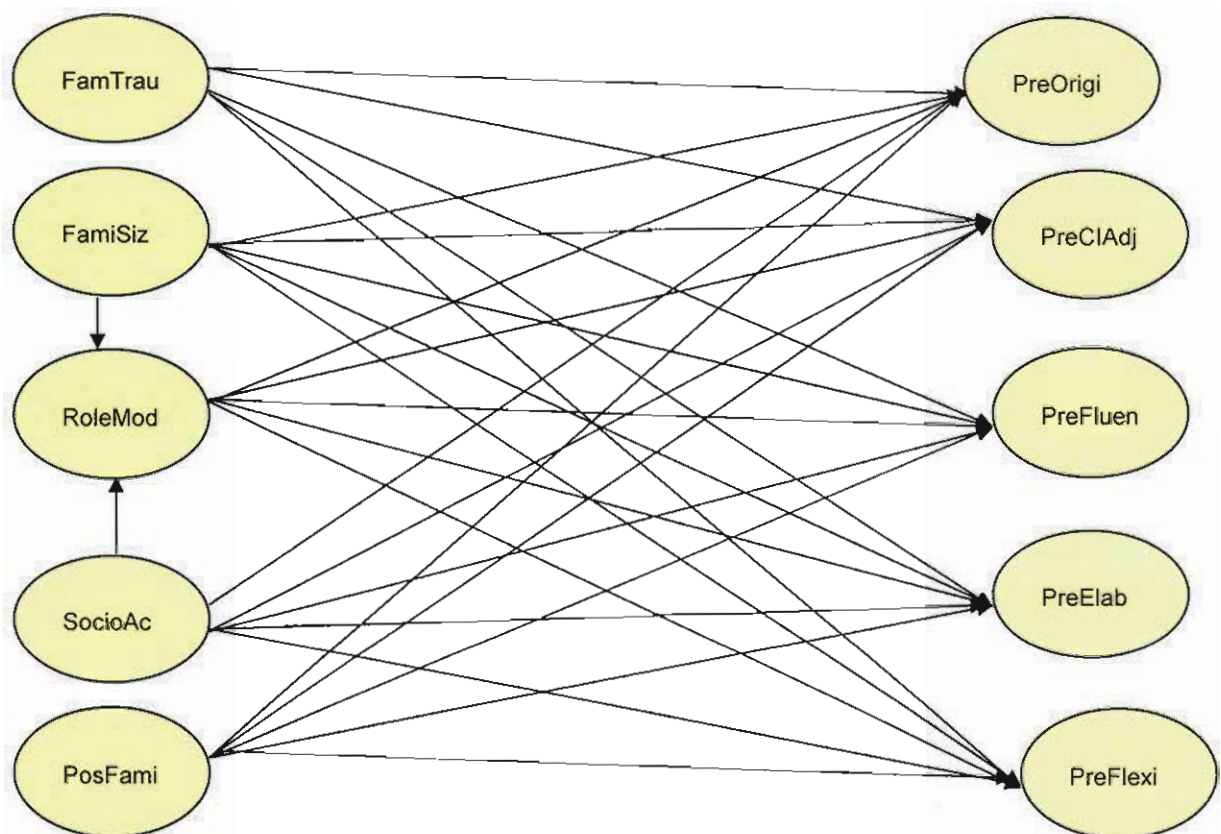
present measured variables that were measured in the same direction together as one latent construct. For example, the latent construct family factors consisted of trauma (1= least trauma), family status (1= two parent family) and family size (1= 1 child = most resources available). It was modelled formatively (F) since it was assumed that these factors lead to (causes) the construct. The researcher recognizes that it, in itself, may affect the results, because it assumes that these conditions may together be responsible for certain differences. Similarly, the formation of a single construct, "socio-economic factors and acculturation", assumes that the level of acculturation in the Western culture achieved through schooling leads to better employment opportunities that leads to better socio-economic factors. Parental education (values 0 to 12 taken as school grades and 13 as post-grade 12-qualification) and Socio Economic Indicators (SEI) values (0 to 10 with 0 very deprived and 10 not deprived) were therefore modelled as a single latent reflective construct. Reflective modelling implies that it was measured by means of its measured variables and not caused by them as in the formative construct "family factors".

Figure 4.6: Model 3: Exploring relationships between contextual factors and creativity index (CI)



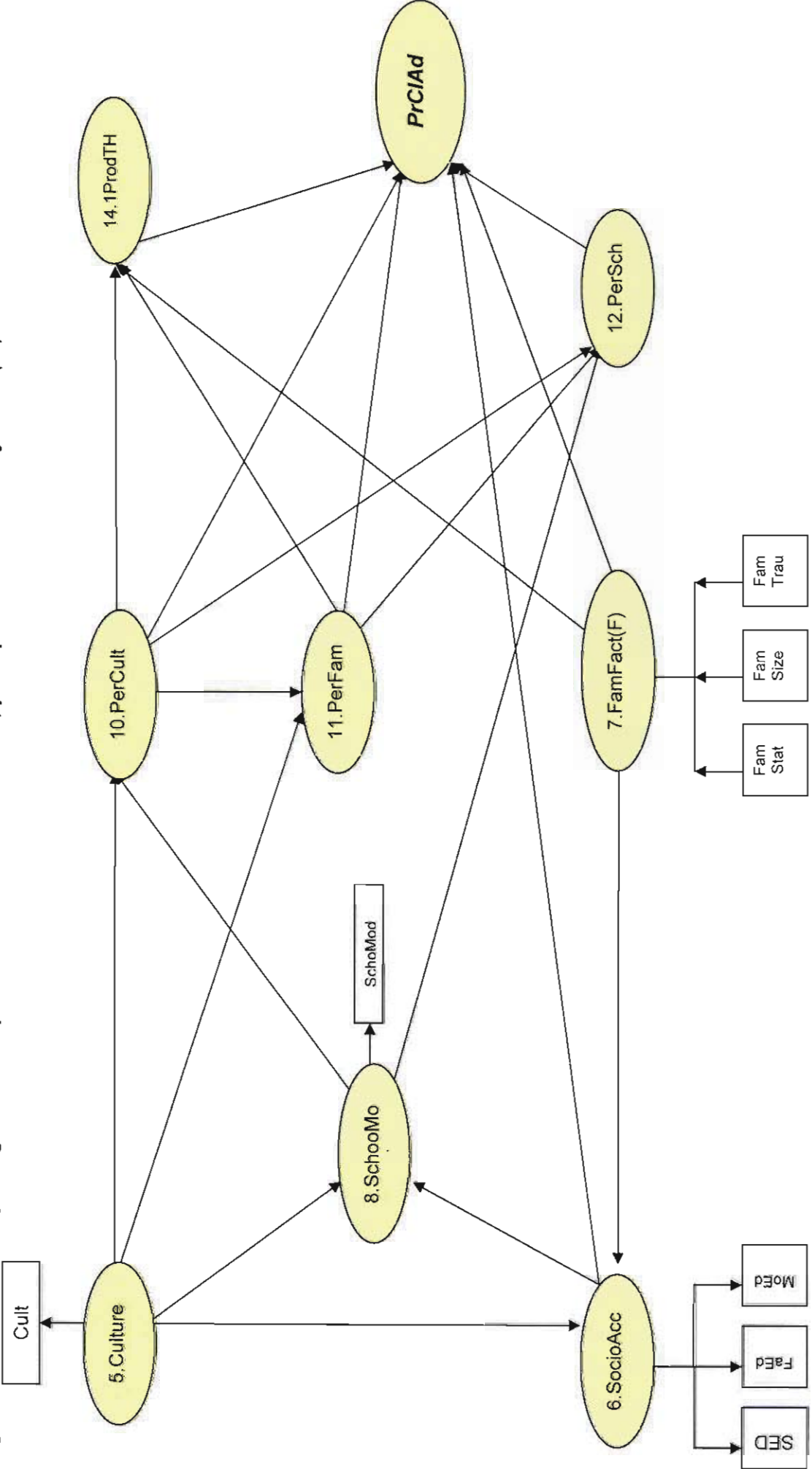
To explore the relationship between contextual factors like role models and creativity index and creative abilities further, model 4 was used.

Figure 4.7: Model 4: Path-model to explore the role of micro factors like choice of role models, family trauma, family size, position in the family and socio-economic and acculturation factors in the development of creativity and creative abilities.



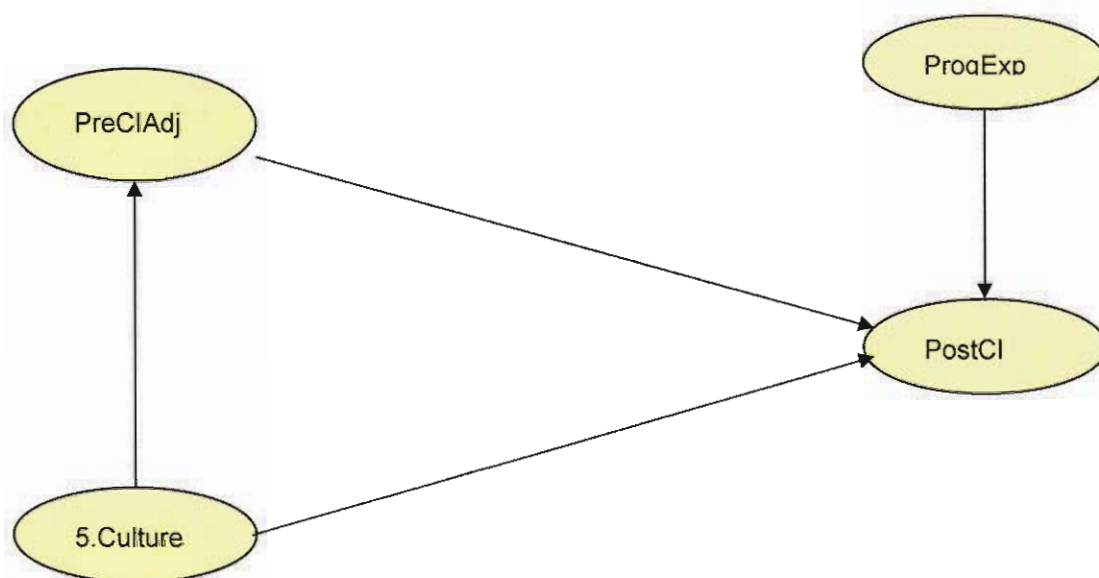
To test hypothesis H_0^4 , namely that there are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity in the participants in this study, model 5 was used. The same model was also used to test hypothesis H_0^5 , that there are no relationships (direct or indirect) between perceptions about the context and creativity in the participants in this study. In Figure 4.8, an alternative hypothesis, namely that at least eight latent contextual and perceptual factors, nr 5, 6, 7, 8, 10, 11, 12 and 14, influence students' creativity in the pre-test, is modelled.

Figure 4.8: Model 5: Exploring relationships between contextual factors, perceptions and creativity index (CI)



To test hypothesis H_0^8 , namely that the possible effects of the different Technology Education programmes on the **creativity indexes** of the participants will not be influenced by contextual factors and /or perceptual factors, models 6 and 7 were used. An alternative to the null hypothesis was that the creativity index in the first (*PreCIAdj*) and second ATTA (*PostCI*) would be related to one another and that both these scores would be related to contextual and perceptual factors. The simple model 6 was first used to explore this relationship between culture, pre-programme ATTA, post-programme ATTA and exposure to the programme.

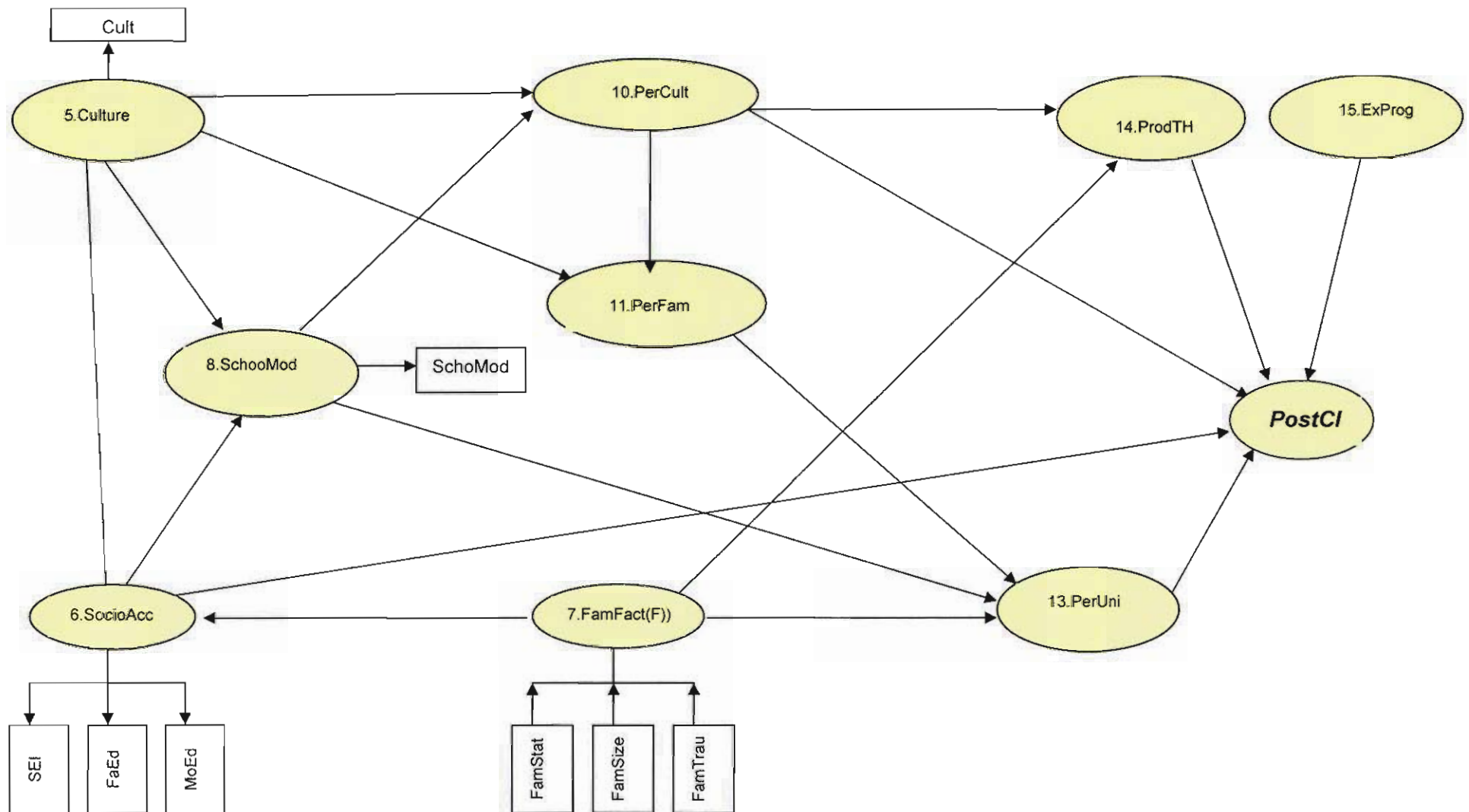
Figure 4.9: Model 6: Relationships between pre- and post-programme creative indexes, culture and programme exposure.



In model 7 (figure 4.10), the pre-programme creativity index was removed. The researcher was of the opinion that its relationship with the contextual, perceptual factors and the creativity index should be clear by this time from the other models and it could relate so strongly with the post-programme creativity index that none of the other relationships would be seen clearly. Model 7 is similar to model 5 (figure 4.8) and uses nine latent factors as influencing students' creativity in the post-test. The pre-programme creativity index is replaced with post-programme creativity (*PostCI*), perceptions of school is replaced with perception of university and the programme exposure (*ExProg*) is included as variable. Factor 15, namely the programme exposure is given below.

15. The programme that the students were exposed to (*ExProg*), namely the basic programme (1) or enriched programme (2).

Figure 4.10: Model 7: Exploring relationships between contextual factors, perceptions and creativity index in post-test (PostCI)



The models were used for exploration of the data. When it was appropriate, other statistical methods were used to compliment, illuminate and elaborate on the observations made, using the SEM models. Since the SEM models are based on linear relationships between variables, other relationships were pointed out where they were observed.

4.9 ETHICAL CONSIDERATIONS

The students were informed about their right not to partake in this study and signed a letter of consent before any tests were performed or questionnaires were filled in. They wrote their names on the forms and were therefore not anonymous. They were, however, ensured about the fact that the information would be treated with strict confidentiality and that privacy would be protected. Only the researcher, the rater and the supervisor had access to the raw data where names were used. The statisticians got keyed-in data without names.

The right of the students to equivalent opportunities was not violated. Since both the students exposed to the basic programme and those exposed to the enriched programme reached the same outcomes as prescribed by the curriculum, no-one was disadvantaged.

Copyright laws were abided to and a contract was signed between the STS scholastic testing service and the researcher. The number of copies of the ATTA used in this study was paid for and a copyright notice in the form, "Copyright © 2000, Scholastic Testing Service, Inc. 480 Meyer Road, Bensenville, Illinois 60106-1617, USA" was inserted on the back of every copy made (as was stipulated in the contract). The testing service was lastly informed about the date of completion of the work.

4.10 SUMMARY

In this chapter, the aims of this study that attempted to understand the phenomenon of creativity and how it could be enhanced were given. The methods used, namely an *ex post facto* method and a quasi-experimental method, were described. The hypotheses were formulated, the variables listed and the research methodology was discussed. The data collection instruments, the population, sample and data analysis, namely descriptive, inferential and structural equation modelling, were described. Attention was given to validity and reliability of the methods and the

instruments.

In the next chapter the programmes that were used in the intervention in the quasi-experimental study will be discussed in detail.

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about learning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER FIVE

TECHNOLOGY EDUCATION PROGRAMMES AIMED AT ENHANCING CREATIVITY

5.1 INTRODUCTION

Certain factors regarding creative behaviour are outside the control and/ or reach of the classroom and are related to macro-environmental factors. Despite this, the occurrences in the classroom may be very powerful. Since human behaviour, creative behaviour also, seems to fit the chaos theory description (*cf.* 2.4.2.1), a small change in how teachers perceive creativity and are able to encourage creativity may have a major impact in the community in the long-run. A number of useful and applicable lessons that were learnt from the literature study are given here.

In this chapter, the rationale for trying to enhance creativity and key factors in enhancing creativity by using Technology Education are discussed. The Technology Education programmes, the basic programme and the enriched programme, that were followed with the participants during this research are also discussed.

5.2 REASONS FOR ENHANCING CREATIVITY

Is it possible to enhance creativity? If it is, is it desirable to try to enhance it? An attempt will be made to answer these questions below.

5.2.1 It is possible to enhance creativity

There is evidence that it is possible to enhance creativity. Scott, Leritz, and Mumford, (2004) found in an analysis of seventy different creativity-enhancing programmes, that well-designed creativity-training programmes typically induce gains in performance with these effects generalizing across criteria, settings and target populations. These effects held when internal validity considerations were taken into account. More successful programmes were likely to focus on the development of cognitive skills and the heuristics involved in skill application, using realistic exercises appropriate to the domain at hand. Osman (1992) also studied the effect of creativity enhancement programmes in third year students and found that *"trends on the various measures were consistent, positive and in the expected (positive) direction, irrespective of the thinking skills programme or combination"*.

5.2.2 Creativity could benefit individuals and the community

In a book called "Education and Ecstasy", Leonard predicted in 1968 that: *"The highly interactive, regenerative, technological society that is now emerging, will require something akin to mass genius, mass creativity, and lifelong learning"*.

What makes mass creativity something desirable? Four reasons are discussed below:

5.2.2.1 Technological innovation is a driving force of economic progress

According to Fischbach (1996), the human capability of creativity leads to technological innovation that *"means to conceive and establish new products, services and ways to produce and deliver them"*. This *"technological innovation is a driving force of economic progress, and therefore of vital importance for modern societies"*.

Homer-Dixon (1995) talks about an ingenuity gap and explains this in terms of the *"new economic growth theory"* or *"endogenous growth theory"*: *"Ideas, as embodied in new technologies, are factors of economic production in addition to capital, labor and land..... "societies are locked into a race between a rising requirement for ingenuity and their capacity to supply it. If a country loses the race, social dissatisfaction will rise, with increasing stress on marginal groups, including those in ecologically fragile rural areas and urban squatter settlements. A persistent and serious ingenuity gap will cause major social changes like declining food production, reduced economic production, and large population movements. These changes undermine regime legitimacy and coercive power, and increase the likelihood of widespread and chronic civil violence. Countries with a critical ingenuity gap therefore risk entering a downward and self-reinforcing spiral of crisis and decay."*

Development and prosperity result from creativity, and prosperity also leads to creativity. Romer (in Homer-Dixon, 1995:3) explains the dynamic interaction between wealth and ingenuity: *"Ideas are the critical input in the production of more valuable human and nonhuman capital. But human capital is also the most important input in the production of new ideas."*

In Biblical terms this means that the more you have, the more you are likely to acquire.

5.2.2.2 Creative people are in demand

Another reason that makes mass creativity attractive is that highly creative people (productive thinkers) tend to be very influential. Their ideas are used and reproduced by masses of other less creative people (reproductive thinkers). On the ideas of one highly creative individual, a whole industry, domain or trend can be built. One creative individual can open up the potential of a new energy source, lay the fundamentals of a system or institute a new way of treating millions of sick people. Wonacott (2002) calls intelligent, creative, autonomous, problem-solvers with interdisciplinary knowledge the gold collar workers. He stresses that they are highly valued and in great demand because they are currently in short supply. Romer (in Homer-Dixon, 1995:3) explains that this is so because ideas can be in many places at the same time, but creative individuals not –*“nor can this person solve many problems at once”*. There is therefore a demand for ingenious people in the marketplace.

5.2.2.3 Creativity is instrumental in human evolution

Creativity and the innovation that is associated with it are also seen as “human improving” instruments. Fischbach (1996) explains: *“by the creation and use of artifacts, mankind affects its internal environment not less than the external one”*.

Culture (the creative products: technology, art, science, ways of behaving) and the creator of culture (humans) both change over time (a concept known as co-evolution). In terms of the Activity Theory, cultural artifacts (such as objects, practices, language) act as mediators in the learning process. Human individuals and communities adapt to meet the challenges of the new contexts and, in doing so, learn new skills and knowledge.

5.2.2.4 The post-industrial era demands thinking, independent and creative individuals

Lastly, society has changed. During the agricultural and industrial eras in human development many people did not have to think, the boss or manager decided what had to be done and had to make the plans, take the responsibility for success or failure and the workers had to do what others decided. Creativity in the worker would be a stumbling block in such a community since it may lead to rebellion and would threaten the *status quo*. For every creative boss a large number of obedient workers were needed. The ratio of productive thinkers to reproductive thinkers would

therefore be one to many. This is exactly what Huber (2000) found in a statistical investigation: creativity is indeed rare. Is this an anachronism from a time that has come to an end? Are the processes of social manipulation and imprinting over centuries then the reason for this? It may be argued that the empowerment of every individual is crucial, since we now live in an information era and information is freely available to all, political power is in the hands of the common man and so forth. If the common man is not thinking independently, people like creative politicians and extremist fanatics can easily manipulated him/her. This would make the system vulnerable. Zuboff (in Hannah & Harris, 1995/1996:7) concludes, based on careful empirical work *"that the post-industrial era mandates innovative methods of information sharing and social exchange"* that will eventually lead to *"a deepened sense of collective responsibility and joint ownership, as access to ever-broader domains of information lend new objectivity to data and pre-empt the dictates of hierarchical authority"*.

It should be clear that enhancement of creativity is possible and desirable. The next question is: How is Technology Education suited to enhance creativity?

5.3 KEY CONSIDERATIONS IN ENHANCING CREATIVITY THROUGH TECHNOLOGY EDUCATION

Sternberg warned in 1986: *"theory, assessment, and instruction in the field of human abilities have tended to emphasize intelligence at the expense of wisdom and creativity"*.

Since research has shown that these three abilities are distinguishable and different, a balance should be struck between educating for each. Sternberg (1986 & 2001), Perkins (2001) and Stanovich (2001) emphasize the need to look at the goals and beliefs of the learner, thinking dispositions, values, morality, cognitive styles and the evaluation of cognition in terms of normative criteria. One must remember the amplifying effect seen in chaos theory. Just enhancing creativity for creativity's sake or creativity at the expense of the other human abilities could potentially breed large-scale problems in future. According to Nickerson (1999:396) and Halpern (2001), awareness of ethical aspects is important. Halpern describes it as a *"value system that balances concern for oneself with concern for others and extra-personal concerns such as concern for the environment"*.

This should be a concern in a creativity enhancement programme.

It may be unlikely that the type of creativity known as “*Creativity with a capital C*” (cf. 2.1) will be achieved by classroom manipulation alone. Certain key ingredients are, however, identifiable from the high level creativity from which one can learn. These key ingredients can be classified as those enhancing the person (such as cognitive, conative and affective factors), those enhancing the context (like social and physical factors) and those enhancing the process (like teaching good process skills). Attention to the person, the process and the context may lead to enhancement of the output, namely the creative product.

5.4 LEARNING IN TECHNOLOGY

A number of questions could be asked about Technology Education namely: “What is the nature of Technology Education?”, “What is learnt in Technology Education?”, “What methodology does Technology Education use?” and “What is the possible role Technology Education can play in enhancing creativity?”

5.4.1 The Nature of Technology Education

Technology Education deals with Technology that is defined in the NCS (Department of Education, 2002) as the “*use of knowledge, skills and resources to meet human needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration*”.

This immediately points to the pragmatic, dynamic and socio-responsive nature of Technology Education. It indicates that basic procedural and a conceptual frameworks (knowledge, skills and resources) need to be transferred. It further highlights ethical issues and the sensitivity and responsibility that need to be transferred.

The NCS Policy document (Department of Education, 2002:4) explains the aims of Technology Education as contributing to technological literacy by providing an opportunity to:

- develop specific skills to solve technological problems;
- understand the concepts and knowledge used in technology, using them in an ethical, responsible manner ; and
- appreciate the interaction between the values and attitudes of humans and technology, the society and the environment.

According to the NCS Policy document (Department of Education, 2002:5), Technology Education gives the learner an opportunity to:

- solve problems in creative ways;
- learn in authentic contexts and real-life situations outside the class-room;
- combine thinking and doing by linking abstract concepts to concrete concepts;
- Do practical assignments using a variety of technological skills addressing a variety of learning styles;
- use knowledge in a goal-directed way and become involved in it;
- handle issues like inclusivity, human rights and social and environmental issues during project work
- use a number of life-skills in authentic contexts; and
- attain more positive attitudes, perceptions and aspirations regarding technologically based careers.

Contrasting Technology Education with that of the well-established and well-known discipline of science may help one to understand the unique nature of Technology Education further (Table 5.1, adapted and tabulated from the arguments of Lewis, 1999:48-50).

Fischbach (1996) is working within the field of engineering (technical) design. He explains that the four challenges of the Klondike creative space (Rarity, Plateau, Isolation and Oasis) are not easily overcome in the field of engineering / technical education. This is so because the field tends to enforce the barriers of the Klondike space. The design of artifacts, processes, organizational structures and arrangements necessary to design, produce and employ technological solutions needs creativity. He explains that there are two distinct domains where the influence of creativity may become realizable, namely the problem space and the solution space. To overcome the challenge of rarity, a wide range of knowledge and frequency of probes are recommended. Overcoming the challenges of isolation (promising regions in solution space are separated by wide distances) and plateau (no gradient indicating the direction to rewarding regions) *takes the courage to fail*. The oasis problem (comfort with existing solutions that discourages ventures that

leave the known, recognized paths) is according to Fischbach, the most difficult to deal with in the engineering /technical field. This is because direct instruction and guidance precludes openness and assures that the result stays within the oasis of purposefulness, security, parsimony and simplicity. The oasis challenge may be easier to meet by using open ill-defined problems and exposure to more than one field. These assumptions may also be true of both science and Technology Education.

5.4.2 Knowledge, values and attitudes to be learnt in Technology Education

What is there to be learnt in Technology Education? Knowledge, and values and attitudes will be discussed in more detail. Hennessey and McCormick (in Williams, 2000:48) distinguish between conceptual knowledge (body of content) and procedural knowledge (activity-related skills) in Technology Education. A third type of knowledge will also be discussed, namely contextual knowledge.

Table 5.1: Comparison between field of Technology Education and discipline of science

Technology Education	Science
Seen as consisting of dynamic fields imbued with a built-in elasticity	Seen as a discipline with a conceptual structure, a body of knowledge
Depends on the test of experience	Depends on empirical tests
Aimed at satisfying needs or perceived needs	Tries to understand, describe patterns and predict phenomena of the natural world
Pragmatic nature leads to rapid decay and regeneration of knowledge	Descriptive nature leads to accumulation of ever increasing body of knowledge
Philosophy without a theoretical framework. The field is still in the making (Rapp in Lewis 1999:50).	Philosophy with a "well-established systematic conceptual framework of basic concept, questions, theses and arguments" exists.
The ability to access, select, process and apply relevant knowledge as needed to solve a specific problem or satisfy a specific need, is needed. High probability that new combination of selected information would originate from activity.	A clear understanding of the systematic conceptual framework is needed if a person wants to add to the framework or change it.
One cannot practise technology without being creative when "developing solutions".	One can be a practising scientist "just doing science" systematically and analytically without adding to knowledge.

5.4.2.1 Conceptual knowledge

The approach of Technology Education to knowledge is pragmatic. Knowing the field is important in technology, but the big issue here is being able to get the relevant knowledge that applies to the problem or need that must be met. Since the knowledge in technology is so dynamic and the fields are so varied, a broad conceptual framework giving an overview over the basic elements of the different fields within the field of Technology should be useful. Depending on the problem to be solved, specific in-depth research is then done accessing and processing the specific knowledge.

The conceptual knowledge that was selected for the South African situation in the GET-band (General Education and Training) is addressed in Learning Outcome two, namely: The learner is capable of understanding and ethically and responsibly applying relevant technological knowledge. The three main content areas are:

1. **Structures:** Leading to the field of Civil Engineering in the Further Education and Training-band (FET).
2. **Systems and Control:** Leading to Electrical- and Electronic and Mechanical engineering fields in FET).
3. **Processing:** Focuses on ways in which materials can be processed to improve its properties to make them more suitable for specific purposes. A wide variety of materials may be used, ranging from food and textiles, to paper, wood, sand and resins (Department of Education, 2002:8).

5.4.2.2 Procedural knowledge

Williams (2000:48) comments, that, although the focus of Technology Education has traditionally been on procedural knowledge, it was mainly emphasizing manipulative skills like safe and efficient usage of tools. Recently there has been a worldwide paradigm shift. In all areas of education the development of cognitive skills is being emphasized. Technology Education is viewed as an excellent vehicle for developing cognitive skills. As a result of this shift, procedural knowledge changed to become more than just manipulative skills. Design and problem-solving processes became the most common processes in the learning area (Williams, 2000:52-54).

Cognitive skills: In contrast, therefore, to what happened in the past in vocational and technical education, Technology Education places a lot of emphasis on cognitive

skills and heuristics. The technological processes represent problem-solving steps. The technological process is discussed in more detail in section 2.3.7. The opportunity for attention to procedural knowledge as it exists in Technology Education, may be used to specifically remedy problems with attitudes towards problem-solving and heuristics of problem-solving.

All levels of cognitive functioning, from the basic knowledge acquisition to the highly complex synthesis and evaluation, are needed and may be developed by this open and dynamic learning area. The NCS (Department of Education, 2002:6-7) states, for example, that during the final stages of the project, the learner will be assessed on analysis, investigation, planning, design, drawing, evaluation and presentation. The presentation may be in oral, written, graphical or electronic form. Idea-generation (fluency), mental modelling (using imagination), concluding in making informed choices to select suitable ideas and resources and detail planning (elaboration) with annotated and dimensioned drawings are expected during the design process. Criteria for the evaluation of products and processes may be given or may be self-generated.

Manual skills: During the design process, sketching and drawing (free-hand, 2D and 3D), rendering and physical modelling are expected. During the making of a model, skills like measuring, forming materials through separating, cutting or shaping, joining or mixing materials, using a variety of techniques and finishing methods, are addressed.

5.4.2.3 Contextual knowledge

The context is emphasized in Technology Education. The South African NCS Policy document (Department of Education, 2002:9) states in Learning Outcome three that *“the learner must show understanding of the interrelatedness of science, technology, the community and the environment over time”*. The economic, political, social and environmental contexts, values and traditions determine the way in which people look at technology and influence the way in which they use technology. This contextualization is also seen in Technology Education curricula in other countries such as the US (Standards 4-7: Technology and Society, in International Technology Education Association, 2002:211) and Australia (Sustainable development and social, cultural and environmental and historical context)(Act BSSS, 2003:3)

5.4.2.4 Values and Attitudes

The first two outcomes in the South African Policy document both mention the ethical and responsible use of processes, knowledge and skills respectively. The third outcome specifically gives attention to indigenous knowledge systems and cultures, the positive and negative impacts of technology on the environment and biases created by technology influencing the values, attitudes and behaviour of people. The aim seems to develop awareness, sensitivity and appreciation towards these issues, as well as a reflective attitude. Identifying, for example, the origin of certain biases, may help in addressing access to certain technologies and doing away with certain traditional barriers that may inhibit creativity.

5.4.3 Ways of teaching and learning technology

The concepts of rote-learning/ reception learning, guided discovery, mediated creativity, as well as independent work (figures 3.9 and 3.10) could be used as a framework to explain the widely used methodology in policy documents for Technology Education.

Three task types, first described by the Nuffield group, namely case studies, resource tasks and capability tasks are also used in South African schools to describe the variety of activities that take place in a Technology Education class.

Case studies: The aim of the case study is to make contextualized learning possible and to make learning relevant. As argued by Cox (1997 *cf.* 3.3.3.2), contextual learning promotes transfer of learning to new situations. It introduces a problem or challenge to the learners (*cf.* 3.3.1.2, 3.3.2.2, 3.3.3.2, 3.5.3.1, 3.6 and figure 3.9). This may be done using a given description, a field trip, a picture or a video of a specific situation or learners may come up with own scenarios. Learners are asked to identify needs, problems, challenges or opportunities in this situation and from these the rest of the activities usually flow. The case study may be seen as an activity depending on and developing information accessing and processing skills. Looking at the situation from different perspectives may foster creativity. The situation may further be tapped for as many problems, challenges, needs and opportunities as possible or by looking at aspects such as short-term needs and long-term needs or by building in certain constraints. Creative abilities may be developed through case studies, especially if students are, for example, challenged to see situations from different perspectives (developing flexibility), to add detail (elaboration), to try to see

different problems and opportunities in the situation (fluency) and to avoid jumping to conclusions (avoid premature closure) (*cf.* 2.3.3).

Resource tasks are short structured tasks with the aim of teaching and discovering new and relevant knowledge. It may include activities such as experiments, investigations, data searches and reception learning. Transfer of culture takes place during these guided, scaffolded and mediated activities. In the process, the learner is equipped with conceptual and procedural knowledge to enable him/her to solve the problem from the case study. This corresponds with the rote learning /reception learning and guided discovery modes of figure 3.10 and the initial stages of dependent learning in figure 3.9. Overemphasis of rote learning should be avoided and overemphasis in the past gave it a bad name in the current South African context. The lack of a clear body of conceptual knowledge in Technology Education is another reason why rote and reception learning may be seen as of less importance. There is place for developing memorization skills in Technology Education and, in doing so, extending the capacities of working and long-term memory (*cf.* 3.3.1.3). In order to retain basic knowledge committed to memory it must be memorized (through rote learning (repetition) and mnemonics) and /or made meaningful (Ausubel and Bloom *cf.* 3.3.2.2). For example; learning to distinguish between the names, symbols, physical appearance and functions of the basic electrical and electronic components requires memorization. Once the learner has committed this basic knowledge about the elements and what they can do to his/her memory, the task of getting to understand how to combine these components in a circuit becomes easy because the learner knows the basic components of the language of electronics and can combine components in a circuit. This further reinforces the basic knowledge and makes it meaningful. A next step could be to guide him/her to design a unique solution to a problem. Even when one starts at the context, the problem situation or electronic device, using it as a case study in an attempt to make the learning relevant and the learner curious about the functions of the elements, there will still be a moment when he/she has to memorize what is what. This has to be mediated by either a person or printed or electronic media. If the learner does not know the basic elements of the system, it would be impossible for him /her to think about the task and make connections or to communicate with others about the task. Progress towards independent work, such as in the capability task, would be impossible. This corresponds with Vygotsky's concept of a person learning something first on an interpersonal social level and then on an intrapersonal level (*cf.* 3.3.3.3).

Capability tasks may be guided or independent activities where learners solve the problem identified in a case study and where they use the knowledge gained during the resource tasks. During this task, they design, plan and make the solution, evaluate and test the solution and communicate the whole process and its outcomes. Initially the process will be mediated till learners become independent enough to proceed in an independent manner. At first it will therefore proceed in the mediated creativity mode as the facilitator models and guides through class small group or personal discussions and gives opportunities for group interaction (figure 5.1). Later and after a number of mediated attempts the learner will be expected to show competence in working in the independent mode. Both creative thinking and critical thinking are valued highly in capability tasks. Analysis of the processes indicates that every step of the design process consists of both divergent and convergent activities (as in CPS *cf.* 2.3.4.2). Divergent activities are like idea generation for finding a problem, for generating suitable specifications, for the design, for criteria for evaluation and for ways of presenting the finished products and communicating the process. Convergent activities include deciding on which problem to solve, which need to address, which idea to select, which material to use and which mode of presentation to choose from the multitude.

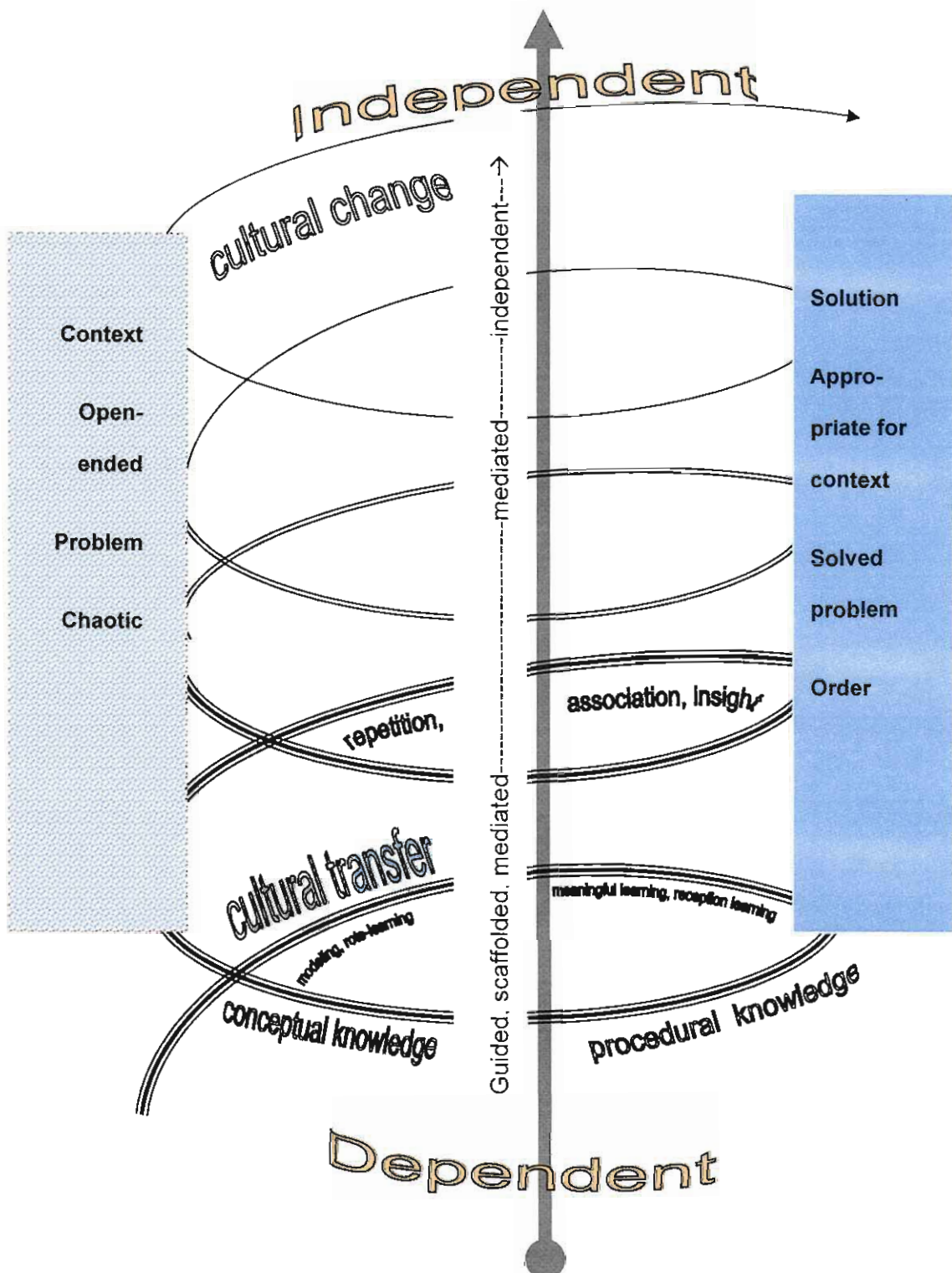
5.4.4 The opportunities for developing creativity in Technology Education

From what was said above, it should be clear that Technology Education provides opportunity for mediating and modelling both the acquisition of basic knowledge, as well as the development of higher order thinking. Synthesis, as the highest level in Anderson and Krathwohl's (2001) rework of Bloom's taxonomy (*cf.* table 3.2), is explicitly addressed in Technology Education. It can, if applied in a way that will stretch the learner to go beyond the obvious, break the mold of conventional habit-bound thinking and address problems with problem-solving. The inhibiting effects of certain paradigms, perceived as truth, may be shifted. Shifting these paradigms may unleash creative powers of people, especially those embedded in traditional cultures, to harness the knowledge systems of their cultures perhaps to assist all humanity against the ill effects of existing technologies.

For a number of reasons, Technology Education lends itself very well to enhancing creativity (Department of Education, 2002: 5-7, 39). To mention a few:

- It is a new learning area without a long established history and well-entrenched content and methodologies.

Figure 5.1: Spiralling between context and solved problems in an ever increasing level of independence



- Although the learning area has its roots in technical education that was mostly

imitational in nature, Technology Education came with a problem-based, activity-based approach that makes open-ended tasks a given. All over the world, emphasis is placed on the development of creativity.

- In the GET-band in South Africa, exposure on a wide knowledge base is possible.
- Integration of information between content areas within the learning area Technology Education and from other learning areas is possible and desirable.
- The emphasis on relevancy and the dynamic nature of Technology Education necessitate the continuous development of new materials and new perspectives.

5.5 THE TECHNOLOGY EDUCATION RESEARCH PROGRAMME

The research was limited in that both the experimental and control groups eventually had to reach the same basic outcomes in terms of the prescribed curriculum. The same basic elements were therefore used in the programmes for both groups, but they were organized and emphasized differently. The control groups (groups 1, 3 and 6) followed a basic Technology Education programme while the experimental groups (groups 2, 4 and 5) followed an enriched programme. The lessons took place once a week over a period of nine weeks in an ordinary lecture hall.

The enriched Technology Education programme is grounded in a social cognitive framework. The differences in acculturation like cultural taboos, thinking patterns and imprinting at school are seen as factors that are responsible for differences in thinking, behaviour and learning. This is based on more than speculation. Brain imaging showed how different cultural practices in child-rearing wire brains differently (Perry, 2002; Hüther, 2006:332)). Trying to change behaviour in a classroom should therefore start by encouraging what was inhibited by culture (or its inverse: inhibiting what was allowed by culture).

5.5.1 The basic Technology Education programme

The researcher compiled the basic compulsory first module when the new learning area was made a compulsory part of the curriculum at the North-West University. The combination of exposure to a basic problem-solving process and encouraging ("forcing") students to look beyond the obvious by using techniques such as brainstorming (to enhance creative process skills), providing an encouraging

classroom atmosphere and opportunities to work as teams in- and outside the classroom (to enhance creative context) were part of the basic programme that all students were exposed to.

5.5.1.1 Attention to the creative person

In an attempt to enhance the creative person, attention was given in the intervention to cognitive, conative and affective aspects of the person.

Cognitive factors

This study was done on students following the first compulsory module designed for Technology Education where the following topics were included:

- The nature and impact of technology
- The rationale for Technology Education
- The methodology and policies of Technology Education in South Africa
- The technological (design) process

Both factual knowledge and cognitive skills received attention. Conceptual Knowledge that was integrated into the course was Energy and Materials. Energy was integrated in case studies that were used as examples and as starting points for problem analysis. The topic of materials was specifically used as subject matter for practising a presentation. Cognitive skills, as given in table 5.1, were addressed during class discussions, assignments, tests and examinations. Opportunities for own ideas and originality were provided in all formal papers. This was done to create awareness among all students that their own ideas and not only learnt facts and ideas were valued. Further it was an attempt to overcome intellectual inertia and loafing in the class situation and to stress the serious intentions of the programme in this regard. Although Amabile (1996: 149-152; cf. 2.4.3.2) observes that knowledge of a pending evaluation might discourage creativity, she gives conditions where it can be stimulating. These conditions are when students have low skills, when constructive feedback results from it, when persistence is expected and when the task is focused. The researcher saw this as applicable in the current research groups.

5.5.1.2 Attention to the creative process

Some of the methods, summarized from the ITEA standards document (see Table 2.5) were used in this Technology Education programme. As described above, it is especially during the instruction of the design process that opportunities exist for exposure to and practising creative thinking abilities such as fluency, elaboration, originality and flexibility (cf. 2.2.2.1.2, 4.6.1). All the groups were exposed to the Technological process in a sequential manner with application at every stage; exercises were done to illustrate activities during every stage separately such as an analysis task, a design task, a making task etc.

During the Investigation Phase, aspects such as data gathering and accessing, processing and analysis were addressed. During the Design Phase, idea generation, incubation, verification and elaboration were addressed.

The Planning Phase addressed aspects of graphical communication, types of technical and working drawings (isometric drawings and orthographic projections), as well as templates, patterns and production schedules. Basic tools and techniques (shaping, mounting and joining and finishing) were addressed during the Make Stage. After exposure to the "Make" Stage, integration of the process took place. A group project was used in which the different steps had to be applied up to the planning phase. The materials, planning and necessary tools were brought to class as a "project-in-a-box" which was given to other groups to be made without any further instructions from the planners. The products and planning were peer-assessed, with clarity of communication, originality of the ideas and suitability for the purpose as criteria. Thereafter the groups were asked to use the guidelines for presentation to plan a presentation on assigned materials such as plastics, wood, metals, etcetera, and finally all groups completed a complete Design-and-Make Project of their own choice, integrating the processes and knowledge that they had learnt. The groups presented their solution to a self-discovered problem to the class.

These methods were applied with both control and experimental groups, since one of the critical outcomes of the curriculum is the development of creative thinking and problem-solving skills. In the enriched programme, however, more explicit attention was given to social aspects, as will be described in section 5.5.2.

5.5.1.3 Attention to the creative context

A problem-based methodology was followed using case studies and contextualizing learning. For both the mentioned groups (experimental and control), group work was used for investigating and solving a problem in a given situation, as well as one of their own choice. Students had to present the problems and later the solutions to the class, in verbal and in written form. The topic of materials was used as content for a group class presentation. They had to use some or other form of drama, rap, puppetry or any other way of presentation to make a certain group of materials (e.g. wood, non-ferrous metals, plastics) interesting and relevant to the class as a whole.

Providing an open atmosphere (table 5.3) in valuing the “incorrect” and “weird” answers could help students to use their imaginations more freely. Opportunities for improving fluency (the generation of large numbers of ideas), flexibility (the generation of different kinds of ideas) and (originality (generation of new ideas)(*cf.* 2.2.2.1, 4.6.1) were provided with both control and experimental groups.

5.5.1.4 Attention to the creative product

As was pointed out in section 2.5.5, one of the creative products expected of students is an original learning programme. Finding, recognizing and choosing situations suitable for classroom activities may be a challenge in itself that requires an open and inquiring mind.

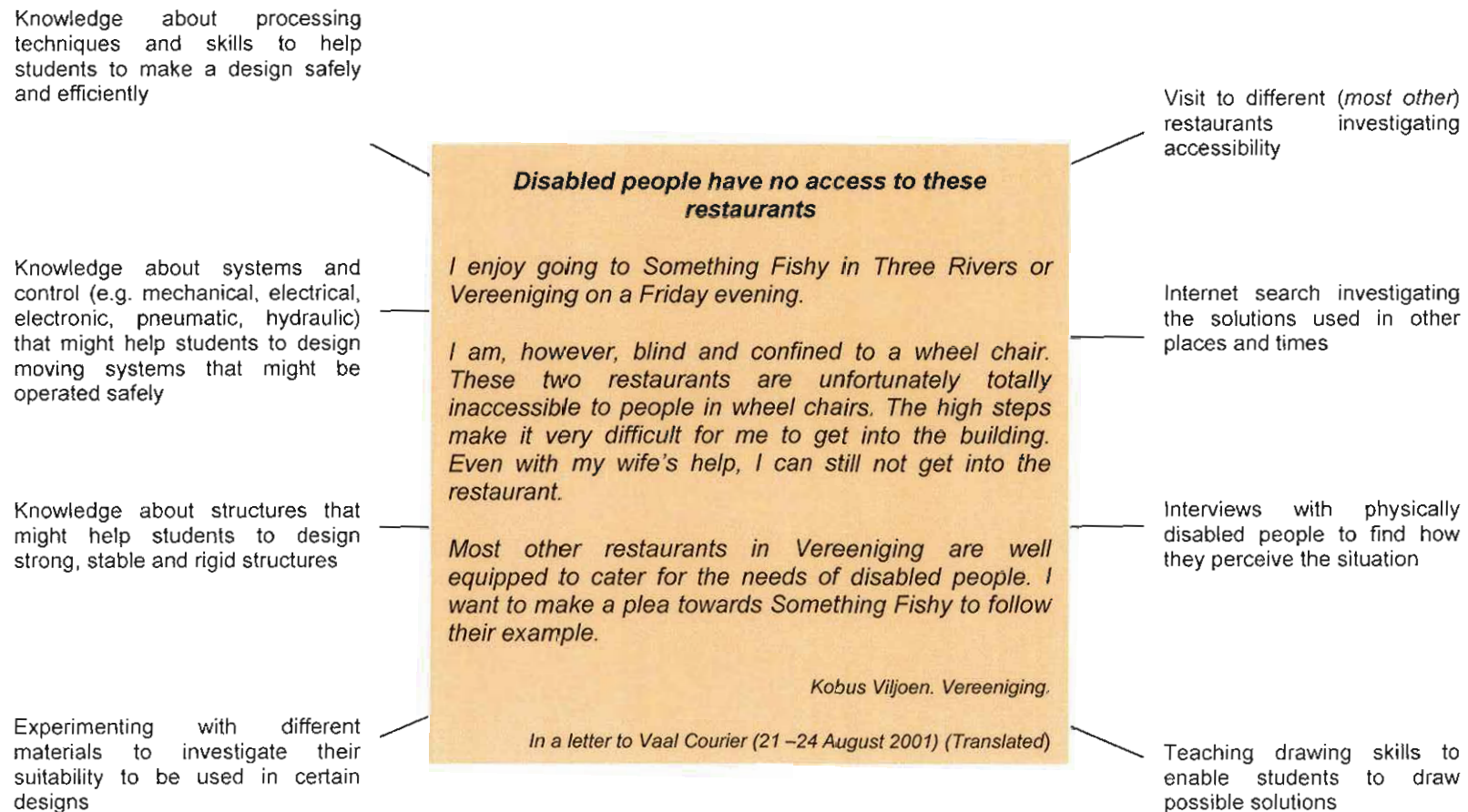
The examples given in figures 5.2 and 5.3 were two activities that were used in an attempt to help students to improve their creative products and fulfil their roles in this regard.

To help students in finding and recognizing the potential of certain situations to be used as appropriate learning programmes, brainstorming opportunities were used as illustrated in figure 5.2. Finding different tasks from a situation depends on divergent abilities such as fluency, flexibility and originality, very similar to those tested by the ATTA test (*cf.* 4.6.1). Once a variety of possible tasks are identified, convergent thinking is used to limit the tasks to those suitable in the specific class situation. This corresponds with the Creative Problem-solving Process (CPS) developed by the Buffalo group (*cf.* 2.3.4.2). Elaboration skills are needed to develop these tasks further into classroom activities.

According to the curriculum requirements, specific contents must be taught to learners at school over a certain period. For the purpose of giving a one-page overview of the Learning programme, the format given in figure 5.3 was developed.

Although this basic programme intended to develop creativity and there were ample opportunities to do so, the question is whether the creativity needed in teachers (*cf.* 1.1, 1.2) was stimulated in reality. Did attention to process skills, for example, do enough to solve problems caused by cultural inhibition? The intervention (enriched *cf.* 5.5.2) programme therefore aimed at enriching /optimizing the given opportunities for developing creativity further, this time by intending to model creative behaviour.

Figure 5.2: Planning a learning programme. Lesson-opportunities from a case study: Using brainstorming to exploit possibilities (only a few possibilities are listed as examples)



5.5.2 The enriched Technology Education programme

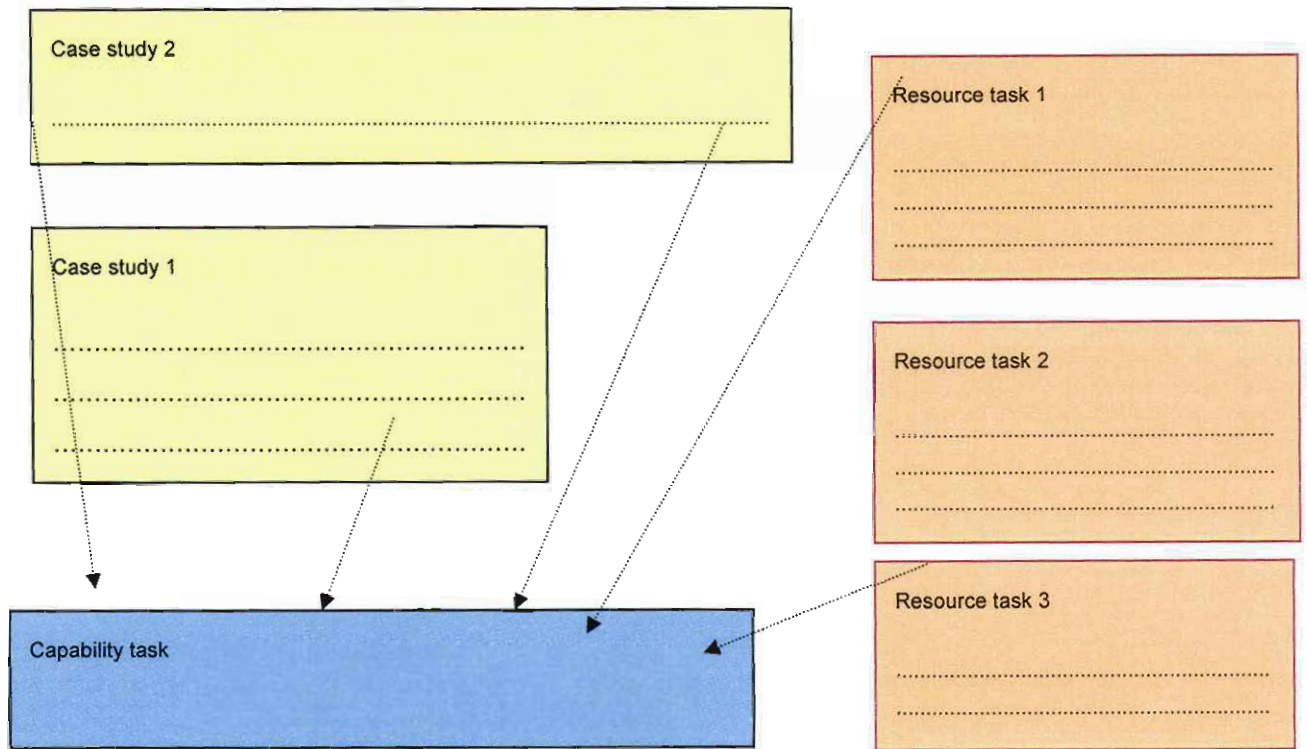
The opportunity provided by Technology Education emphasizing an understanding of the interrelationships between science, technology, society and the environment (*cf.* 5.4.1) was grasped explicitly with the experimental group.

The enriched Technology Education programme to which the experimental groups 2, 4 and 5 were exposed, followed the same basic programme as described above. The methodology was similar to that followed with Groups 1 and 6. The basic programme therefore already addressed creative process skills.

The enriched programme went a little further by also giving specific attention to aspects like:

- Exposure to creative role models (*cf.* 2.4.3.4). Two interventions, namely a literature search about inventors and a reflection on a video of creative teachers used as case study, were executed in this regard. In enhancing these it was hoped that the creative products (*cf.* 2.5) would ultimately be enhanced. The enriched programme attempted to:
- Change the perception of what is considered as desirable behaviour by working in conative and affective domains (*cf.* 2.2.3).
- Trying to *change* the thinking of the student him/herself (**person** *cf.* 2.2) about how he/she views desirable behaviour (as reflected by the **context** (*cf.* 2.4) in which he/she finds him/herself). This was done through modelling creative behaviour (*cf.* 2.4.3.4 and 3.3.3.1) as desirable and acceptable. By providing them with creative role models, the researcher attempted to expose the students to strange attractors (*cf.* 2.4.2.1) that could provide them with models modelling creativity as desirable behaviour.
- *Inspiring* the students and to help them open up their perspectives.
- Explicit idea generation techniques and attitudes. Additional and explicit brainstorming activities, asking for more and more ideas before closure on one optimum idea, were also included to enhance creative process skills further.

Figure 5.3: Format for Learning Programme



Main fields and integrating cross-fields (Mark applicable ones)

	Systems & Control	Structures	Processing
Safety			
Information			
Materials			
Energy			
Indigenous Technology			
Communication			

Learning Outcomes & Assessment standards NCS (Mark the ones applicable)

LO	1. Technological Processes										2. Technological knowledge			3. Technology & Environment		
ASSESSMENT STANDARDS	INVESTIGATE			DESIGN			MAKE	EVALUATE	COMM	Structures	Processing	Systems and Control	Indigenous knowledge	Impact of Technology	Biases	

Assuming that the few “correct” answers that the majority of students tend to give in design tasks were culturally imprinted, it was considered important to provide them with creative role models to signal to them that creative answers were allowed and that it was acceptable to leave the safety of the “oasis” (Perkins in Fischbach, 1996, *cf.* 2.4.2.1). The researcher was of the opinion that the students must be helped to discover that commitment and perseverance (not a wealthy upbringing or belonging to a certain cultural background) are key factors in innovation. This could lead to a belief that own efforts determine success or failure. Rotter (in Mearns:2005) in his social learning theory (*cf.* 2.2.3.2, 2.4.3.1 and 2.4.3.2) explains: “...people are motivated to seek out positive stimulation. Expectancy is the subjective probability that a given behaviour will lead to a particular outcome, or reinforcer”.

If one therefore wants to change behaviour, one should start with perceptions or expectancies.

5.5.2.1 A research assignment: inventors modelling creativity as desirable social behaviour

Firstly the experimental groups two, four and five had to do the following assignment: Research the life and contributions of any three inventors from a list of seventy inventors (details about race, field of expertise and gender were provided). Some of the questions that had to be answered about the inventors were about their sources of ideas and inspiration, the reasons for their success and the impact of their inventions on society and the environment. Many of the inventors on the list came up with inventions that changed the technological progress of humankind despite personal hardships and prejudice. This task fitted well within Technology Education – especially when the technological processes, the impact of technology and biases that exist which limit people’s access to technology were studied.

5.5.2.2 Watching a video and reflecting on creative classroom situations

Early in the course, the experimental group was exposed to creative teachers from a video series, produced during the Creative Classroom Project (1999-2004). This project is the result of collaboration between Project Zero, based at the Harvard Graduate School of Education, and the Disney Worldwide Outreach. It aimed at producing tools and knowledge that will inform and support creativity in teaching (Ritchhart, Moran, Blythe & Reese, 2002). The students used a worksheet (table 5.2) with questions during and after watching the videos. The video session was concluded with a class discussion about how

these teachers stretched the boundaries and grasped opportunities for creative work. The aims with the videos were to change the perspectives of the students to be more open and to create awareness of the fact that creative output was valued specifically in this course. It attempted to stretch them to try to look at situations from different perspectives, avoid premature closure and use their imagination.

5.5.2.3 Idea generation techniques and attitudes creating stimulating classroom atmosphere

Assuming that the below average outcomes of the pre-programme ATTA-tests and the low creative production observed in course work were due to lack of confidence, idea generation skills and attitudes, it was seen as important to create a class atmosphere of acceptance, encourage delayed judgment (resisting premature closure) and teach specific idea-creating techniques.

Besides the exposure to creative role models as described above, additional brainstorming opportunities were provided in class in the enriched programme apart from those provided in the basic programme. Special techniques were taught, such as delaying judgment till a large number of ideas (such as possible learning experiences that could be derived from a specific problem situation (*cf.* figure 5.2) are generated and built on the ideas of others (as observed during CPS training, a personal experience during September 2005 at Paul Roos Gymnasium at Stellenbosch (*cf.* 3.5.3.2)). One person would, for example, mention the idea of a field trip to the *Something Fishy* restaurant to investigate the problem regarding access for disabled people (*cf.* figure 5.2). Another person may build on that and mention field trips to other places with access. Another may mention “*What about our university buildings?*” and another may build on that by mentioning the idea that one must actually see how one can get around on the campus in a wheelchair for a day, and so forth. The use of structured brainstorming as with checklists (*cf.* 2.5.4) (such as combining existing ideas, adding on to ideas, subtracting from ideas, twisting ideas, changing the shape, the re-arrangement of the parts, making it very smaller or larger) was included as class activities. For example, the experimental group in the study was asked to come up with ideas for a new kind of toothbrush in a class session. By changing the shape, they came up with ideas like a horseshoe-shaped vibrating toothbrush that fits inside the mouth. By making the toothbrush extremely small, they came thought of germ-detecting discs. Inversion brought the idea of teeth brushing the brush instead of the brush brushing the teeth. While chewing a substance such as bubblegum, the teeth could be cleaned (this materialized in the new bubblegum with teeth-cleaning particles that became available during 2006, but was imagined by the class of 2005). Free brainstorming activities were

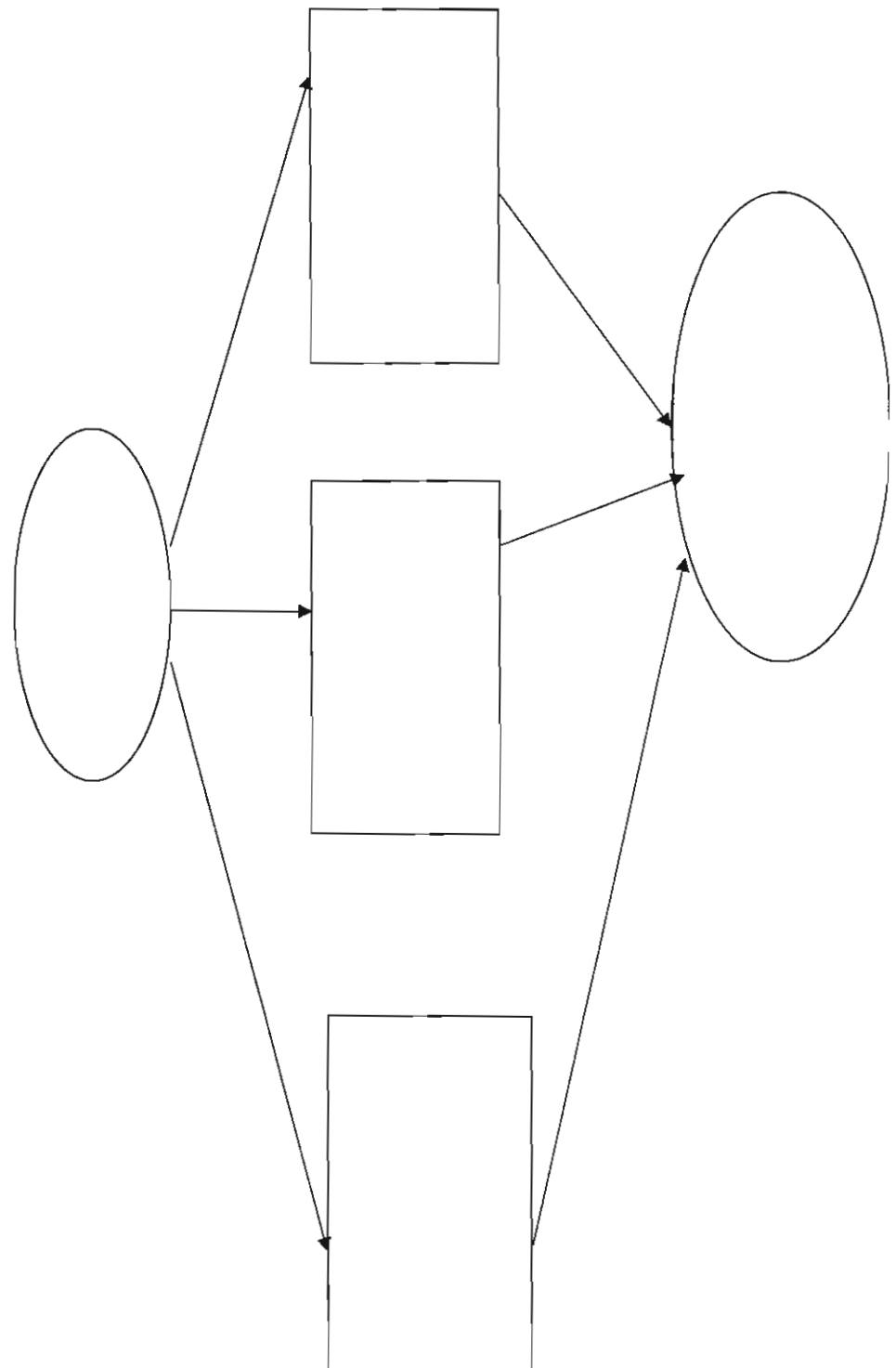
used as part of the technological process, as well as to find ideas for a learning programme from a given situation. The brainstorming procedure was first followed as a guided class activity, then as a small group activity and afterwards as an individual activity. A new situation was used every time.

Table 5.2: Questions used in guiding reflection on video series

Answer the questions about the three teachers in the video: <i>Beantwoord die vrae oor die drie onderwysers in video:</i>	History teacher from Madeira <i>Geskiedenis-onderwyser van Madeira</i>	Teaching the blind <i>Onderrig van blindes</i>	Oysters <i>Oesters</i>
1. Was a problem investigated in this class? If the answer is "yes", what problem? <i>Is 'n probleem in die klas ondersoek? Indien jou antwoord "ja" is, watter probleem?</i>			
2. What content /concepts did the children learn in this class? <i>Watter inhoud/ begrippe het die kinders in die klas geleer?</i>	About..... <i>Aangaande.....</i>	About...../ <i>Aangaande</i>	About...../ <i>Aangaande ...</i>
3. What skills did the children learn in this class? <i>Watter vaardighede het die kinders in die klas geleer?</i>			
4. What attitudes did the children learn in this class? <i>Watter houdings het die kinders in die klas geleer?</i>			
5. What makes this class different? <i>Wat maak die klas ongewoon?</i>			

6. Use the accompanying guideline and compile a flow diagram of the learning programme that the teacher from Madeira followed to show the different activities and their interrelationship to one another.

Volg die riglyn wat hierlangs aan gegee word en stel 'n vloeddiagram saam van die leerprogram wat die onderwyser van Madeira gevolg het – toon die verskillende aktiwiteite aan en hoe hulle met mekaar verband hou.



Project Zero, Disney/ Harvard School (Ritchhart, *et al.*, 2002)

5.6 CRITICAL EVALUATION

In this chapter, the arguments for enhancing creativity are given and the key considerations for enhancing creativity through Technology Education are described. The nature of Technology Education and why it could be seen as suitable for enhancing

creativity in a classroom situation are discussed. The enriched Technology Education programme that was used in this study viewed human development from a social cognitive paradigm. Behaviour is seen as dependent on how a person is acculturated. Some educational practices and cultural beliefs may be hampering creativity, while others encourage it. The basic technology programme was “culturally neutral”, while the enriched Technology Education programme attempted to address certain inhibitory factors that were assumed to be present in some students. The enriched programme focused on providing creative role models from literature and on videos, influencing students’ perception to see creative behaviour as desirable and to value one another’s creative contributions (for example, in class activities such as brainstorming).

The exposure of the students to Technology Education was limited to one 70-minute period per week over a 9-week period. It nevertheless provided an opportunity to attempt to train students to use their creative abilities with more confidence. The results of the different programmes, namely the basic Technology Education programme and the enriched Technology Education programme that were described in this chapter, will be given and discussed in chapter 6.

5.7 SUMMARY

In this chapter the basic – and enriched programmes for developing creative thinking abilities in Technology Education with pre-service teachers at the North-West University, Vaal Triangle campus, were highlighted. The next chapter will focus on the data analysis and interpretation.

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about earning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER SIX

DATA ANALYSIS AND INTERPRETATION

6.1 INTRODUCTION

The results of two studies will be handled in this chapter. First the results of the *ex post facto* study will be discussed. This study attempted to understand what the situation is regarding creativity when the participants enter the course and find possible reasons for this situation. Thereafter, the results of the quasi-experimental study that attempted to see what the effects of Technology Education programmes were on the creativity of the participants, will be reported.

6.2 STUDY 1: THE *EX POST FACTO* STUDY

The *ex post facto* study attempted to understand the relationships between different contextual factors, personal factors, perceptions resulting from differences in upbringing, schooling and so forth and creativity (creativity index and creative abilities, *cf.* 4.6.1) in the pre-programme ATTA. They will be discussed in the following sequence:

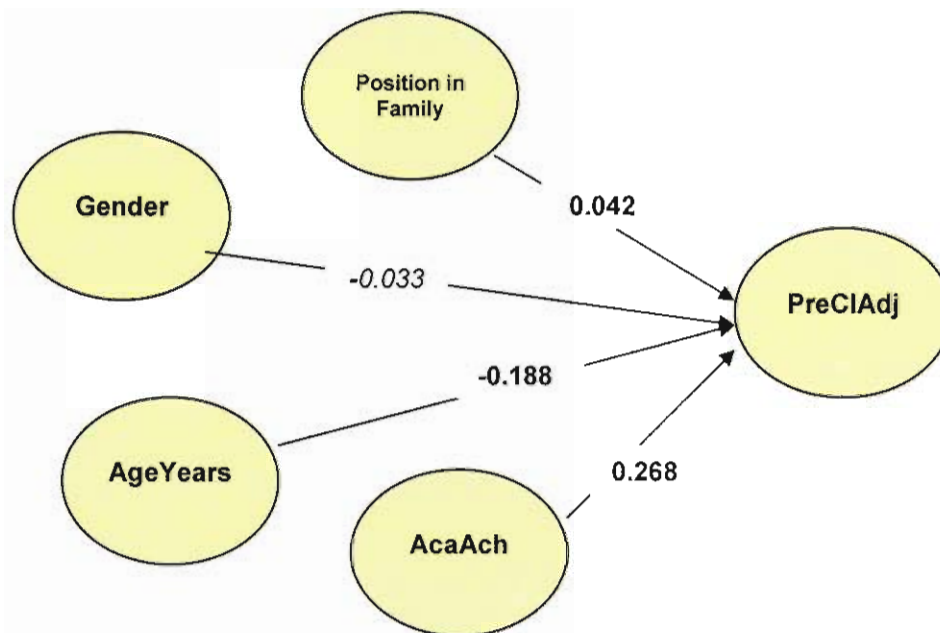
1. Personal factors and creativity index
2. Process factors and creativity index
3. Contextual factors and creativity
4. Relationships between context and creativity
5. Relationships between contexts and perceptions about context
6. Relationships between perceptions about contexts and creativity
7. Relationships between contexts, perceptions about context and creativity
8. Integration of contextual factors, process factors and creativity

6.2.1 Personal factors and creativity index

Assumption 1: Personal factors like academic achievement (as measure of academic ability); age, gender and position in the family may influence creativity.

According to the null hypothesis H_0^1 , personal factors have no significant influence on the creativity of participants participating in this study. Model 1 was used to explore the relationships between personal factors and creativity index. All participants were used to explore these relationships.

Figure 6.1: Model 1: Personal factors and creativity index



The only personal factor modelled in model 1 (figure 6.1) that showed a path coefficient larger than 0.2 was academic achievement in Technology Education ($AcaAch = 0.286$). Age ($AgeYears$) had a path coefficient of nearly 0.2, namely -0.188. According to Chin (1998:7), “Standardized paths should be around 0.20 and ideally above 0.30 in order to be considered meaningful....., paths of .10, for example, represents at best a 1 percent explanation of variance.” The relationships between creativity and these two personal variables, will be discussed in detail and the remaining two variables, namely position in the family ($FamiPos$) and gender ($Gender$), will be explained briefly.

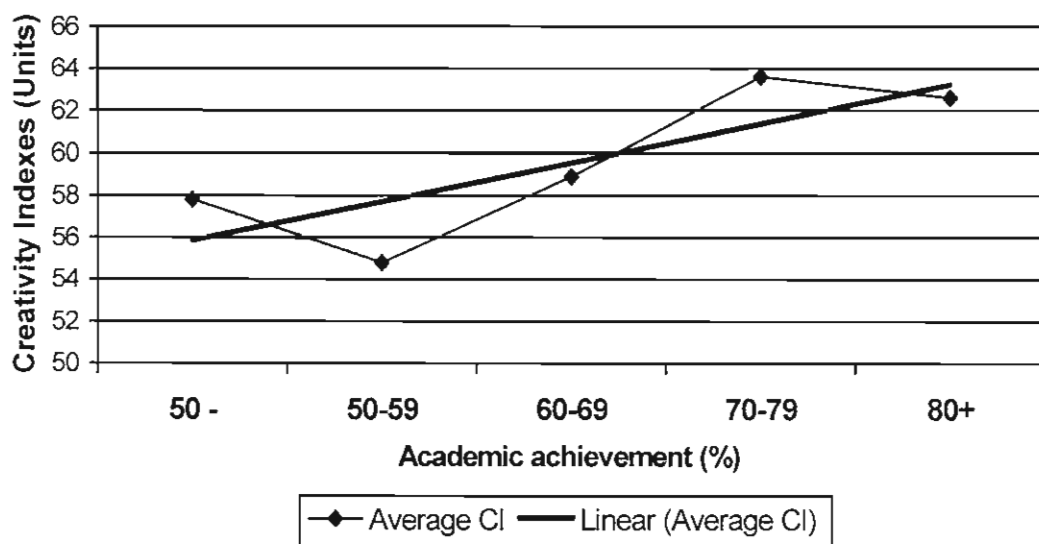
6.2.1.1 Academic achievement

From model 1 it became clear that the strongest predictor of creativity index in this model was academic achievement ($AcaAch = 0.286$). With stronger academic achievement, the chances that the participants will have a higher creativity index improve. This relationship is, however, not as simple as it may seem at first glance. The results, as portrayed in table 6.1 and figure 6.2, of the relationship between academic achievement and creativity indexes give a more detailed breakdown of the situation.

Table 6.1: Average examination results of Group 1-6 1st year Technology Education participants when compared to their average creativity indexes

AcaAch (%)	50 -	50-59	60-69	70-79	80+
Total CI	925	2300	3239	3567	2316
Average CI	57.8	54.8	58.9	63.6	62.6
N	16	42	55	57	37

Figure 6.2: Average examination results of Group 1-6 1st year Technology Education participants when compared to their average creativity indexes



Although the overall trend is that the higher the academic achievement, the higher the creativity level (see trend line in figure 6.2), it is interesting to see that the participants who scored below 50% in the examinations scored higher regarding creativity than those who scored between 50 and 59%. Moreover, those who achieved between 70 and 79% in the examination scored higher regarding creativity than those that scored above 80%.

To explore this relationship further, creativity level (a simplified version of the creativity index (CI) (refer to tables 4.5 and 6.2 to see how CI and creativity level relate) was taken as the independent variable and academic achievement was plotted as a function of creativity level in figure 6.3. This again indicated that very high achievement and very high

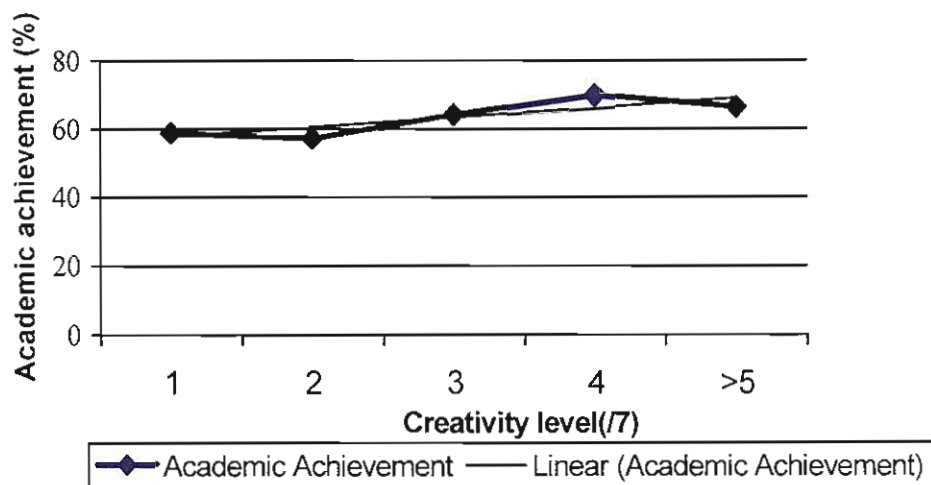
creativity levels do not necessarily go hand in hand. Those participants with higher than average creativity levels of 5 and 6 are not necessarily the high achievers in the class. In this study, they scored an average of 66.6% when compared with 70.3% for the participants who tested on creativity level 4 (average). This means that the higher the creativity levels, the higher the marks up to creativity level 4, after which a higher academic achievement ceases to relate to a higher creativity level and *vice versa*. Moreover the average academic achievement of the participants who tested on creativity level 1(very low) scored slightly better academically than those participants on creativity level 2.

This may emphasize a number of aspects: creativity is not the same as academic achievement and examination papers test more than creative abilities. Creativity and academic abilities are related, but are not necessarily directly correlated. High academic ability does not guarantee high creative abilities and *vice versa*.

Table 6.2: The relationship between creativity level and academic achievement in Technology Education in all first year B Ed participants participating in this study (N = 207)

CI	<50	50-59	60-67	68-73	74+
Level	1	2	3	4	>5
Total	171	286	534	211	100
Frequency	29	50	83	30	15
Academic Achievement	58.9	57.2	64.3	70.3	66.6

Figure 6.3: The relationship between creativity level and academic achievement in Technology Education of all the participants in this study (N =207)



6.2.1.2 Age

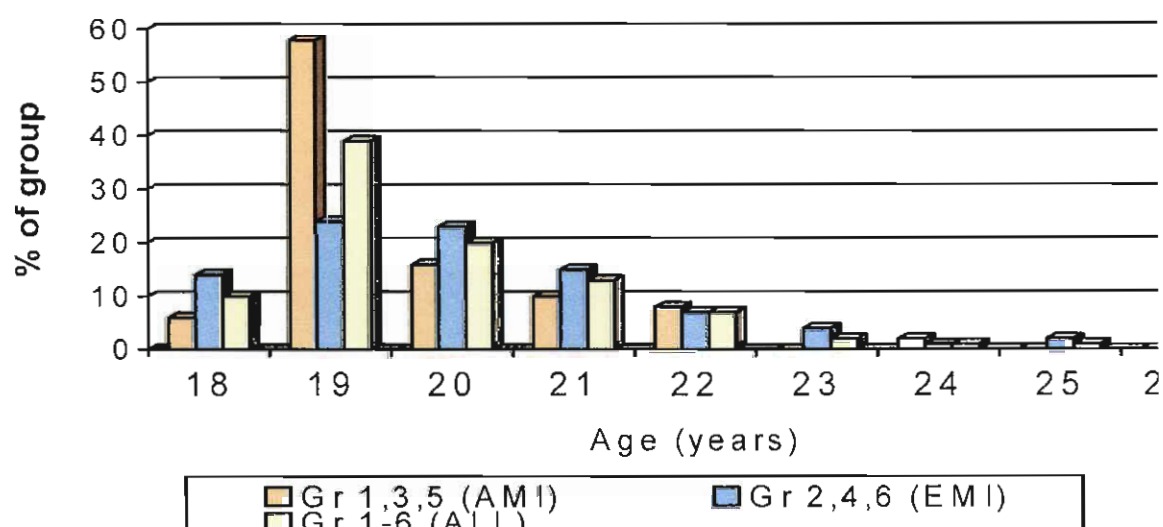
Age (*AgeYears*) was the other personal variable that showed a path strength greater than 0.1 (-0.188) in the PLS model 1. The older the participants were, the lower were their creativity indexes.

As is seen in table 6.3 and figure 6.4, the majority (49%) of the participants who enrolled for first year B.Ed courses are between 18 and 19 years old, coming straight out of school. A higher percentage of the participants of groups 1, 3 and 5 (64%) than of groups 2, 4 and 6 (38%) fall in this category. The ages in the AMI group range between 18 and 24 (a range of only 6 years) and those in the EMI group between 18 and 39 (a range of 21 years). The average age of groups 1, 3 and 5 (Afrikaans Medium of instruction (AMI)) is 19.7 years and that of groups 2, 4 and 6 (English medium of instruction (EMI)) is 21.1 years. The age difference of a little more than a year may be related to a number of factors: a higher incidence of contextual factors leading to late school entrance, failing a year at school, working before enrolling for studies at the university or other training before starting at the university, with a purpose such as getting finances or building up the required m-count to gain entrance to the university.

Table 6.3: The age distribution in Group 1 to 6

Age (Years) Group	18	19	20	21	22	23	24	25	25+	Average age
Gr 1, 3 and 5	5 6%	52 58%	14 16%	9 10%	7 8%	0 0%	2 2%	0 0%	0%	19.7
Gr 2, 4 and 6	16 14%	28 24%	27 23%	18 15 %	8 7%	5 4%	1 1%	2 2%	13 11 %	21.1
Gr 1-6	21 10%	80 39%	41 20%	27 13%	15 7%	5 2%	3 1%	2 1%	13 6%	20.5
%	49%		33%		9%		8%			

Figure 6.4: Age distribution of different groups of participants. Afrikaans medium of instruction (AMI) compared with English medium of instruction (EMI) and total group (ALL)



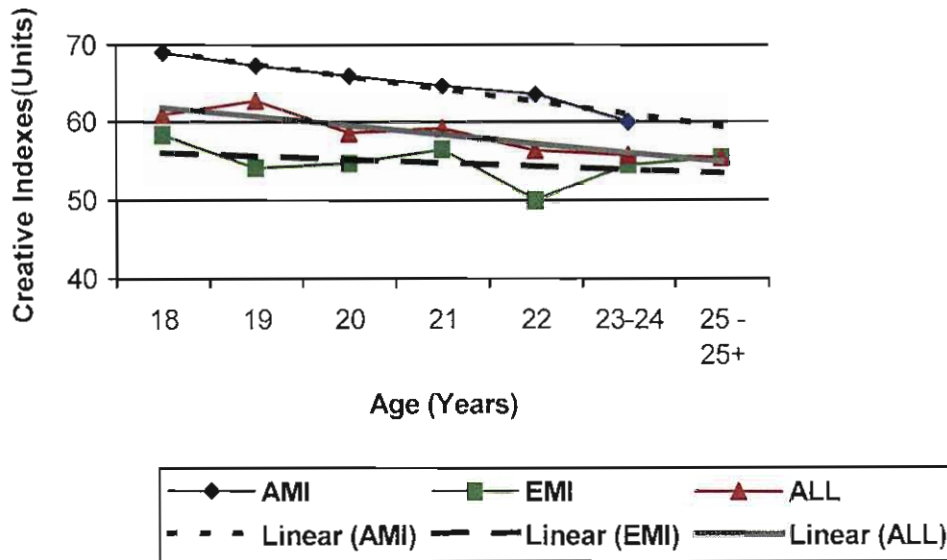
Age and levels of creativity: A general downward trend (as also apparent from the negative value in model 1, figure 6.1) is seen in creativity index as age increases in the first year education participants, as illustrated by the data in tables 6.4 and figure 6.4. The slightly declining trend in creativity level as age increases is seen with all participants, no matter what their backgrounds were.

The 18-19-year-olds, although not part of the OBE-curriculum as such, may have benefited indirectly from the change in emphasis of the curriculum and the training that teachers received over the past eight years using more student-centred and problem-solving methods. The decrease of creativity index (CI) with increasing age may be affected by the observation that the younger participants at this university often come from schools in the immediate vicinity of the university. They may have a network of friends, whereas the older participants may come to the university as individuals with little support. This may affect their confidence (especially at the beginning). Older participants may have worked for a few years after school. The downward trend of the CI as age increases may indicate that the workplaces that these participants were exposed to may have been inhibiting creativity more /or encouraged it even less than schools. It may perhaps indicate that the older participants opting for the education degree have less creative personalities. It may also indicate that the younger participants are more confident and less inhibited than the more mature participants.

Table 6.4: Age distribution in the different groups of 1st year education participants, namely: Afrikaans medium of instruction (AMI), English medium of instruction (EMI) and all compared with the creativity indexes (CI)

Age (Years)	18	19	20	21	22	23-24	25-25+	N
AMI (N)	5	52	14	9	7	2	0	89
Average CI	69	67.3	66	64.7	63.57	60	n.a.	
EMI (N)	16	28	27	18	8	6	15	118
Average CI	58.3	54.1	54.7	56.5	50.1	54.5	55.5	
ALL (N)	21	80	41	27	15	5	13	207
Average CI	60.9	62.7	58.6	59.22	56.4	55.8	55.5	

Figure 6.5: Creative index correlated with age



6.2.1.3 Gender and position in the family

The variables gender (*Gender*) and position in the family (*FamiPos*) showed only weak and in reality meaningless relationships in the model 1 (figure 6.1). The relationship between gender and creativity index showed an indirect relationship (-0.033). One (1) was used to indicate male and two (2) female participants. The indirect relationship therefore indicated that the female participants were slightly, but insignificantly more creative than the male participants.

The positive relationship between position in the family and creativity index, indicated that the later born children (2 and higher) showed higher creativity indexes than the first-born children in the families (Simonton, 1988:412). Looking at the profiles of the participants with creative level scores of 5 and 6 and those who scored 1 we also see the pattern as described above. Only thirteen participants out of groups 1 to 6 scored 5 (CI = 74 to 77) and only two scored 6 (CI = 78 or above) in the pre-test (after it had been adjusted as explained in chapter 4). Out of the fifteen who scored 5 or 6, four were eldest, nine youngest (60%) and two middle children in their respective families. Thirteen (13) out of the twenty-nine participants (45%), with creative level scores of 1 (CI- scores smaller than 50), were first-born participants while six (20%) were the youngest in their families.

This seems to contradict findings by researchers such as Simonton (1988:412) who places the firstborn child in the position of being the most likely to be eminent. Simonton explains

the eminence of firstborn children in terms of Zajonc's "*confluence model*". The amount of environmental stimulation that the firstborn receives is credited. One must, however, remember that what is illustrated in this study are not eminent geniuses, but ordinary creativity that might still (or might not) blossom into eminency. Furthermore, other characteristics besides creative abilities (such as intrinsic motivation and certain personalities) may be involved in determining whether a person will become eminent or not.

6.2.1.4 Conclusion

These findings lead the researcher to reject the null hypothesis H_0^1 , and accept the alternative hypothesis H_a^1 . Creativity is related to personal factors. As could be expected, the relative influence of the different factors differs. In the simple model in figure 6.1 only four factors were considered and only direct relations between them and creativity index were modelled. Many more factors may be included in a model to determine the direct and indirect influences of personal factors.

6.2.2 Process factors and creativity index

The break-down of the ATTA into the different creative abilities may shed some light on the weak and strong points of the participants when they started with the Technology Education programmes. These abilities are needed during the creative process (that forms part of the technological process (*cf.* 2.3)) if problems are to be solved in creative ways. The creative abilities, namely fluency, originality, elaboration and flexibility, are discussed in more detail in chapter 4.

Assumption 2 assumed that certain cognitive abilities or skills are important in the creative process. These skills can be transferred from one person to another through modelling by example, mentoring and mediation (*cf.* 2.4.3.5). The null hypothesis H_0^2 stated that there is no difference in the strength of the relationships between creativity index and the different creative abilities used in the creative process in the participants in this study.

Model 2 (as depicted in figure 6.6) shows the relationships between different creative abilities and CI in this study. It shows that some creative abilities were strongly related and others weakly related to the differences in creativity index in the participants in this study.

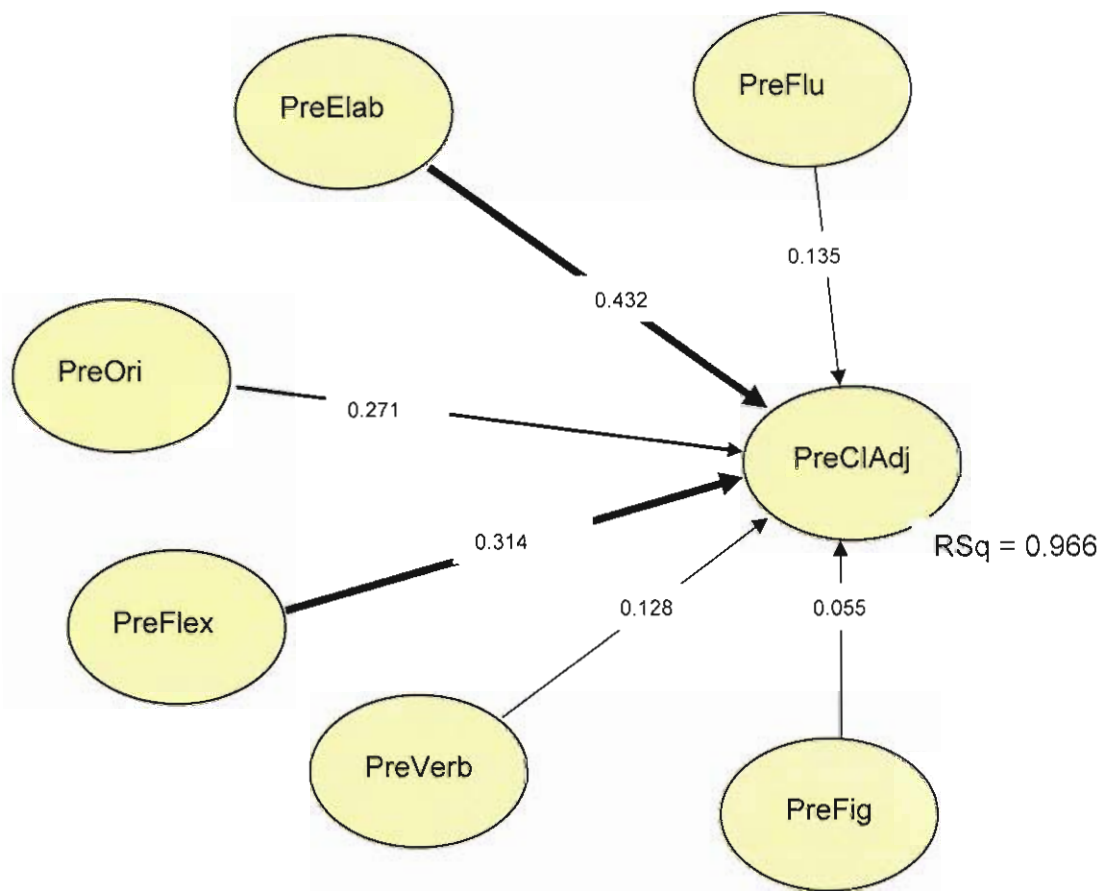
The six abilities shown in model 2, the four creative abilities plus the two creativity indicators, namely verbal and figural, explained 96.6% of the variance in the Pre-ATTA

test. The strongest relationships shown in this model are those between creativity index and elaboration (0.432) and flexibility (0.314). How unusual the ideas were (originality) correlated fairly strongly and positively with the CI (0.271). This indicates that these abilities contributed most to the difference found in the creativity indexes of the participants. Participants with the inability to elaborate (write or draw more details) or be flexible (write or draw ideas from different categories) scored lower. Most participants who got a score of less than fifty in the creativity index (Creativity Level 1) had scores of zero for elaboration (23 out of 29 or 79%). Quite a number of participants with CIs below 50 scored 0 for flexibility (11 out of 29 or 38%). This was a surprise to the researcher who expected that it would be the number of ideas given (fluency) that would make the big difference. Also the verbal and figural indicators had smaller correlations. The weakest relationship was with pre-test figural indicators (0.055).

This information implies that elaboration and flexibility are the areas of greatest need regarding creativity process skills. Interaction between the different creative abilities was not modelled in this simple model.

These findings lead the researcher to reject the null hypothesis H_0^2 , and accept the alternative hypothesis H_a^2 . Some creative abilities such as elaboration and flexibility influencing the creative processes, are more of a problem for participants than others.

Figure 6.6: Model 2: Process skills contributing to creativity index



6.2.3 Contextual factors, creativity index and creative abilities

Contextual factors will be discussed under the following three headings: Contextual factors and creativity, contextual factors and perceptions about the context and perceptions about the context and creativity. Models 3, 4 and 5 tried to investigate the possible direct and indirect relationships between contextual factors and creativity. It further tried to determine whether perceptions about the context are implicated in creativity and whether these perceptions are related to the context. It lastly attempted to see how the whole web of context, perceptions about context and creativity interact. Models 3, 4 and 5 tried to determine whether the null hypotheses H_0^3 , H_0^4 and H_0^5 must be accepted or rejected. The participants in groups 3, 4, 5 and 6 ($N = 162$) were used to test these hypotheses where perceptions were included, because they were the ones who completed both the biographical and perception questionnaires, as well as the ATTA. When perceptions were not included, the whole group of participants ($N=207$) was used to make maximal use of the available data.

6.2.3.1 Contextual factors and creativity

Assumption 3 stated that contextual factors such as socio-economic factors, cultural emphasis on conformity, a family and/or school culture that discourages innovation and the lack of training to value novelty and think creatively might be responsible for the inability of participants to seize opportunities for creative work.

The null hypothesis H_0^3 , hypothesized that there are no relationships (direct or indirect) between contextual factors and creativity. Model 3 was used to model these relationships with Visual PLS.

The latent constructs that were composed of a number of measured variables, namely family factors (*FamFact*) and socio-economic factors and acculturation factors (*SocioAcc*) had fairly good construct reliabilities in this model. The reliability statistics differed slightly from those used in model 4 onwards where perceptions were included (see table 6.6). The reason for this, as explained earlier, is that the data used in model 3 were from groups 1 to 6 (N=207) and in model 4 and onwards, the data from only groups 3 to 6 (N=162) (or in model 4 sub-groups thereof) were used. The values for composite reliability for the whole group were 0.730765 for *FamFact* and 0.880651 for *SocioAcc*. (Attempts to model parental education and socio-economic factors separately led to multi-co-linearity problems that manifested as sign changes (Kennedy, 2002:1-13)). The AVE values for these two constructs were 0.485176 and 0.711351 (with square roots well above 0.5, as recommended by Gefen and Straub (2005: 94) on 0.6965 and 0.8434 respectively) and the Cronbach-Alphas were 0.510384 and 0.799203 respectively.

After running the model, insignificant paths with values below 0.1 were trimmed away as well as constructs with R^2 -values of less than 0.015. This necessitated the removal of paths from family factors to CI and from *SocioAcc* to CI from the model. The first was removed due to a very low path coefficient and the second because its sign-change showed that multi-collinearity existed. It was already represented in the other paths through school model, role model and family factors (Kennedy, 2002:8). The results obtained with the trimmed model are given in the model 3 in figure 6.7. The very weak insignificant path between role model and CI (0.008) was retained because it was of specific interest to this study. The value of the coefficient was too weak to be definitely positive or negative (non-stationarity) and another model (model 4 in figure 6.10) was used to explore the relationships of the choice of role models with contextual factors and creativity.

In model 3 (in figure 6.7) 34.0% of the variance of the construct Adjusted Pre-Programme Creativity index (*PreCIAdj*) is explained by the contextual variables, namely culture, role models, school model, *SocioAcc* and family factors. Similarly, the model explains 51.6% of the construct school model (*SchoMod*). 51.8% of the variance of the reflective latent endogenous construct *SocioAcc* is explained by the factors that contribute to it in the model, namely family factors, culture and the measured exogenous factors, namely SEI (measured on a scale from 0-10) and mother and father's educational levels (*FaEd* and *MoEd*), (measured on a scale from 0 to 13). 3.5 % of the variance in the construct role model is explained by the factors feeding into it, namely *SocioAcc* and the choice of role model (0 indicated no or self as role model, 1 indicated mother or female relative, 2 father or male relative, 3 teacher, 4 celebrity and 5 public leader. The sequence was chosen to represent concentric spheres circling out from the most intimate (proximal) relationships to further away (distal)). The formative latent construct, family factors, (*FamiFact*) consisted of the measured factors family trauma (no trauma like death or divorce in the family was indicated with 1 and trauma with 2), family size (*FamSiz* =number of children), family status (*FamStat* with two parents living together as indicated with 1 and other situations like living with grandparents with 2).

Strong relationships with values of 0.55 and above were found between culture and *SocioAcc* (-0.585), *SocioAcc* and school model (*SchoMod*) (-0.664). Significant paths with values > 0.30, but < 0.50 were found from school model to creativity index (*PreCIAdj* = -0.386) and values > 0.20, but < 0.30 from *FamiFact* to *SocioAcc* (-0.251) and from culture to creativity index (*PreCIAdj* = -0.216). The *SocioAcc* was weakly and negatively related to the choice of role models (*RoleMod* = -0.186), which was in turn very weakly related to *CI* (*PreCIAdj* = 0.008).

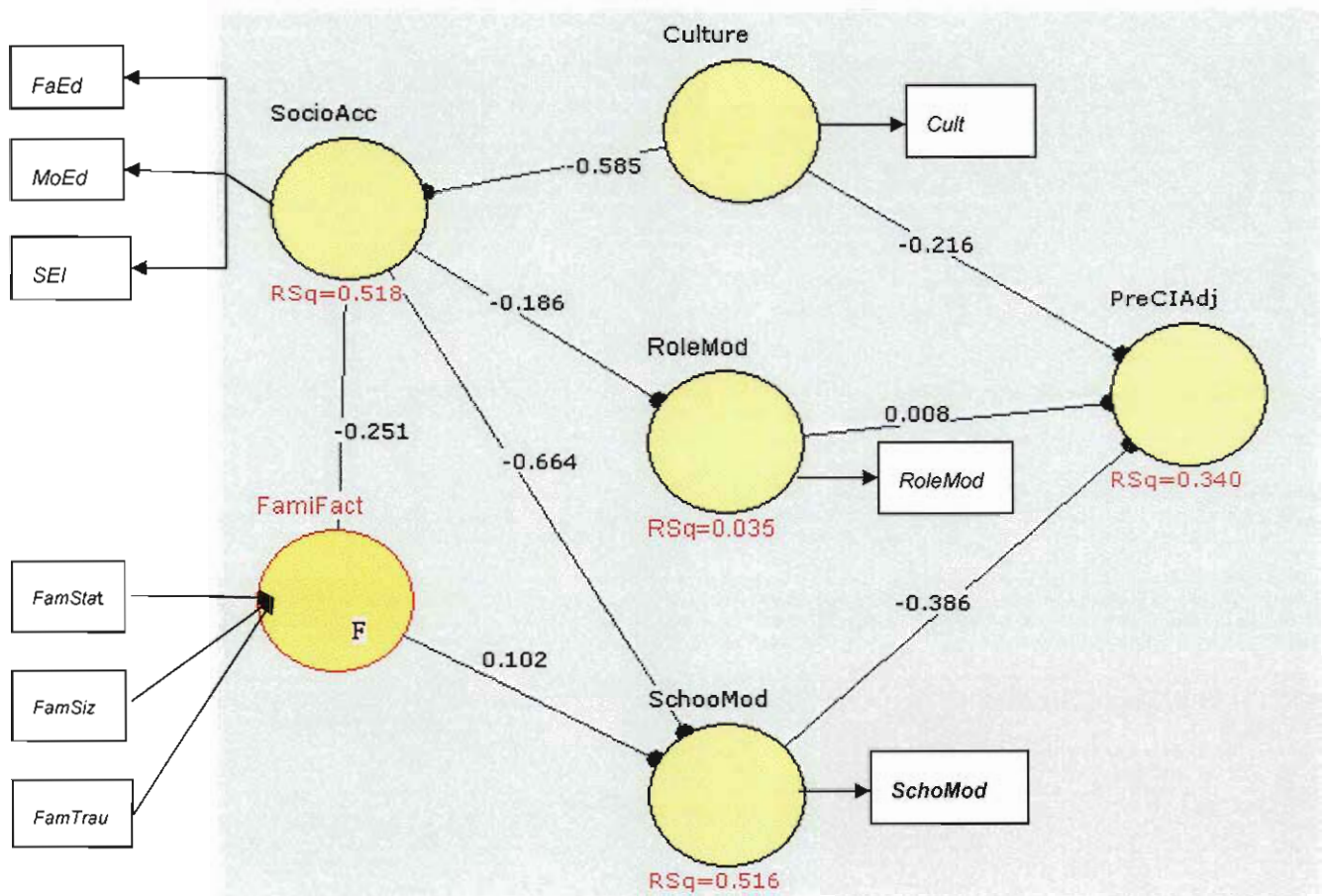
The relationships found in this model are discussed below:

- *Culture to CI (-0.216)*. Culture 1 is non-African culture and culture 2 indicates African culture. For various reasons, discussed in detail in chapter 2.4 and to be discussed later, the educational practices in Western culture seem to encourage high levels of creativity when compared with other cultures, e.g. African and Asian. In this study, the creativity indexes of the participants from non-African cultures were also higher than those of participants from African cultures.
- *School model to CI (-0.386)* The school model 1 represented previous model C schools with teachers from mainly non-African cultures, whereas school model 2 represented township schools with teachers from mainly African cultures. The negative

relationship shown here between culture and CI, links with that of the cultural transfer through modelling and mediation.

- *Culture to SocioAcc (-0.585) and family factors to SocioAcc (-0.251)*. Participants from culture 1(non-African) came from more well-to-do families than those from culture 2, explaining the negative relationship between culture and socio-economic factors. The parents of participants from Culture 1 (non-African) were better schooled (Grade 11.9 and 11.4 for father and mother respectively) than those from Culture 2 (African) whose parents had much lower schooling (Grade 7.5 and 8.3 for father and mother respectively). Participants who were more well-to-do, were more likely to come from households with two parents. 79 % (86 /109) of culture 1 came from households with two parents and 47% (46 / 98) of the participants from African culture lived in a two-parent-household. Where parents had a higher education and where the household consisted of two parents, the family situation was generally less deprived.
- *SocioAcc to school model (-0.664)*. The better the socio-economic position (closer to 10) and the higher the parental education (closer to 13), the more likely it was that the participants attended previously model C schools (indicated with 1).
- *SocioAcc to role model (-0.186)*. The better the economic status and the parental education of the parent, the more likely it was for the student to choose a role model closer to home (closer to 1). The general tendency shown by the trend line (in figure 6.8) and indicated by the regression coefficients in the PLS model (figure 6.7) indicates that the closer to home the choice was, the higher the creativity indexes were. This relationship is not as simple as that. As is shown in table 6.5 and figure 6.8, the participants who chose their father as role model had the highest creativity indexes, whereas those who chose political and other leaders as role models had the lowest creativity indexes.

Figure 6.7: Model 3: Contextual factors and creativity Index

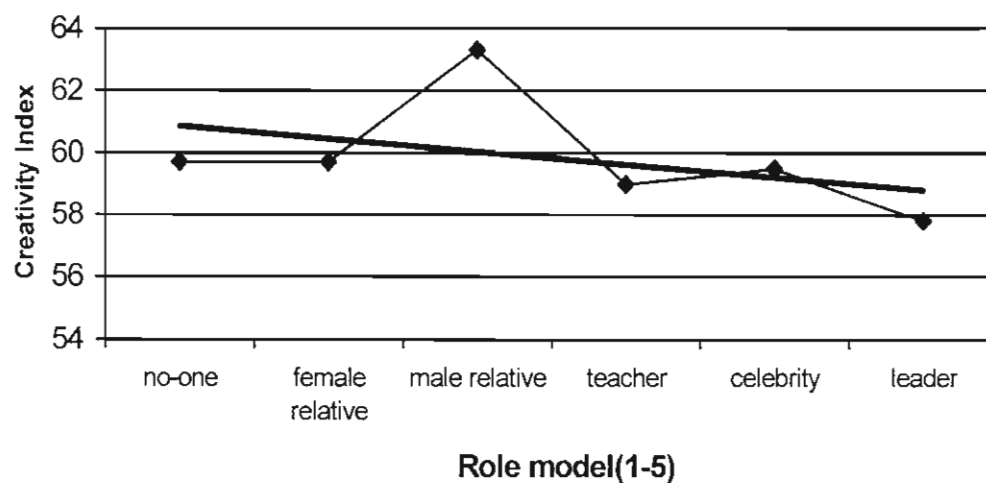


Generally, the following observations were made in the choices of role models: Family members, and specifically the mother, were the most popular choice in all the groups irrespective of culture, age or gender. Celebrities rated second in all groups and teachers third. The low popularity of teachers is surprising, considering that all these participants selected teaching as their career. Social and religious leaders were more popular in the African groups, than in the non-African groups. Mr Mandela was the most popular social leader. This may reflect on the low profile of non-African leaders in the current political situation in South Africa and the high profile of African leaders. It may further indicate that race plays a role in who people aspire to be like. Another difference is that male relatives (fathers, brothers) were as popular as celebrities in the non-African groups whereas they were not strongly supported in the African groups. This may be connected to the statistics mentioned above, showing that only 47% of the African participants came from households with two parents living together, in comparison with 79% in the non-African cultural group, indicating the possibility that the absence of a father leaves a mark on the creativity of the children.

Table 6.5: Choice of role model related to creativity index

	Level of exposure and intimacy of relationship decreases 						
Role model	Self or No-one	Mother	Father	Teacher	Celebrity	Leader	N
Numerical value	0	1	2	3	4	5	
Creativity index	59.7	59.7	63.3	59	59.5	57.8	
N	19	89	31	15	36	17	207

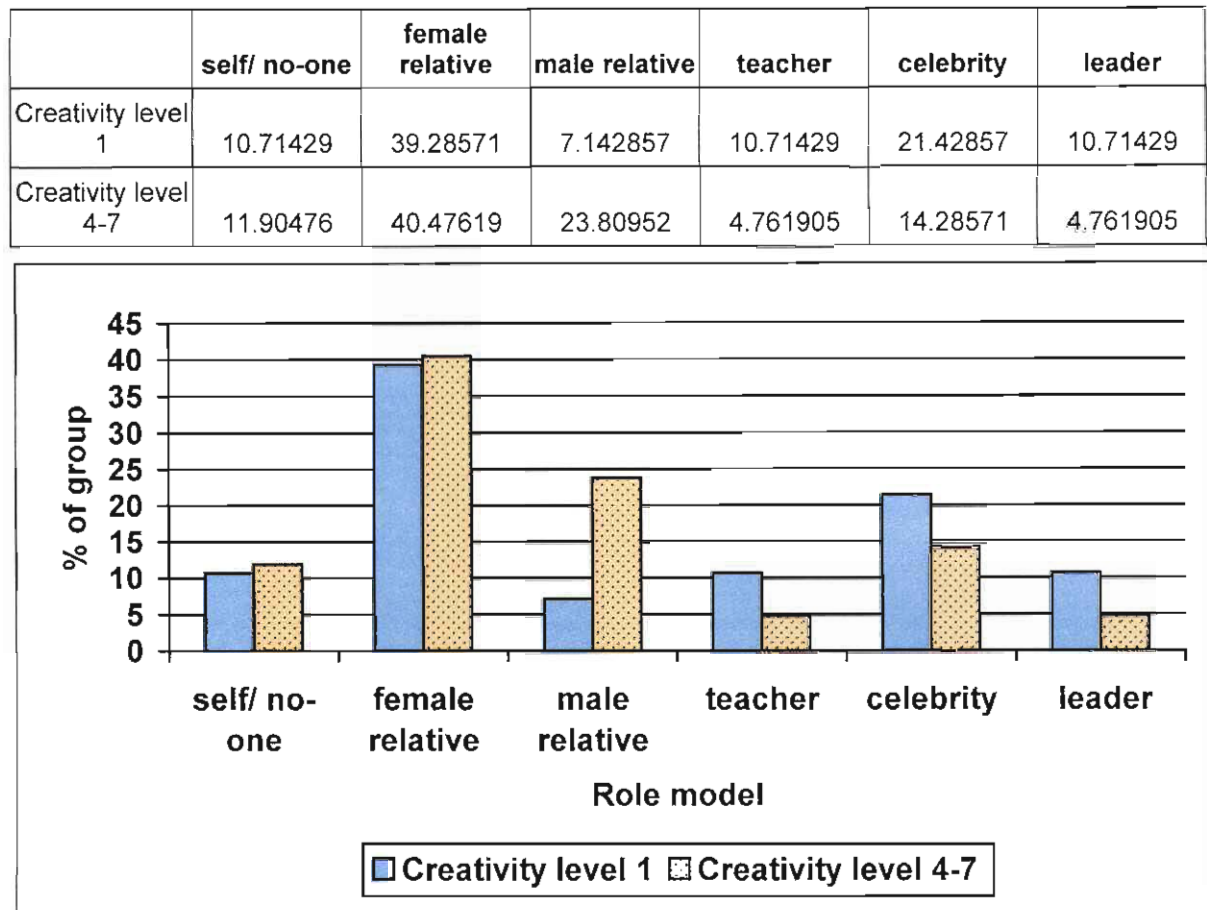
Figure 6.8: The relationship between choice of role model and creativity index



In table 6.5, the relationship between choice of role model and creativity index is shown and figure 6.8 represents this data graphically. In figure 6.9, the choices of participants who tested very low in the ATTA (creativity level 1) are compared with those of participants who obtained above average (4 and above). Although it must be remembered that these are weak relationships, both these graphs, 6.8 and 6.9, may point to the important role of the involvement of the parents in the lives of the children as a contributor to the development of creativity. Celebrities and public leaders are paragons (*cf.* 2.4.3.4): far away and not observed and followed in the minute details of everyday life in the way one thinks and the way one solves problems. One sees in these paragons the result of these day-to-day processes, but not the process of acquiring them. In the life of the developing child, these intimate interactions and support may be factors that make a

difference.

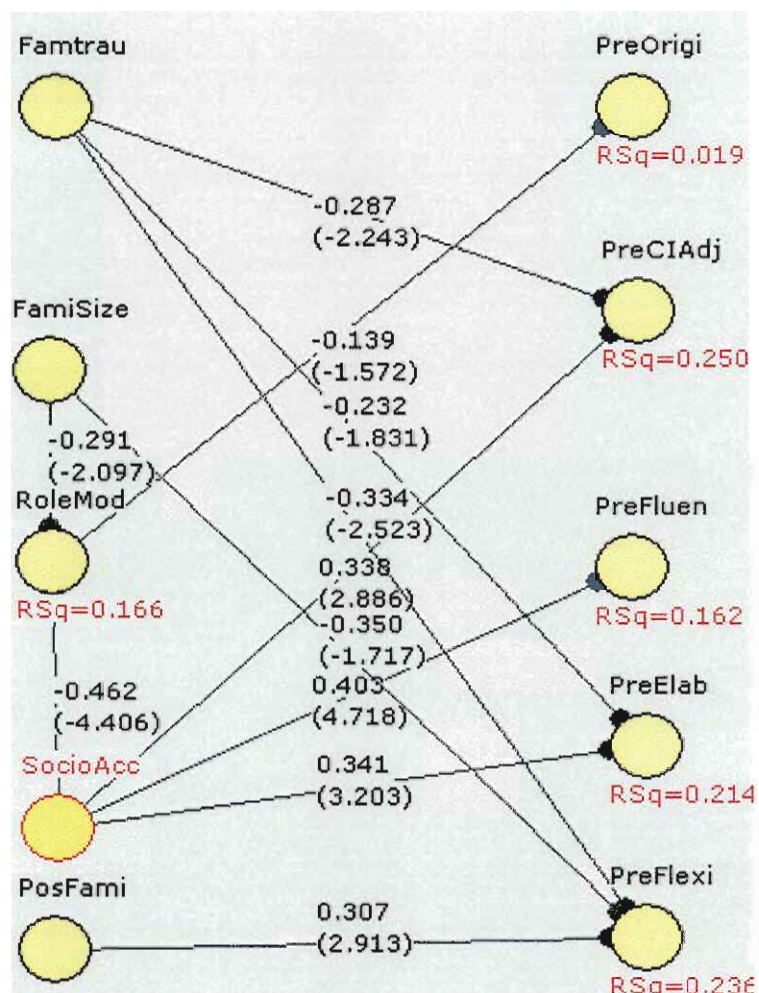
Figure 6.9: Comparison of choices for role models in participants who tested on creativity level 1 in the pre-programme ATTA with those who obtained 4 and above



After observing the relationships between role models and creativity as described above, the researcher decided to leave the choice of female relative and no-one out of the model and select only the cases who chose male family members (2), teachers (3), celebrities (4) and public figures (5). Data from groups 3 to 6 were used. Eighty-one participants chose male relatives, teachers, celebrities and social leaders (>1) as role models and they remained in the data matrix for model 4 (Figure 6.10). This model explored the relationships among the contextual factors and creativity and creative abilities (process skills), namely fluency (*PreFluen*), originality (*PreOrig*), elaboration (*PreElab*) and flexibility (*PreFlexi*). The contextual factors were *SocioAcc*, role model (*RoleMod*) and the micro-contextual factors, that were modelled as part of the construct family factors in the other models, namely trauma (*FamTrau*), family size (*FamSize*) and, as part of personal factors in model 1, position in family (*PosFami*).

The proposed model 4 (*cf.* figure 4.6) was trimmed heavily to remove all the insignificant paths. The final model (figure 6.10) explained 25% ($R^2=0.250$) of the variance in creative index, 16.2% of the variance in fluency, 21% of the variance in elaboration and 23.6% in the variance in flexibility, while only 1.9% of the variance in originality was explained. Position in the family affected flexibility significantly (0.307) with a medium effect (Cohen in Howie, 2002: 99), meaning that the younger children in the family showed greater flexibility than the older children. *SocioAcc* had positive and significant relationships with respectively elaboration (0.314 = medium), fluency (0.403= large) and the creative index in total (0.388 =medium). The higher the socio-economic index and the higher the parental education, the higher these creative abilities were. Family size related negatively and significantly (-0.350 = medium) to flexibility. It means that the smaller the family size, the more likely it was that the participant showed the ability to view the situation from different perspectives. The absence of family trauma contributed to flexibility (-0.334= medium) and elaboration (-0.232 = small). The only creative process skill that related with a path coefficient of more than 0.1 to role model, was originality (-0.139 = small). Choosing a male relative, mainly the father, was related weakly to originality and significantly to the size of the family: the smaller the family size, the more likely it was that the child would choose the father (0.291 = medium). The higher the socio-economic situation, the more likely it was that the participant would choose his/her father (-0.462 = large).

Figure 6.10: Model 4: Path model to explore the role of micro factors (like choice of role models, family trauma, family size, position in the family and socio economic and acculturation factors) in the development of creativity and creative abilities



T-values of larger than 1.68, obtained by the bootstrap method (with 100 re-samplings) and indicated in brackets below the path coefficients in model 4, showed that all the paths were significant on $p = 0.05$, except for the path between role model and originality which was significant on $p = 0.1$ level.

Were there then no relationships (direct or indirect) between contextual factors and creativity as proposed in the null hypothesis H_0^3 ? Strong relationships seem to exist especially between some contextual factors (such as school model and culture) and creativity index. Other contextual factors (role model, family factors and *SocioAcc* seem to interact with one another in such a way that they also influence the creativity index. The null hypothesis H_0^3 , may therefore be rejected and the alternative hypothesis H_a^3 , accepted. Contextual factors do influence creativity directly and indirectly. In conclusion

and connecting to the rejection of the null hypothesis H_0^2 , it was also observed that not all contextual factors affect the different creative abilities equally. Some are related to the absence of trauma (elaboration and flexibility), the father or other male family member standing out as a role model (originality), smaller family size and later position in the family in the case of flexibility. *SocioAcc* seems to affect fluency and elaboration skills the most.

6.2.3.2 Contextual factors and perceptions about the context

In the null hypothesis H_0^4 , the assumption is made that there are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity. Model 5, presented in figure 6.11, was used to explore the relationships between contextual factors, perceptions about the context and the outcome variable, namely adjusted creative index in pre-programme ATTA.

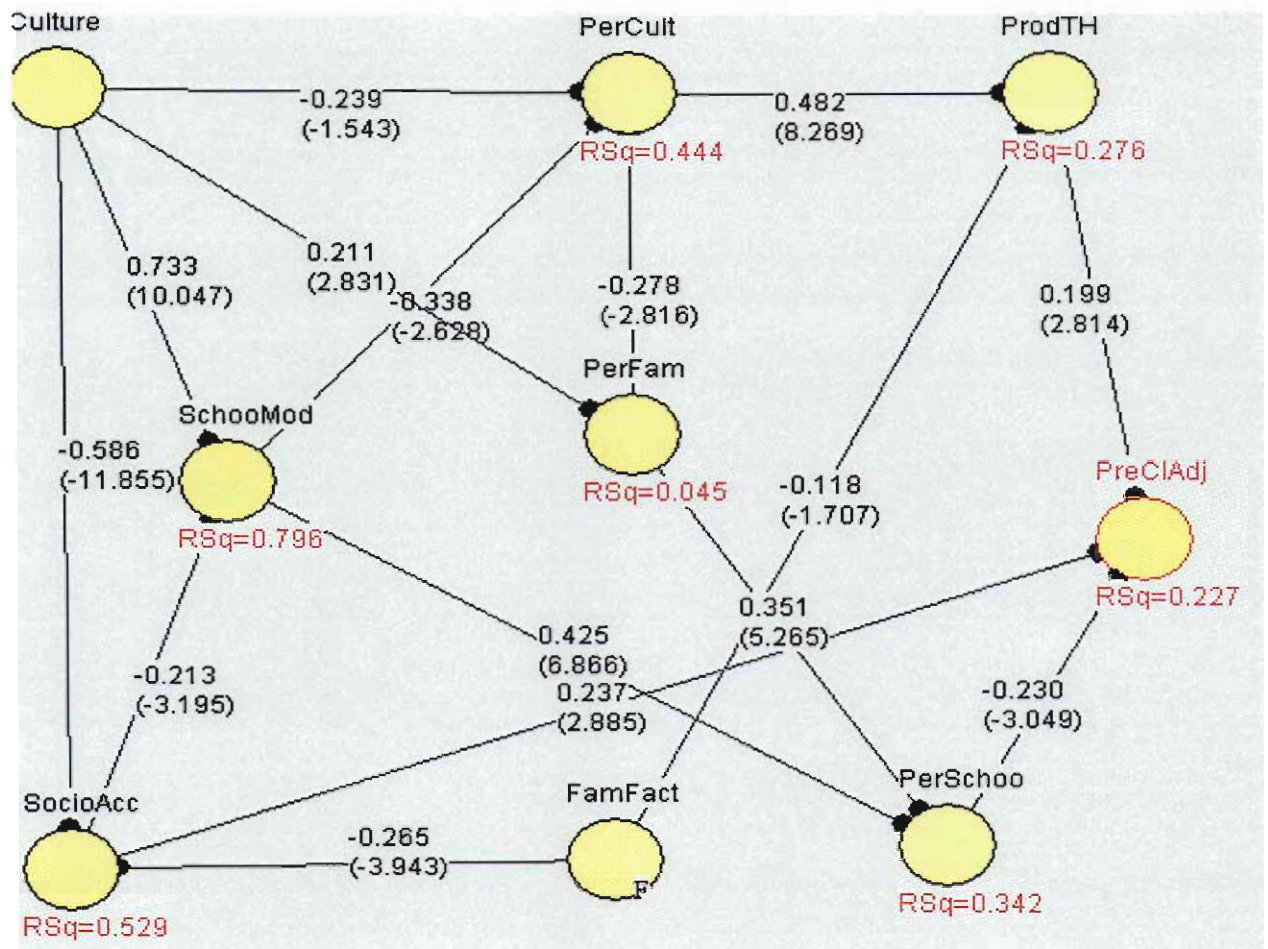
The latent constructs and measured items retained in model 5 are given in table 6.6. After the model was run for the first time, the matrix loadings and cross-loadings were checked. This showed that a number of the questionnaire items were less strongly related to their own construct than to other constructs. To ensure the convergent and discriminant validity of the constructs, these renegade items were therefore removed and their removal led to an increase in the construct reliability and Cronbach-Alpha. Some of the constructs showed very low or even negative Cronbach-Alphas, meaning *“that the items do not truly have positive covariances, and therefore may not form a useful single scale because they are not measuring the same thing”* (Nichols, 1999). This is the reason why the construct items are not numbered chronologically in table 6.6.

Constructs had to fulfil the following criteria to remain in the models: Positive Cronbach-Alphas of 0.44 (which is low) or larger and the square root of the AVE larger than 0.5 (Gefen & Straub 2005:94). This made the removal of constructs like internal locus of control and innovative problem-solving from the model necessary: *“they did not measure the same thing”*. Path coefficients below 0.1 were trimmed from the model, as well as constructs with R^2 s smaller than 0.015. As can be seen in table 6.6, the construct with the highest reliability was perception of school (*PerScho*) with a value of 0.836776 (rounded off to 0.84), followed by *SocioAcc* with a Cronbach-Alpha of 0.799204 (rounded off to 0.80) (Garson, 2006a). The factor with the lowest reliability that was left in the model, was productive thinking (*ProdTH*) with a Cronbach-Alpha value of 0.448776 (rounded off to 0.45).

Table 6.6: Latent factors with their measured variables, Cronbach-Alphas, *convergent (composite) and *discriminant (AVE) reliability data

Latent Factor	Item N	Measured Variables	Tested	N of items	Cronbach-Alpha	Composite reliability	AVE
Socio-economic and acculturation factors (<i>SocioAcc</i>)	1 2 3	Father's education Mother's education Socio-economic status		3	0.80	0.88	0.71
Family Factors (<i>FamFact</i>)	1 2 3	Family trauma Family status Family size		3	0.51	0.67	0.43
Perception of culture as stimulating creativity (<i>PerCult</i>)	1 2 4 7 9 11	Stick to traditional ways Study important to enhance family status Communalistic needs more important Hierarchy dominates Successful people less feeling for others Obedience to elders very important	Degree of conservatism (inverted)	6	0.54	0.71	0.31
Perception of family as a context stimulating creativity (<i>PerFam</i>)	1 3 5 6 7 8	Own opinions valued Own opinions encouraged Debate encouraged Family encourages further study Encourages responsibility Builds on one another's ideas	Degree of appreciation at home	6	0.71	0.80	0.40
Perception of school as a context stimulating creativity (<i>PerScho</i>)	2 3 4 5 6 7 8 9 10 11	Freedom to express thoughts Surprises with <u>unusual ideas</u> Admiration for achievement of success Experiments with <u>unusual ideas</u> Encourages <u>many ideas</u> in problem-solving Encourages <u>open debate</u> Encourages curiosity Welcomes <u>new ideas</u> Encourages thinking in <u>unexpected ways</u> Open-ended questions	Encouragement of creativity at school	10	0.84	0.87	0.41
Perception of university as a context stimulating creativity (<i>PerUni</i>)	4 6 7 8 10 11	Stimulating teaching methods Use of variety of sources encouraged Looking together for knowledge Diverging encouraged Encourages open debate Stimulating questions		6	.69	0.79	0.39
Productive thinking as important outcome of education (<i>ProdTH</i>)	2 3 4 5 9	Traditions ensure success Good manners aim of education Imitation important Strict rules most important Fantasizing should be discouraged	Degree of conformity as ideal outcome of education (inverted)	5	.45	0.69	0.32
*Criteria used for inclusion of constructs in models: 6.1.1.1 Reliability: Cronbach-Alpha > + 0.448 6.1.1.2 Discriminant reliability: Square root of AVE > 0.5 6.1.1.3 Convergent reliability: Composite reliability > 0.65 6.1.1.4 Bold printed items were turned around			*Criteria used for inclusion of items in constructs: In Factor Structure Matrix of Loadings and Cross-Loadings (Output of Visual PLS): 6.1.1.5 Convergent reliability: Contribution of item to "home" construct > contribution to other constructs 6.1.1.6 Positive contribution to construct				

Figure 6.11: Model 5: Path model representing the relationships between contextual factors and perceptions about the context as stimulating creativity



T-values were calculated, using the resampling bootstrap facility of Visual-PLS. For the number of participants ($N = 162 \gg 30$), the t-value table gives the value of 1.64 as significant on a p-level of 0.05 (*cf.* table 4.7). These t-values are indicated in brackets below the path coefficients in the model. All the numerical values (except for the coefficient of the path between culture and perception of culture) were large enough to be significant at a p-value < 0.05-level. That means that the probability that the differences between the groups are due to a chance finding is less than 5%. The path between culture and perception of culture was significant only on p<0.1-level, meaning that the chances of getting this relationship by chance increased to 10% (Easton & McColl, n.d.). The signs of the t-values of the negative path coefficients were negative, indicating that they lie in the left tail of the normal distribution (Lowry, 2000:5; Statsoft, 1984-2003:1-7, Statsoft, 1984-2003 :1-26).

Model 5 shows a number of weak (0.1 to 0.24), medium (0.25-0.40) and strong relationships (>0.40) between contextual factors and perceptions about the context (Cohen in Howie, 2002:99):

- Culture and perception of culture (*PerCult*) are negatively related (path coefficient = -0.239). With an R-square of 0.444, 44.4% of the variance in perception of culture was explained by the factors leading into it, namely culture, school model attended (*SchoMod*) and perception of family (*PerFam*) The negative relationship refers to the participants from the non-African culture 1 perceiving their culture as stimulating and the African participants perceiving their culture as “not stimulating” creativity. Perception of culture, in turn, was significantly related to the perceptions that participants had about what the ideal outcome of education is, namely productive thinking (*ProdTH*= 0.482), of which the model explained 27.8% of the variance. This implicates that participants from culture 2 (African) perceive outcomes of education that are considered in the literature as promoting conformity as important. They value following traditions, learning good manners and following strict rules, learning through imitating adults and avoiding fantasizing higher than found in the participants from culture 1 (non-African) (*ProdTH* items 2,3,4 5 and 9-see table 6.6). Productive thinking has a path coefficient of 0.199, leading to creativity index indicating that participants who perceived the inverted factors in the construct productive thinking as important had higher creativity indexes. In other words, participants who agreed with the items as they are written in table 6.6 had lower creative indexes and these participants were more likely to come from culture 2 (African) who also perceived their culture as not conforming to what is seen in literature as factors stimulating creativity.
- Culture is strongly related to the school model attended (0.733): a relationship that was explained earlier. The lower the culture value (1= non-African), the lower the model of school (1= model C). The school model was fairly strongly and positively related to the perceptions that participants had of their school as a place stimulating creativity (*PerSchoo* = 0.425). It means that the participants who attended township schools (nr 2) were more positive about their schools as places that encourage creativity. The negative relationship between the perception of school and the creativity index (*PreCIAdj*= -0.230) shows that the positive perception that the participants coming from township schools may have about their schools as stimulating creativity, does not lead to enhanced creativity. They might have perceived the schools as stimulating in comparison to their culture, which they perceived as “not stimulating.” Participants from previous model C schools did not experience their schools as places enhancing

creativity. Despite this, their creativity indexes were higher.

- Culture is strongly and negatively related to *SocioAcc* (-0.586). *SocioAcc* was related with a medium path coefficient with family factors (*FamFact* = -0.265) indicating that higher socio-economic conditions and parental education relate to lower family factors (1= two-parent families). This situation (values closer to 1) leads to higher productive thinking (*FamFact* → *ProdTH* = -0.118). If participants associate strongly with the **inverted** forms of the measured items in this latent construct as outcomes of education, their creativity indexes tend to be higher in the pre-programme ATTA. In this case, the relationship between the inverted productive thinking construct and the creativity indexes (*ProdTH* → *PeCIAdj*) had a path coefficient of 0.199. Culture was further related to the perception that participants had about their families as context stimulating creativity (0.211) and that, in turn, was fairly strongly related to the perception about the school as a context stimulating creativity (0.351). It means that participants from African cultures were also more likely to perceive their families as contexts stimulating creativity. Perception of family was not directly related to creativity significantly, but through perception of school it showed that these perceptions about school and family were naïve and did not translate into higher creative indexes. In contrast the non-African participants were more cynical about their families and schools as contexts for nurturing creativity, but more positive about their culture. This translated into higher expectations about productive thinking as an ideal outcome of education that is associated with higher creativity indexes in the pre-programme ATTA.

Revisiting the questions in table 6.6 makes one realize that the participants from township schools may have been more appreciative of their schools and their families than the participants who attended model C-schools. It may, however, be that they experienced less of a challenge, which is needed for learning and the development of creativity (*cf.* 2.4.2, 2.4.3). It is, after all, the presence of manageable stress (*cf.* 3.3.1, 3.3.2, 3.3.3 & 3.5.3) and not the absence of stress causing adaptive changes in the brain that causes learning to occur and creativity to develop. The presence of conflict (*cf.* 3.3.1.2, 3.3.2.3 and 3.4) is further implicated in the development of creativity. Perhaps the questionnaire determined how comfortable, valued and accepted these participants felt at school (*PerScho*) and in their families (*PerFam*), more than how challenged they felt. Teachers from model C schools might have expected more from the learners, making them feel less accepted, but more challenged and more conflicted. This also goes for the families of the participants who attended, model C-schools. (This situation is reminiscent of the work of Howie (2002:182) and Howie and Plomp (2004:2) who observed that mathematics

teachers who felt more appreciated by learners and society produced lower results and *vice versa*.)

The relationships seen in this model led to the rejection of the null hypothesis H_0^4 , namely that there are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity. There are, as implied in the alternative hypothesis H_a^4 , significant, less significant and insignificant relationships among the different contextual factors and perceptions about these contexts as contexts where creativity is stimulated.

6.2.3.3 Perceptions about the context and creativity index

The null hypothesis H_0^5 assumes that there are no relationships (direct or indirect) between perceptions about the context and creativity. Model 5 was also used to explore these relationships.

Relationships were found between perception about culture and perception of cultures ($Culture \rightarrow PerCult = -0.238 = \text{weak}$) and perception of culture and productive thinking as ideal outcome of education ($PerCult \rightarrow ProdTH = 0.482 = \text{strong}$). The more positive the culture was viewed as stimulating creativity, the more productive thinking was valued, but the less positive the participants were about the family and the school they attended as places encouraging creativity. The perceptions of family and school were, however, negatively related to the creativity index as discussed above. In model 5, the viewpoint about productive thinking as an ideal outcome of education was only weakly related to creativity index (0.199). The positive relationship shows that the two go together. The model explains 22.7% of the variance of the creativity index.

From the relationships observed in model 5, the null hypothesis H_0^5 may be rejected: creativity relates to the perceptions that participants have about their contexts and how they view the ideal outcomes of education. The alternative hypotheses H_a^5 can therefore be accepted. Putting all the information together further leads to the acceptance of hypothesis H_a^6 : that both contexts and perceptions of whether the contexts model creativity as acceptable behaviour, influence creativity.

6.2.3.4 Conclusion about the context, perceptions about the context and creativity

What was observed in this section could be summarized as follows: Direct and indirect relationships exist between:

- Contextual factors and whether creativity is perceived as acceptable behaviour

- Contextual factors and creativity indexes and creative abilities
- Perceptions about different life spheres (contexts) as stimulating creativity and creativity indexes and creative abilities.

6.3 STUDY 2: THE QUASI-EXPERIMENTAL STUDY

The quasi-experimental study tried to determine whether exposure to the basic Technology Education programme, with emphasis on the creative process, has a positive, no or negative effect on the creativity of the participants. The effect of this basic programme was compared with the effect of an enriched programme. In this study, it was assumed that exposure to creative role models combined with exposure to creative processes should have a more positive effect on creativity levels of participants than just exposure to creative processes. The null hypotheses H_0^6 , H_0^7 and H_0^8 were formulated:

H_0^6 : The difference in Technology Education programmes followed will have no significant effect on participants' creative indexes.

H_0^7 : The difference in Technology Education programmes followed will have no significant effect on participants' creative process skills (creative abilities).

H_0^8 : The differences in contextual and perceptual factors will have no effect on the response of the participants' creativity indexes due to their exposure to different Technology Education programmes.

Since convenience samples were used, the groups exposed to the different programmes were not equivalent (making this a quasi-experimental study instead of a true experimental one). The pre-test results were adjusted, as suggested by Trochim (2006b:1) (cf. 4.7.2), to make provision for the non-equivalent groups by removal of the pre-test error. The formula below was used to adjust the pre-test creativity index scores, because the reliability data thereof were available (Goff & Torrance, 2002: 33, 34):

$$X_{adj} = \text{Mean of pretest} + r (\text{original score} - \text{mean of pretest})$$

The mean of the whole group (N=207) was 59.95694. The adjustment formula was therefore:

$$\text{Adjusted score} = \text{Mean} + KR21 (\text{score of every individual} - \text{mean})$$

$$X_{adj} = 59.95694 + 0.9 (x - 59.95694)$$

The following examples are given to show what happened to the data during the adjustment thereof: a score of 82 changed to 79.795694, 65 changed to 64.495694, 59 changed to 59.095694, 42 changed to 43.795694 and 12 changed to 16.795694. The mean remained on 59.96. The median changed from 62 to 61.8. The standard deviation changed from 12.44 to 11.20 and the standard error of measurement (SEM) changed from 3.934476094 to 3.541028485.

The overall effect was that the higher scores were adjusted downwards and the lower scores upwards. The data was therefore “pressed inwards” towards the mean, which stayed the same. These adjusted pre-test scores were used in *all* analyses.

6.3.1 Programme exposure and creativity indexes

A one-sample *t*-test was used to compare the creativity index of the whole group of first year education participants in this study (N= 207) with that given in the manual of the ATTA (see tables 6.7 and 6.8). The average of the participants in this study was 59.99 compared with 69.43 for the norm population (Goff & Torrance, 2002:30, 34). This showed that there was a reason for concern and that the concern about under-developed creative thinking abilities was not unfounded.

H_0 ⁶ hypothesized **that the difference in Technology Education programmes followed will have no effect on participants’ creativity indexes**. A description of the data will first be given, followed by the results of independent two sample *t*-tests and dependent *t*-tests (paired one and two-sample *t*-tests) that were used to investigate the effects of the programme.

Before the exposure to the Technology Education programmes, the minimum of the creativity indexes of the whole group of participants was 15.9, the maximum 79.7, the median 61.7 and the mean 59.9 with a standard deviation of 11.2 (see table 6.7). After the exposure, this changed to minimum 23.0, maximum 83, median 65 and the mean 64.8 with a standard deviation of 7.74. For the two different groups the statistics were as follows: Basic programme exposure: minimum 27.6, maximum 79.8, median 63.6 and the mean 62.9 with a standard deviation of 8.9. After the exposure this changed to minimum 44.0, maximum 83, median 65 and the mean 65.0 with a standard deviation of 7.9. The mode changed from 60.8 to 65 (giving a creative level 3 as the most common level in both cases).

The effect of the enriched programme regarding the same statistics were as follows: Before the exposure, minimum 15.9, maximum 76.2, median 60.9 and the mean 57.7 with

a standard deviation of 12.3. After the exposure these values changed to: minimum 23.0, maximum 81.0, median 65.0 and the mean 64.7 with a standard deviation of 7.68. The average creativity index scores obtained by the participants in this study (59.9), was therefore far below the mean for the test norm population (69.43). After the exposure, the index on 64.8 was still below that of the norm population, but significantly closer to it.

From this data it was clear that the groups differed regarding all the different statistical indicators and the huge differences in standard deviations show how diverse even the groups within themselves were. The groups that followed the enriched programme and the African group that followed the enriched programme had the largest standard deviations (table 6.7), namely 12.3 and 11.7 respectively. The exposure to the enriched programme changed this standard deviation to 7.6 and 8.31 respectively. This compares well with the sigma of the ATTA given in the test manual, namely 7.87 (Goff & Torrance, 2002:33) (*cf.* 4.6.1).

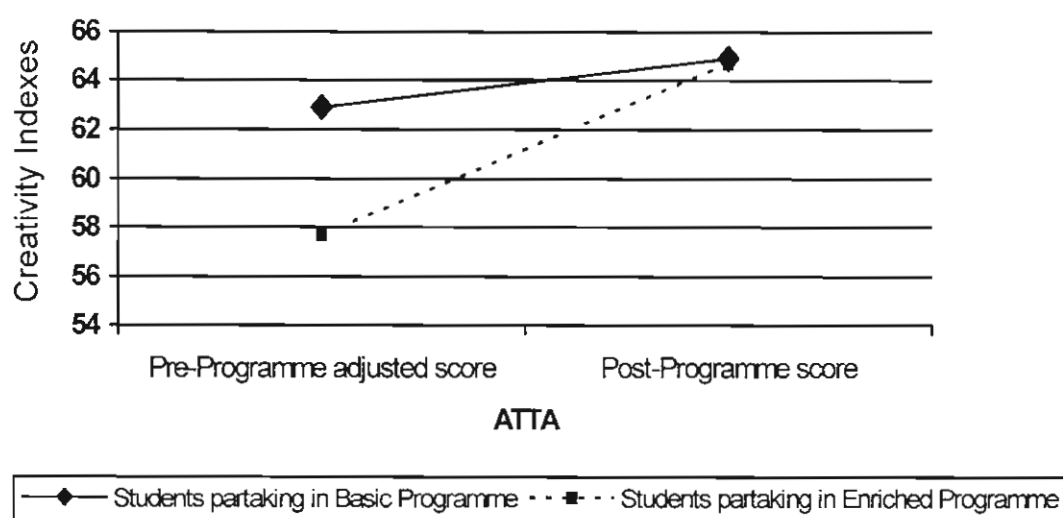
An **independent two-sample t-test** was used to determine whether the two groups were equivalent before the programme. This was therefore used to compare the average of the creativity indexes of the group that was exposed to the basic Technology Education programme with that of the group that was exposed to the enriched programme. The data in tables 6.7 and 6.8 indicate what was suspected: the two groups were not equivalent; the necessity of adjustment of the pre-test results was confirmed. The group that was exposed to the basic programme (N=90) had higher average creativity indexes (mean =62.91618) than the group (N=117) that was exposed to the enriched programme (mean = 57.74311) in the pre-test. The difference was significant, with a p-value of 0.000903. The standard deviations for these two groups also differed, with 8.897307 for the basic programme group and 12.30026 for the enriched programme group, the f-test giving an F-ratio of 1.911224, showing that the standard deviations of the populations from which the two samples came were not equal.

A **paired one-sample t-test** was used to compare observations from the two measurement occasions for the whole group and the means of the creativity index before and after the programme. The pre-programme average of the 207 participants in this study was 59.99. After exposure to the Technology Education programme, the average was 64.83. A Cohen's D was calculated, and with a value of 0.51, showed a medium effect of Technology Education programme (basic and enriched) on all the participants.

A **paired two-samples t-test** was also used to compare observations from the two measurement occasions for the groups that were exposed to the different programmes,

namely the basic and enriched programmes. The average creativity indexes were now 64.95556 and 64.72650 for the groups exposed to the basic programme and the enriched programme respectively. In the post-programme ATTA, the differences between the two groups therefore disappeared: the large p-value of 0.833479 confirms the insignificance of the difference between them. The standard deviations for the two groups were now more or less the same with 7.871027 for the basic programme group and 7.67511 for the enriched programme group. The net results of the two programmes are compared in figure 6.12. This graph illustrates how the participants who were exposed to the enriched programme started on a lower level and caught up with the group that was exposed to the basic programme. The group that was exposed to the basic programme, however, also gained: the average of the group exposed to the basic programme increased from 62.91618 to 64.95556, which was shown in the t-test for dependent samples to be a small effect (Cohen's $D = 0.029$) (see tables 6.8 and 6.9). The average of the group exposed to the enriched programme increased from 57.74311 to 64.72650, showing a Cohen's D of 0.51, pointing to a medium effect. Both these values were of practical significance. For the exposure to the basic programme, the p-value was 0.005235 and for the exposure to the enriched programme, the p-value was 0.000000. The null hypothesis H_0^6 , may therefore be rejected: the initial significant differences in creativity indexes in the group that followed the basic programme and of the group that followed the enriched programme were eliminated, the regression lines nearly crossed over. The alternative hypothesis H_a^7 is therefore accepted. The difference in Technology Education programmes had a significant different effect on the creativity indexes.

Figure 6.12: Comparison of average creative indexes of students who followed the basic programme with those that followed the enriched programme.



6.3.2 Programme exposure and creative process skills

In testing hypothesis H_0^7 , namely that the **difference in Technology Education programmes followed will have no effect on participants' creative process skills (creative abilities)**, paired t-tests were again employed.

The creativity index depends on the creative abilities that may be seen as creative process skills as well as creativity indicators (verbal and figural). The creative abilities in the pre- and post-test are compared in table 6.10 and shown graphically in figure 6.13. The two programmes seem to have had different effects regarding the two hot spots, elaboration and flexibility, identified earlier.

After exposure to the enriched programme, elaboration (+1.92), fluency (+1.86), and flexibility (1.53) increased with values of 1.25 or more and showing significance with p-values of 0.00000, 0.000023 and 0.000133 respectively. After exposure to the basic programme, elaboration (1.25) was the only skill that increased to a similar extent ($p=0.000008$). Originality (0.28) was not stimulated significantly by the enriched programme or by the basic programme (0.33). For the whole group, fluency, elaboration and flexibility increased significantly with p-values of 0,000000, 0,000000 and 0,000062 respectively.

As can be seen in table 6.10 and figure 6.13, elaboration seems to be the creative ability that was the biggest problem in both groups. When compared to the means given for the populations from the ATTA-manual (Goff & Torrance, 2002) the other abilities of the group exposed to the basic programme exceeded the average. Besides the elaboration, fluency and flexibility abilities of the group that was exposed to the enriched programme were also below the mean for the "manual population". After the programme it was only elaboration that still lagged behind in both groups.

Table 6.7: Descriptive statistics regarding the creativity indexes of students in different selected groupings

Gr	ALL		AMI		EMI		African		Non-African		Basic Programme		Enriched Programme		African Basic Programme		Non-African Basic Programme		African Enriched Programme		Non-African Enriched Programme	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mode	60,8	65,0	64,5	65,0	60,9	60,0	60,9	57,0	64,5	68,0	62,7	68,0	60,9	65,0	63,6	57	62,7	68	60,9	65	74,4	71
Maximum	79,7	83,0	79,8	83,0	77,1	81,0	69,9	75,0	79,8	83,0	79,8	83,0	76,2	81,0	69,9	68	79,8	83	67,2	74	76,2	81
Minimum	15,9	23,0	43,8	44,0	15,9	23,0	15,9	23,0	27,6	44,0	27,6	44,0	15,9	23,0	27,6	51	43,8	44	15,9	23	27,6	57
Range	64	60	36	39	61	58	54	52	52	39	43	39	60	58	42	19	36	39	51	51	49	24
Median	61,7	65,0	67,2	69,0	58,2	62,0	56,8	61,5	66,3	69,0	63,6	65,0	60,9	65,0	57,3	57	65,4	68	56,4	62,5	67,2	70
Mean	59,9	64,8	66,5	68,3	55,2	62,3	53,9	61,1	65,7	68,3	62,9	65,0	57,7	64,7	55,5	58,3	66,1	67,8	53,3	61,3	65,1	69
St Dev	11,2	7,7	6,7	6,9	11,5	7,4	11,1	7,13	7,9	6,6	8,9	7,9	12,3	7,6	9,3	4,8	6,61	7,2	11,7	8,3	9,6	5,8
N	207		89		119		100		107		90		117		27		63		73		44	

Although the creativity indicators are reported in table 6.10, they are seen as evidence of "creative strength" (Goff & Torrance, 2002:15) and are not interpreted as creative process skills here. It is, however, notable that both the verbal and figural creative indicators improved significantly in the groups exposed to the enriched programme, whereas a significant decrease was observed in the verbal creative indicators, as well as a slight decrease in the figural creativity indicators of the group that followed the basic programme. Why this happened, is not clear and could be the topic of a new study. Overall, however, the whole group gained significantly in the verbal creativity indicators ($p= 0.001624$) and nearly significantly in the figural creativity indicators (0.050606).

The null hypothesis H_0^7 , namely that the difference in Technology Education programmes followed will have no effect on participants' creative process skills (creative abilities) could be rejected. The alternative hypothesis H_a^8 can be accepted, namely that the creative abilities were affected and certain abilities were affected more than others by the different programmes.

Table 6.8: Results for the independent t-test

Variable	Independent T-tests										
	Group 1: Exposed to basic programme Group 2: Exposed to enriched programme										
	Mean Basic Programme	Mean Enriched Programme	t-value	df	p	Valid N Basic Programme	Valid N Enriched Programme	Std Dev Basic Programme	Std Dev Enriched Programme	F- Ratio Variances	p Variances
Pre-programme Creativity index (PreCIAdj)	62.91618	57.74311	3.368405	205	0.000903	90	117	8.897307	12.30026	1.911224	0.001564
Post-programme Creativity index (PostCI)	64.95556	64.72650	0.210510	205	0.833479	90	117	7.871027	7.67511	1.051704	0.793804

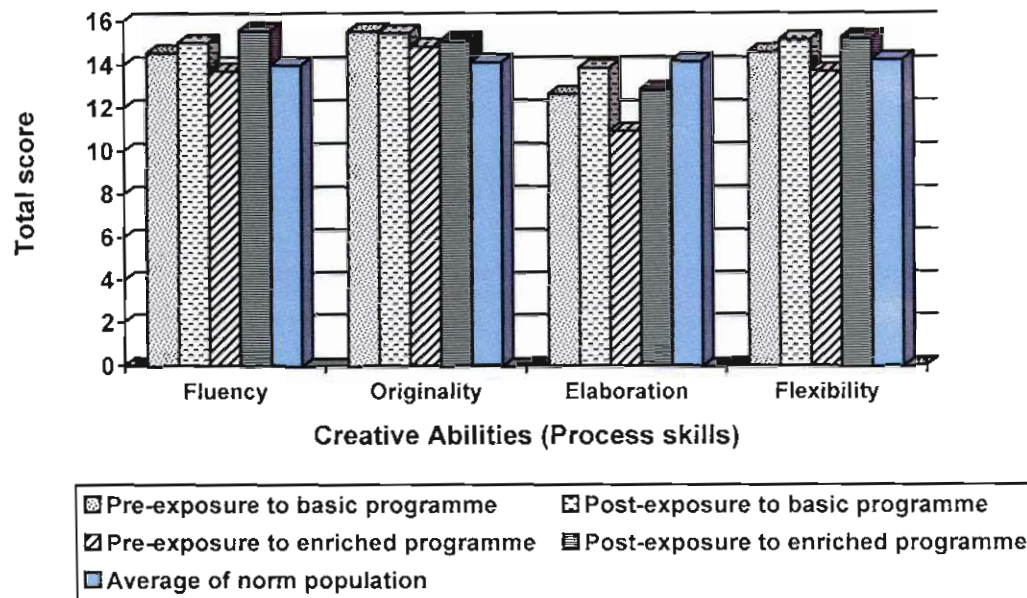
Table 6.9: Results for the dependent t-test

BASIC PROGRAMME	T-test for dependent samples								
	Marked differences are significant at p = 0.05000								
	Mean	Std.Dev	N	Diff	Std.Dev Diff	t	df	p	Cohen's D
PreCIAdj	62.91618	8.897307							0.29 : small effect of basic programme
Post CI	64.95556	7.871027	90	-2.03937	6.758139	-2.86280	89	0.005235	
ENRICHED PROGRAMME									0.66 : medium effect of enriched programme
PreCIAdj	57.74311	12.30026							
Post CI	64.72650	7.67511	117	-6.98339	10.57914	-7.14017	116	0.000000	
ALL PROGRAMMES									(64.82 -59.99)/ 9.422 = 0.51 : medium effect of Technology Education programme as a whole
PreCIAdj	59.99227	11.22521							
Post CI	64.82609	7.74275	207	-4.83382	9.422855	-7.38062	206	0.000000	

Table 6.10: Average creative abilities before and after the application of the basic and enriched programme

Groups 1-6 (N=207)	Creative abilities				Creativity indicators		
	Fluency	Originality	Elaboration	Flexibility	Verbal	Figural	Total creativity indicators
Mean (Goff & Torrance, 2002)	14.011	14.149	14.116	14.247			9.897
Before Exposure to Basic programme	14.65	15.07	11.56	14.60	1.38	3.93	5.31
After Exposure to Basic programme	14.88	15.40	13.44	15.15	0.91	3.54	4.45
Difference	+0.23	+0.33	+1.88	+0.55	-0.36	-0.39	
p	0.321612	0.439345	0.000008	0.062269	0.000606	0.29945	
Before Exposure to Enriched programme	13.73	14.86	10.96	13.71	0.9	3.32	4.22
After Exposure to Enriched programme	15.58	15.15	12.89	15.25	1.7	4.15	5.85
Difference	+1.85	+0.28	+1.92	+1.54	+0.80	+0.83	
p	0.000000	0.393151	0.000023	0.000133	0.000000	0.000587	
Before Exposure to Technology Education programme	14.08	15.15	11.69	14.10	1.19	3.74	4.93
After Exposure to Technology Education programme	15.33	15.28	13.32	15.21	1.51	4.10	5.61
Difference	+1.25	+0.13	+1.63	+1.11	+0.32	+0.36	
p	0.000000	0.582136	0.000000	0.000062	0.001624	0.05	

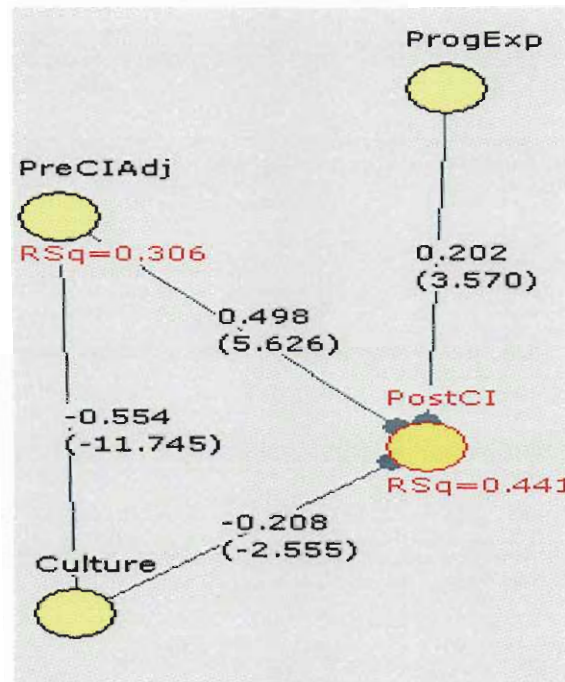
Figure 6.13: Comparison of the average creative abilities (process skills), before and after exposure to the basic and the enriched programme respectively, with that of the norm population



6.3.3 Contextual and perceptual factors and the effect of programme exposure on creativity indexes

Visual-PLS was again used to investigate the validity of the null hypothesis H_0^8 , namely that the differences in contextual and perceptual factors will have no effect on the response of the participants' creativity indexes due to their exposure to different Technology Education programmes.

Figure 6.14: Model 6: Relationships between pre- and post-programme creative indexes, culture and programme exposure.



Model 6 (figure 6.14) was used to model the relationships between culture, pre-programme creativity index, programme exposure and post-programme creativity index. The model explained 44.1% of the variance in the post-programme creativity index and 30.6% of the variance in the pre-programme creativity index. From this model it became clear that the results of the pre-programme creativity index were strongly and negatively related to the culture of the participants ($Culture \rightarrow PreCIAdj = -0.554 = \text{strong}$). It means that the African culture (indicated as 2) was strongly related to a lower creativity index in the pre-programme ATTA ($PreCIAdj$). This dependence on culture diminished in the post-programme creativity index to only $-0.208 (= \text{weak})$. The programme exposure was directly related to the post-programme creativity indexes ($ProgExp \rightarrow PostCI = 0.202$). The enriched programme had positive effects on the post-programme creativity indexes. This relationship of 0.202 is below 0.3, indicating that it is significant, but not of practical significance. The strongest predictor of post-programme creativity indexes was still the pre-programme creativity indexes (with a path coefficient of 0.498). It means that the higher the pre-programme creativity index, the higher the post-programme creativity index was.

A more elaborate model 7 (figure 6.15), based on model 5 (figure 6.11), explored the relationships between the factors that were shown to have significant relationships in

the *ex post facto* study. Since perceptions were included in this model, the data of the 162 participants of groups 3 to 6 were used to model the relationships. The factors used in this model were:

- Personal factors (Academic achievement (*AcaAch*))
- Contextual factors (culture (*Culture*), school model (*SchoolMod*), *SocioAcc*), family factors (*FamFact*))
- Perceptions about ideal outcomes of education (*ProdTH*)
- Perceptions about different spheres of life (contexts) as stimulating creative behaviour, perception of culture (*PerCult*), perception of school (*PerSchool*) and perception of family (*PerFam*)

Three new variables were added, namely:

- Exposure to programme (*ExProg*: Basic programme indicated with nr 1 and enriched programme indicated with 2)
- Perceptions about the university as a place where creativity is enhanced (*PerUniv*)
- Output dependent variable, namely creativity index in post-programme creativity index (*PostCI*)

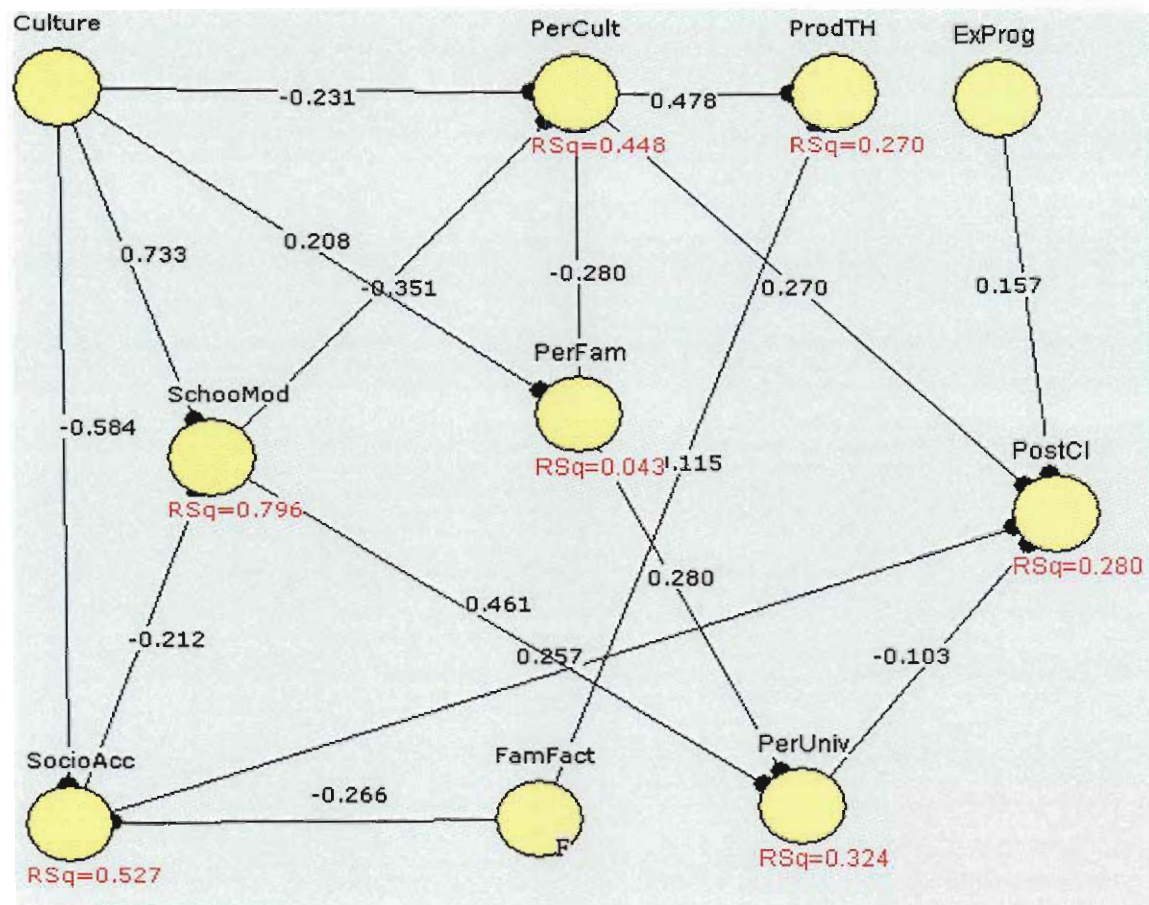
This model explained 28.0% of the variance in the final output variable, namely post-programme creativity index (*PostCI*). Relationships with path coefficients below 0.1 were trimmed out. The strongest personal factor (from model 1), namely academic achievement had to be removed from the model due to these low coefficients. Other paths that were trimmed out include those between productive thinking and post-programme creativity index, the paths from family factors to the post-creativity indexes and school model attended to post-creativity indexes.

The relationships between contextual factors culture, school model, *SocioAcc* and family factors were similar in direction and relative strengths to those already described in the *ex post facto* study and discussed with models 3(b) and 5. In table 6.11, the cultural composition of the two groups, namely those exposed to the basic programme and those exposed to the enriched programme is given. What is new in this model is that participants from township schools (all African) perceived the

university as a more creativity-enhancing experience than those from model C-schools (African and non-African) with a relationship of 0.461 between school model attended and perception of university. This is similar to what was seen in model 5 regarding their perception of the schools they attended. Participants from township schools felt about as positive about the university ($SchoolMod \rightarrow PerUni = 0.461$) as they did about their school at the time of the pre-test ($SchoolMod \rightarrow PerScho = 0.425$). Positive perceptions about the family as a context stimulating creativity ($PerFam$) was also related to the perception of the university as a place stimulating creativity as it was in the case of the school in model 5 ($PerFam \rightarrow PerScho = 0.351$ and $PerFam \rightarrow PerUni = 0.280$). The negative relationship between perception of school and pre-programme creativity index was stronger than that between perception of university and post-creativity index, but the correlation between these positive perceptions and a low creativity index was reduced in the post-test ($PerSchool \rightarrow PreCIAdj = -0.230$ and $PerUni \rightarrow PostCI = -0.103$). This positive perception about the university was, however, as was the case with the school, not translated into higher creativity indexes. To explain the relationship between these positive perceptions and the lower creativity indexes one may think of low expectations and/or naivety. *SocioAcc* was positively related to post-programme creativity index (+0.257) as it was to pre-programme creativity index (+0.237).

The strongest contributors to the post-programme creativity index were the perceptions of culture (0.270), *SocioAcc* (0.257) and the programme the participants were exposed to (0.157), with the enriched programme having a stronger effect.

Figure 6.15: Model 7 : Relationships between pre- and post-programme creative indexes, culture and programme exposure



The hypothesis H_0^8 , namely that the differences in contextual and perceptual factors will have no effect on the response of the participants' creativity indexes due to their exposure to different Technology Education programme,s cannot be accepted as is. Culture affects SocioAcc and that, in turn, affects, with schools attended, the post-programme creativity index with path coefficients of larger than 0.1. With the pre-programme creativity index, these factors accounted for 45% of the variance of the post-programme creativity index. The coefficients between perceptions of participants regarding the university and about productive thinking were so weakly related to their post-programme creativity indexes that the paths had to be trimmed out.

Since it was shown in the previous sections that culture influences socio-economic factors as well as the school attended and that other factors like family factors are also strongly related to culture and socio-economic factors, it was seen as appropriate to investigate the null hypothesis H_0^9 , (that the possible effects of the programme on the creative abilities of the participants will not be influenced by

contextual factors) and the null hypothesis H_0^{10} (that contextual factors have no effect on the “modifiability” of participants regarding creativity), by comparing the participants of the African cultural group who were exposed to the enriched programme with those who were exposed to the basic programme. The same was done within the non-African group.

Table 6.11: Creativity indexes in ATTA tests before and after exposure to basic and enriched programmes related to the cultural groups to which participants belong

	Basic Programme	Enriched Programme	Total	Basic Programme			Enriched Programme		
Culture	N	N	N	CI (Pre)	CI (Post)	p-value	CI (Pre)	CI (Post)	p-value
Mean (Goff & Torrance, 2002:30, 34)			175					69.43	
Non-African	63	44	107	66.2	67.8	0.01313	65.1	68.9	0.00272
African	27	73	100	55.3	58.3	0.04813	53.3	61.2	0.00000
TOTAL (N)	90	117	207						

Non-African participants: The CI of the non-African group exposed to the basic programme started on 66.2 and improved slightly towards the norm group mean 67.8. Although regression towards the mean could have caused a pseudo effect here, the result ($p=0.01313$) is significant (table 6.11 and figure 6.16). The CIs of the non-African group, exposed to the enriched programme, increased from 65.1 to 68.9 (nearly on the norm group average). The fact that this group started on a level lower than that of the participants in the basic programme (65.1 compared to 66.2) and crossed over the basic group (67.8 compared to 68.9) indicates a small but true and significant programme effect ($p = 0.00272$).

African participants: As can be seen in table 6.11 and figure 6.16, the CI of the African group exposed to the basic programme started on an average of 55.5 and improved slightly to 58.3 ($p=0.048131$). In comparison, the African group exposed to the enriched programme, increased from an average lower than that of the group exposed to the basic programme, but crossed over (53.3→61.3). These results represent a true and significant programme effect ($p = 0.0000$).

From the description above and the data in table 6.11 and figure 6.16, it therefore becomes clear that culture was a factor in how the participants responded to the respective programmes. The creativity indexes of both groups increased with both programmes. One may argue that the increase with the basic programme may be explained to a certain extent by maturation or regression towards the norm group (Goff & Torrance, 2002:30). With the enriched programme, however, the creativity indexes of both cultural groups, African and non-African, were initially slightly lower in the groups that followed the enriched programmes. After the enriched programmes had been followed, the creativity indexes of the exposed groups crossed over and were now higher than those of the groups that followed the basic programmes. According to Trochim (2006a:5), this crossover phenomenon represents a true programme effect and is not subject to either maturation or regression-towards-the-mean validity threats. The creativity indexes of the African group increased more than that of the non-African group with both programmes. It was, however, only in the enriched programme and with the African group that a large and significant increase in creativity index was seen ($p = 1.4383 \times 10^{-9}$). This increase in creativity index is significant on $p = 0.005$ level. It means that chances are less than 5 in a 1000 that this change could have occurred by chance.

Figure 6.16: Comparison of the average creativity indexes of participants from different cultural groups who followed the enriched programme with those that followed the basic programme

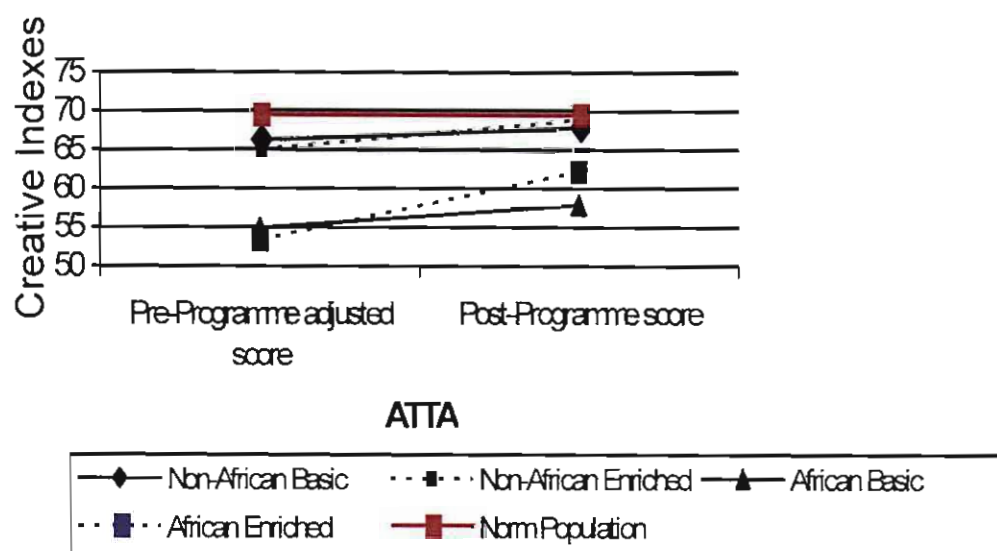


Table 6.12: Comparison of the average creative abilities of participants from different cultural groups who followed the enriched programme with those that followed the basic programme

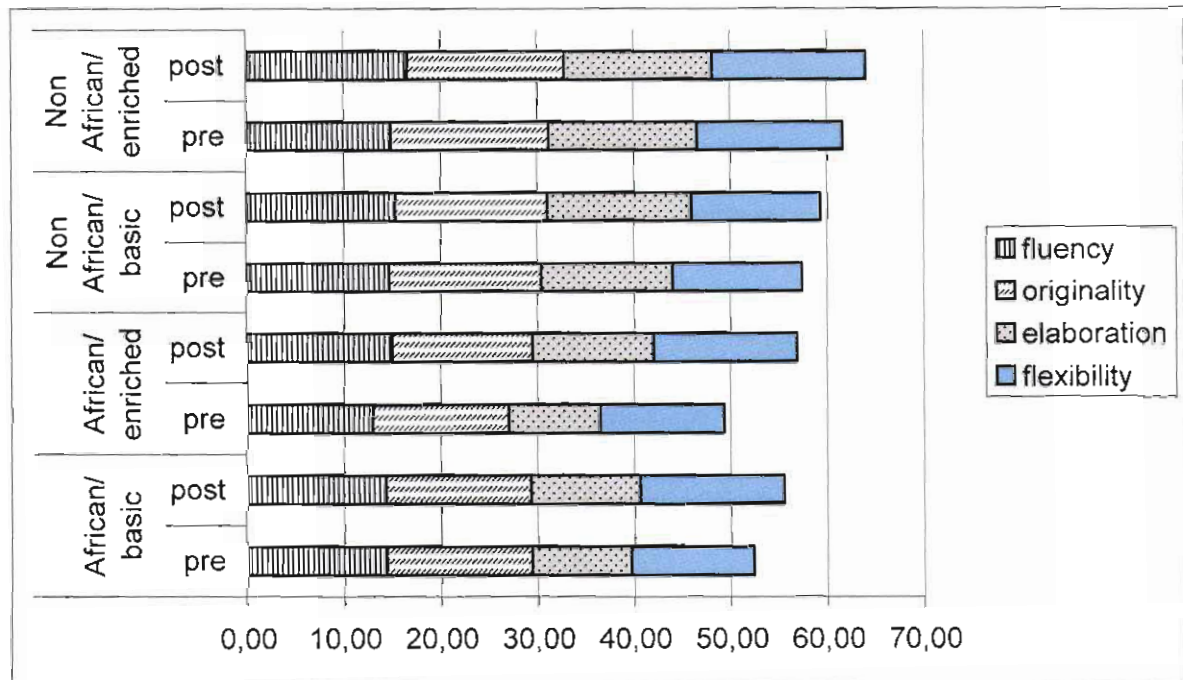
Culture	African (N=107)				Non-African (N=100)			
Programme exposure	Basic		Enriched		Basic		Enriched	
Creative ability	pre	post	pre	post	pre	post	pre	post
Fluency	14.35	14.27	12.99	14.96	14.63	15.33	14.91	16.58
Difference	+0.08		+1.97		+0.70		+1.67	
p-value	0.41888		0.00000		0.00009		0.00001	
Originality	15.00	14.96	13.99	14.47	15.75	15.66	16.27	16.22
Difference	+0.04		0.48		-0.09		-0.05	
p-value	0.46950		0.15300		0.40257		0.45663	
Elaboration	10.27	11.35	9.44	12.58	13.59	14.92	15.36	15.27
Difference	+1.08		3.14		1.33		-0.09	
p-value	0.05108		0.00000		0.00003		0.48403	
Flexibility	12.73	14.88	12.86	14.81	13.40	13.38	15.07	15.96
Difference	+2.76		1.95		-0.02		+0.89	
p-value	0.01755		0.00040		0.37490		0.03600	

From table 6.12 and figure 6.17 it is clear that the participants from the two different cultural groups responded differently to the stimulation that they received in the two programmes. The main effects seen with the African group in response to the basic programme were improvements in **elaboration** and **flexibility** skills. The non-African group exhibited significant increases in **fluency** and **elaboration** with the basic programme.

After exposure to the enriched programme **all the abilities** of the African group increased, with significant increases in all the abilities except originality. The non-African group showed slight decreases in originality and elaboration. Their **fluency** and **flexibility** increased significantly. Not one of these two programmes, however, stimulated the creative abilities of the non-African group to the same degree as it did

for the African group.

Figure 6.17: Comparison of the average creative abilities of participants from different cultural groups who followed the enriched programme and those that followed the basic programme in the pre programme ATTA with that of the post programme ATTA



This led to the rejection of both the null hypotheses H_0^9 , namely that the possible effects of the Technology Education programmes on creative abilities will not be influenced by **contextual factors** as well as the null hypotheses H_0^{10} , namely that cultural factors specifically will have **no effect on the “modifiability”** of participants regarding creative abilities. The specific enriched programme that was followed had as its aim to provide social support for behavioural modification more than anything else. This programme could not help participants who did not have a problem in this regard to become more creative. It could, however, do this for participants who needed to be dis-inhibited. To get further increase and an increase in creativity of the non-African participants, a greater degree of challenge may be needed (*cf.* 2.4.3.5).

6.4 SUMMARY

In this chapter, the results of the statistical analysis were reported and discussed. It was seen in the *ex post facto* study that personal factors, contextual and process factors contributed to the situation as is. In the quasi-experimental study it was seen

that an enriched programme did succeed in bringing the groups exposed to the basic and enriched programmes on the same level, but not one of the programmes could bring any of the groups to the levels given in the manual as the mean for the population used in the design of the test. The enriched programme did, however, have an effect with practical significance in the case of the participants from the African culture. A greater challenge and wider knowledge acquisition are suggested to stimulate all participants further. In chapter seven the conclusions and recommendations for this study will be given.

Chapter 1 Orientation and statement of the problem				
Chapter 2 Creativity				
Section 2.1 Concept clarification	Section 2.2 The creative person	Section 2.3 The creative process	Section 2.4 The creative context	Section 2.5 The creative product
Chapter 3 Theories about learning and the stimulation of creativity				
Chapter 4 Empirical research design				
Chapter 5 Technology Education programmes aimed at enhancing creativity				
Chapter 6 Data analysis and interpretation				
Chapter 7 Findings, conclusions and recommendations				
Bibliography				
Appendixes				

CHAPTER SEVEN

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This chapter will provide an overview of the study and the findings, conclusions and recommendations will be discussed. Attention will be given to the problems investigated in the study, the aims and hypotheses of the study, the findings of the literature study and the empirical study, and the fate of the hypotheses. It will further discuss the limitations of this study and give ideas about what further studies can be conducted based on this current one.

7.2 OVERVIEW OF THE STUDY

The chapters in this thesis will be discussed one after the other to give a brief overview of what was done and found in each.

7.2.1 Chapter one: Orientation and statement of the problem

Chapter one gave the aims, rationale and hypotheses of this study: It concluded that it would be worthwhile, in the light of the demands for creative work expected of teachers in the current educational paradigm, to investigate what the *status quo* is in participants who opt for education as a career. It was further seen as important to investigate ways in which the creativity of students could be enhanced by using the opportunities provided by subjects like Technology Education specifically.

7.2.2 Chapter two: Creativity

In Chapter two the literature was scrutinized for information about what creativity is, what common characteristics creative people share and what distinguishes them from less creative people, what the steps of the creative process are and the skills needed to go through them, the contexts that are conducive to encouraging creativity, as well as those that inhibit it and lastly the creative product as outcome of the creative process. It concluded that all creativity is not equal. Ordinary creativity can be found in all people, but the creativity of geniuses is brought about by the confluence of certain genetic and social circumstances, difficult and perhaps even risky to try to simulate. Creativity depends on a combination of genetic and ordinary

mental processes that are activated by certain conditions in the life of individuals. Culture, socio-economic factors, ways in which children are acculturated, the role models they are exposed to and the support or lack of support in their lives, may all play roles in how creative they will turn out to be and/or the ways in which they will be creative.

7.2.3 Chapter three: Theories about learning and stimulation of creativity

Chapter three focused on the different learning theories, what they have to say about creativity and how this behaviour could be learnt or inhibited. Emphasis is placed on objectivist theories like Behaviourism, Connectionism and Neuroscience, on cognitive theories like Constructivism, Gestalt and Experientialism, on social cognitive theories that focus on the ideas of mediation, scaffolding, modelling and, lastly, on theories that try to reconcile and integrate different aspects of the others. The chapter concludes with a model for teaching and learning creative behaviour and skills, starting on the level of readiness suitable to the individual (*cf.* figure 3.10). Chaos is seen as the ultimate starting point for original work, since little interference may lead to less brainwashing and less imitation. Chaotic conditions may, however, interfere with the proper acquisition of knowledge and skills necessary for normal development. On the other extreme is the condition of reception and rote learning that, although necessary, must also be used with discretion, since it may inhibit creativity. Mediated creativity and guided discovery are halfway stations that can support individuals while giving them enough freedom to explore.

7.2.4 Chapter four: Empirical research design

In this chapter the instruments that were used to test for creativity and for creative abilities were discussed. The questionnaires used for gathering biographical data and for perceptions about the contexts to which the students were exposed were also discussed. The statistical methods that were used to analyse the data that were obtained were also explained. It included descriptive and inferential statistics, as well as structural equation modelling, specifically PLS-path modelling. The reasons for the choice of the different methods were given. The guidelines for interpretation of the obtained statistics were discussed. Attention was given to technical detail, validity and reliability of these instruments and statistical methods.

7.2.5 Chapter five: Technology Education programmes aimed at enhancing creativity

Chapter five described in detail the different programmes that were followed in Technology Education over the three years of the study. Applications of the basic Technology Education programme, with its emphasis on process skills, were compared with the enriched Technology Education programme to which emphasis on creative role models as well as explicit encouragement of creative behaviour was added.

7.2.6 Chapter six: Data, findings and interpretations

In chapter six the results of the *ex post facto* and the quasi-experimental studies were recorded, analysed and discussed. Data handling prior and during analysis and matters like measures to ensure construct validity, handling data from non-equivalent groups and significance testing were discussed as they were applied to the data matrix for this study. Selected data were given in tables, illustrated with graphs and path models. The decisions whether to reject or accept the null hypotheses or alternative hypotheses were given and discussed.

7.3 FINDINGS OF THE LITERATURE STUDY

The findings from the literature study will be discussed looking at the concept of creativity, the creative person, process, context, product and learning creativity.

7.3.1 The concept of creativity

Creativity was found to be a phenomenon occurring in human societies leading to change, innovation, invention, renewal and adaptation. It was also found to be a characteristic of an individual that may or may not lead to innovation or invention (*cf.* 2.1.2). Different components were found to be present wherever creative contributions were made, namely a creative person, a creative process, a creative context and finally a creative product(*cf.* 2.2.2.3, 2.4.2.5).

7.3.2 The creative person

The creative person is seen as a complex person with both desirable and less desirable characteristics (*cf.* 2.2.3.1). Some may argue that creativity is a kind of intelligence or learning style (*cf.* 2.2.2.1 & 2.2.2.2), but others are of the opinion that the most important contributors to creativity seem to be personal characteristics and

thinking styles (*cf.* 2.2.2.3.& 2.2.3). Personal abilities that are implicated are the ability to persevere, to work independently, to develop mechanisms for self-motivation and self-rewarding, to access the right hemisphere of the brain, to alternate between the left and the right hemispheres as demanded by the task, a large attention span, low latent inhibition leading to openness, access to memory stores with information in chunked form and a well-developed working memory for juggling with ideas. Different creative styles are seen in different individuals (*cf.* 2.2.4). In a creative team these different creative styles can compliment one another. Individuals with different creative styles and strengths fulfil different needs present in the community. Some personal factors enhance an individual's creativity while others inhibit it (*cf.* 2.2.5). Technology Education may be utilized to address cognitive, conative and affective factors that may inhibit an individual's creativity (*cf.* 2.2.6).

7.3.3 The creative process

The mental processes involved in the creative process seem to be ordinary thinking processes (*cf.* 2.2.2.1.4; 2.3.1 & 3.3.1.2). The person creating something often goes through a number of distinguishable steps like preparation (learning, observing), incubation (subconsciously busy with problem), illumination (Gestalt, insight or complete solution to problem or possible solutions to the problem appear seemingly effortless) and verification (practical aspects sorted out) (*cf.* 2.3.2). In different cultures and different contexts these steps will be experienced and/or described in different ways (*cf.* 2.3.2.2). Knowledge of the process can lead to situations where the process can be taught explicitly and applied deliberately (*cf.* 2.3.4). Skills that were tested in this study that are process-related include fluency (the ability to generate many possibilities), originality (the ability to generate new possibilities), elaboration (the ability to generate details about the possibilities) and flexibility (the ability to generate possibilities from different categories). The technological process as taught in Technology Education, addresses process skills specifically (*cf.* 2.3.6). It therefore provides an opportunity to enhance creativity in the areas where needs with process skills exist.

7.3.4 The creative context

The context is the system within which the individual functions. The context is described here as a complex natural evolving system (*cf.* 2.4.1) The context in which a person grows up and finds him/herself in, is seen as a strong accelerator or inhibitor of latent creative abilities. This context, made up of cultural practices, beliefs,

attitudes, resources like physical resources and time as well as the needs of the community, can cultivate an attitude of acceptance for change or intolerance to change. Creativity does to culture what mutations do to genes (*cf.* 2.4.2.3). Since creativity usually brings change in a stable situation, change is not always good or acceptable (*cf.* 2.4.2.4). An inability to change is, however, also sometimes detrimental. Creativity in the individuals in a community therefore gives plasticity and adaptability to that community. The degree of creativity that could be allowed, is regulated by external factors like environmental change. Internal factors like creative genius, present in the community, also play a huge role in bringing about change or in accelerating change. Challenging contexts that shape the behaviour and personality towards openness and independence, and provide appropriate role models, motivation, networks of support, mediation and cognitive development, are needed to stimulate creativity (*cf.* 2.4.3). Technology Education can contribute to the development of a context that stimulates creativity by paying attention to the physical context, but specifically also to the social context (*cf.* 2.4.4).

7.3.5 The creative product

Creative products are the outcomes when a person, stimulated by an encouraging context, goes through the creative process. The product in itself can act as an accelerator of change and an artefact in mediating creativity and learning (*cf.* 2.5.2). Co-evolution is the effect that products have on humans: as the products evolve, so also does the human culture and *vice versa* (*cf.* 2.4.3.5). A study of products can therefore lead to the discovery of trends and prediction of future trends and products. Products reflect the spirit of the time. The product is evidence that the process took place and can be evaluated as such (*cf.* 2.5.2 & 2.5.3). The ultimate purpose of a Technology Education programme aiming to enhance creativity is to enable the participants to produce more creative products. For teachers, these products would be the lessons, learner support materials and assessment tools and situations that they design (*cf.* 2.5.4 & 2.5.5).

7.3.6 Creativity and learning

Creativity is a behaviour, an attitude and a way of thinking that can be learnt, encouraged and inhibited to a certain degree. Ways on how to teach creativity include modelling, networking, mediating and guiding, challenging and providing a context in which it can be enhanced (*cf.* 3.3.3; 3.3.4. & 3.5.3) This context may be described as open, non-judgmental, with opportunities for networking, exposure to a

number of creative role models, challenging, inspiring and sometimes even starting in chaos (cf. 2.4.3). **Balance** is important (cf. 3.5.1): without proper knowledge and skill acquisition, creativity becomes unlikely. This is so because failure to access knowledge from the domain (cf. 2.4.2.2) or to process and use this knowledge, hampers development as every individual “invents the wheel” from scratch. Exposure to a **wide variety of knowledge** enables a person to make unusual combinations as would be expected of him/her in order to be creative (cf. 3.5.3.2). A very important incentive for proper knowledge and skill acquisition, is that the process through which knowledge is acquired, is **instrumental in brain development**: a process that is highly experience dependent (cf. 2.4.2.2; 3.3.1; 3.3.2; 3.3.4 & 3.5.3.). On the other hand, without the freedom to explore and to fail, a student may develop the “*afraid to die*” syndrome (cf. 3.3.1.3.4) making risk taking, and therefore creativity, unlikely. Manageable stress is the main factor in stimulating learning, also learning creativity (cf. 2.4.3.5, 2.4.3.6, 3.3.1.2.2). **Cognitive conflict** is another important factor in learning creativity since it provides motivation by creating a potential difference between the reality and a dream (cf. 3.4).

7.4 FINDINGS OF EMPIRICAL INVESTIGATION

7.4.1 The *ex post facto* study

The findings in the *ex post facto* study are discussed under the headings of person, process, context and product.

7.4.1.1 The creative person

Certain personal factors like age, position in the family, gender and academic achievement were tested, using PLS-path-modelling (cf. 6.2.1). It was shown that of the factors that were tested, academic achievement was the strongest predictor of creative abilities. The relationship showed that, generally, stronger academic achievement goes hand in hand with creativity indexes up to a point: the participants who scored 80% and above showed lower creativity indexes than those who scored between 70 and 80% (cf. 6.2.1.1). This relationship confirmed what was also described in the literature (cf. 2.4.3.7). Age was the other relationship with a path coefficient larger than 0.1. It indicated that the older the students in this group were, the lower their creativity indexes. One may speculate about the reasons for this. One reason may be the introduction of OBE in the later years. Another may be that the African group that tested lower in the pre-test was on average a little more than a

year older than the non-African group (*cf.* 6.2.1.2). Although gender and position in the family showed insignificant relationships in the path models, they were also discussed briefly (*cf.* 6.2.1.3).

7.4.1.2 The creative process

The different creative abilities (fluency, originality, elaboration and flexibility) were tested. It was found that the participants generally had most problems with elaboration (the ability to add detail). The second category giving problems was flexibility: the ability to give responses from different categories or perspectives (*cf.* 6.2.2). It was further found that process skills related to contextual factors (*cf.* 6.2.3.1). Position in the family affected flexibility significantly: the later born children participating in this study showed a higher ability to look at a situation from different perspectives. Flexibility was however negatively affected by bigger family size. This related to the effect of socio-economic and acculturation factors. The higher the socio-economic index and the parental education were and the smaller the family size was, the higher the flexibility and elaboration creative abilities were. The absence of family trauma contributed significantly to flexibility. Choosing a male relative (mainly the father) as a role model, was related weakly to originality. After exposure to both the Technology Education programmes the abilities generally improved, but elaboration was still not up to par. The participants involved in the enriched programme showed significant improvements in all abilities except originality (*cf.* 6.3.2).

7.4.1.3 The creative context

PLS-path modelling was used to test the relationships between contextual factors, perceptions about the context and the creativity in the pre-programme and post-programme ATTAs.

- Strong correlations were found between culture, *SocioAcc* and school models attended. The school model attended was the strongest predictor of creativity index in the pre-test, followed by culture (*cf.* 6.2.3.1). The choice of family members, especially males, seems to be linked to higher creativity indexes. The absence of the father in the family seems to affect a person's creativity negatively. This could be because of the effect of the fathers's absence on the socio-economic position of the family, but may also be related to challenges and the cognitive modeling provided by the father. This relationship could be

researched further, because it has implications in the school situation where few male teachers enter the profession.

- Besides the relationships reported above, it was found that the school model is strongly and negatively related to the perception of own culture as stimulating creativity. Participants who attended previously model C schools were more positive about their cultures as stimulating creativity. This positive relationship also related strongly with perceptions that productive thinking practices are valuable outcomes of education. Participants who perceived their families as contexts that stimulate creativity, also perceived their schools as stimulating creativity, but not their cultures (*cf.* 6.2.3.2).

The positive perceptions about culture as stimulating creativity and productive thinking as a valuable outcome of education is associated with higher creativity indexes. The positive perception about family and schools as contexts that stimulate creativity are associated with lower creativity indexes. This could be explained as the result of lower expectations of the participants regarding these contexts. Perceptions are subjective and relative. For example: An enthusiastic response to the question whether they debate the pros and cons of situations at home is still relative. One student may respond less enthusiastically if the degree of participation in a debate does not meet his/her expectations, while another, with less opportunity for debate may think that it is enough, especially if that is how he/she is acculturated (*cf.* 6.2.3.2 & 6.2.3.3). A further possible reason may be that participants from the previous model C schools felt less accepted, more conflicted, but more challenged because their teachers may have demanded more of them. The families with higher socio-economic status and higher parental education could also have challenged the participants from these contexts more (*cf.* 2.4.3.5). Although the support and acceptance were present in the families and classrooms of the students who showed lower creativity, the challenge and exposure to experiences that stretched them could have been absent.

In conclusion: Significant direct and indirect relationships exist between contextual factors and creativity indexes, contextual factors and whether creativity is perceived as acceptable behaviour, as well as between perceptions about different life spheres (contexts) as stimulating creativity and the creativity indexes.

7.4.1.4 The creative product

Although considered as important and relevant, creative products *per se* were not used in the *ex post facto* part of this study. The reasons for this are discussed in detail in 2.5.2.2 and 2.5.6.

7.4.2 The quasi -experimental study

The effects of the different Technology Education programmes are again discussed under the headings of person, process, context and product.

7.4.2.1 The creative person

A change in the creativity index of a person is here seen as a change in the creativity of a person. All participants benefited from the Technology Education programmes that they were exposed to, with a medium effect for all (*cf.* table 6.10).

Participants who were exposed to the basic programme showed higher creativity indexes to start off with (*cf.* figure 6.12). Their creativity indexes increased slightly, shown as a small, but significant effect. The creativity indexes increased much more dramatically in the group exposed to the enriched programme. It was also interpreted as a medium effect (*cf.* 6.3.1; tables 6.7; 6.8, 6.9 & figure 6.12).

7.4.2.2 The creative process

A change in the creative abilities of an individual is treated as a change in the creative process skills applied by a person.

Elaboration, fluency and flexibility increased significantly as result of exposure to the enriched programme. Elaboration was the only skill that was stimulated significantly as result of the basic programme. Originality was not stimulated significantly by any of the programmes followed. Both programmes therefore had a stimulating effect on the problem area, namely elaboration (*cf.* 6.3.2; table 6.10 & figure 6.13).

7.4.2.3 The creative context

The question is: Did the Technology Education programmes that were followed have the same or different effects on the participants who were from different contexts? Do participants from different backgrounds respond the same or differently to the same programmes?

From the data it is clear that participants from African backgrounds responded very well to the enriched programmes (large effect). The same is not true of the participants from non-African backgrounds. Although their creativity indexes improved slightly, the increase was not statistically significant. The basic programme had a slight positive effect on both cultural groups, but these effects might be explained by maturation and /or regression towards the mean (*cf.* 6.3.3; table 6.11 & figure 6.16).

The question to the answer asked in the first paragraph of this section is therefore: Yes, the background of the participants makes them more or less modifiable with a programme like the one applied in this study.

A greater challenge (less structure and more “chaos”) is recommended for participants as soon as they have the necessary attitudes and skills to go to the next level of less dependent learning.

7.4.2.4 The creative product

Although creative products were available and are considered as important and relevant, they were not analysed in the experimental part of this study. Besides the fact that it would have made the study more complex and longer, the subjectivity and the problem with comparison of pre and post product results would have been very difficult. Giving the same task for comparison purposes would have jeopardized the validity of the study, since the learning that occurred in the pre-test would definitely have affected the post-test results. Different tasks, in turn, would have been difficult to compare. The reasons why they were not included are discussed in more detail in 2.5.2.2 and 2.5.6.

7.5 FINDINGS REGARDING THE AIMS OF THIS STUDY

The aims of this study will be given one by one and the findings made regarding each of them will be discussed thereafter:

1. To determine the creativity indexes and creative abilities of pre-service teachers in Technology Education.

It was found that the 207 students enrolled in the full-time education course at this university over a three-year period had an average creativity index of 59.99, compared to 69.43 for the norm population used in the manual. This was a significant difference that led the researcher to the conclusion that the perception that pre-

service teachers are struggling to seize the opportunities for creative work was not unfounded and that there was reason for concern (*cf.* 6.3.1; table 6.9).

2. To investigate the factors that impact on the creativity indexes and creative abilities of pre-service teachers in Technology Education.

The Visual-PLS models showed that:

- **personal factors** such as academic achievement and age (*cf.* 6.2.1) were related significantly to the pre-programme creativity indexes;
- **process factors** that were identified as problems were the ability to elaborate and the ability to be flexible (*cf.* 6.2.2);
- **contextual factors** such as culture, school model attended and *SocioAcc* (*cf.* 6.2.3) were related the strongest to the pre-programme creativity indexes; and
- **perceptions** about family and school were inversely proportional to creativity indexes and perceptions about culture and productive thinking were directly proportional to the creativity index (*cf.* 6.2.3.)

3. To explore how the creative thinking abilities of pre-service teachers in Technology Education can be improved.

In the literature study (*cf.* 2.2 & 2.3) it was found that creativity is a complex phenomenon, but depends on the use of ordinary mental skills. Creativity is seen as a result of a confluence of different factors: imagination, knowledge, motivation, intelligence, personality, thinking styles and certain environmental conditions (Sternberg, 1988:125-146; Feldman, 1999:169; Sternberg & Lubart, 1999:3-15). Creative behaviour can be learnt to a certain degree through processes such as modelling, networking, mediation and support (*cf.* 3.3.3; 3.5 & 5.2.1). Early childhood conditions are important in this regard, but much can be done later on to provide a context that is conducive to enhancing creativity. Since creativity is a kind of cultural mutation and may be disrupting well-functioning systems, creative behaviour is inhibited by all cultures to varying degrees (*cf.* 2.4.2.4). To get individuals from cultures that inhibit creativity heavily to perform creatively may need disinhibition by making the creative behaviour acceptable and desirable. Motivation, inspiration and perseverance are considered as important and manageable challenge is one way of stretching an individual to perform creatively (*cf.* 2.4.3.5 & 3.3.1.2.2). Technology Education, with its open and problem-solving nature, emphasis on process skills, opportunity to provide learners with open-ended tasks and expose them to a wide

variety of knowledge, provides an ideal opportunity for enhancing creativity (cf. 5.4).

4. To design and implement a programme to enhance the creative thinking abilities of pre-service teachers in Technology Education.

Two different programmes were applied to the participants (cf. 5.5), namely a basic programme (cf. 5.5.1) and an enriched programme (cf. 5.5.2). The basic programme is the programme that was followed over the past number of years at this university and involved emphasis on process skills. A small significant improvement in creativity indexes was seen in the participants that were exposed to this programme (cf. 6.3.1). Except for a significant improvement in elaboration skills, not one of the other creative abilities was affected significantly (cf. 6.3.2).

The enriched programme focused on disinhibition of cultural stumbling blocks by emphasizing creative role models and making creativity desirable behaviour. Creative indexes showed a medium and significant increase and all creative abilities except originality improved (cf. 6.3.2). The difference between the group exposed to the basic programme and the group exposed to the enriched programme was significant at the beginning of the programme. At the end this difference was insignificant. The enriched programme applied to African participants yielded very good results when the effects of the programmes were compared within cultural groups (cf. 6.3.3; table 6.11 & figure 6.16).

7.6 ACCEPTING OR REJECTING HYPOTHESES

7.6.1 Study 1: *Ex post facto*

Assumption 1 was that personal factors (such as age, position in family, academic achievement and gender), process-related factors (such as ability to generate many ideas, new ideas, different ideas and add detail to ideas), contextual factors (such as culture, socio-economic factors and acculturation of parents (*SocioAcc*), family factors and school model attended) and perceptions of whether contexts (such as culture, family and school) model creative behaviour as desirable behaviour might be responsible for the inability of students to seize opportunities for creative work. This assumption was investigated step-by-step using the hypotheses below:

The null hypothesis H_0^1 that personal factors have no significant influence on the creativity of participants in this study had to be rejected. Personal factors such as age and academic achievement had significant influences. This led to the modification of the alternative hypothesis H_a^1 : Some personal factors have significant influence on

the creativity of participants in this study (*cf.* 6.2.1).

The null hypothesis H_0^2 , that there is no difference in the strength of the relationships between creativity index and the different creative abilities used in the creative processes in the participants in this study, had to be rejected: Elaboration and flexibility stood out as problem areas that had significant influences on the difference in creativity indexes. This lead to the acceptance of the alternative hypothesis H_a^2 : There are differences in the strength of the relationships between the creativity index and the different creative abilities. Some creative abilities influencing the creative processes are more of a problem for the participants in this study than others (*cf.* 6.2.2)

The null hypothesis H_0^3 , that there are no relationships (direct or indirect) between contextual factors and creativity in the participants in this study, had to be rejected. Contextual factors such as culture, school models attended, socio-economic factors and acculturation of parents had significant paths leading to creativity indexes. Also, contextual factors influence creative abilities differently. This lead to the acceptance of the alternative hypothesis H_a^3 : There are direct and indirect relationships between the contextual factors and creativity (*cf.* 6.2.3.1).

The null hypothesis H_0^4 , that there are no relationships (direct or indirect) between contextual factors and perceptions about factors that may stimulate creativity in the participants in this study, was also rejected and the alternative hypothesis H_a^4 accepted: There are direct and indirect relationships between contextual factors and the perception that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres) (*cf.* 6.2.3.2).

The null hypothesis H_0^5 , that there are no relationships (direct or indirect) between perceptions about the context and the creativity in the participants in this study, was rejected. This lead to the acceptance of the alternative hypothesis H_a^5 : There are direct and indirect relationships between the perceptions that participants have about whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres) and their creativity indexes (*cf.* 6.2.3.3).

Rejection of the null hypotheses H_0^1 , H_0^2 , H_0^3 , H_0^4 and H_0^5 lead to the acceptance of the alternative integrated hypothesis H_a^6 , that there are direct and indirect relationships between the personal, process and contextual factors and whether creativity is modelled as acceptable behaviour by the specific contexts (life spheres)

and direct and indirect relationships between the perceptual and contextual factors and their levels of creativity (cf. 6.2.3.4).

7.6.2 Study 2: The quasi-experimental study

Assumption 2 was that exposure to creative role models, modelling creative behaviour as desirable, combined with exposure to creative processes, should have a more positive effect on creativity indexes of participants than just exposure to creative processes.

The null hypothesis H_0^6 , that the difference in Technology Education programmes followed will have no significant effect on participants' creativity indexes can be rejected. The alternative hypothesis H_a^7 and H_a^9 are accepted. Explicit training of pre-service teachers to view creative behaviour positively had a definite positive effect on participants' creative indexes and exposure to the different Technology Education programmes had different effects on participants' creative indexes (cf. 6.3.1).

The null hypothesis H_0^7 , that the difference in Technology Education programmes followed will have no significant different effect on participants' creative process skills (creative abilities), can be rejected. The alternative hypothesis H_a^8 , namely that the difference in the programmes will have significant different effects on the different creative abilities is accepted. Fluency, elaboration and flexibility were all stimulated significantly by the enriched programme, whereas the basic programme stimulated only the elaboration skills significantly (cf. 6.3.2).

Assumption 3 states that the context from which a student comes determines the effect that a programme aimed at enhancing creativity may have on his/her creativity index.

The null hypothesis H_0^8 , that the possible effects of the different programmes on the creativity indexes of the participants will not be influenced by the contextual and perceptual factors, cannot be accepted in this form. The alternative hypothesis H_a^{10} , that the effects of the programmes on the creativity indexes are dependent on the contextual and perceptual factors is accepted. Culture affected *SocioAcc* and that, in turn, affected, together with schools attended, the post-programme creativity index (cf. 6.3.3).

The null hypothesis H_0^9 , that the possible effects of the different programmes on the creative abilities of the participants will not be influenced by the contextual and

perceptual factors, can also not be accepted in this form. The alternative hypothesis H_a^{11} , that the effects of the programmes on the creative abilities are dependent on the contextual and perceptual factors, is accepted (*cf.* 6.3.3).

Finally, the null hypothesis H_0^{10} , that contextual factors have no effect on the “modifiability” of participants regarding creativity, cannot be accepted. The alternative hypothesis H_a^{12} , that contextual factors have an effect on the “modifiability” of participants regarding creativity, is accepted and therefore needs to be considered when designing programmes aimed at enhancing creativity. The specific enriched programme that was followed aimed to provide social support for behavioural modification first of all. This programme could not help participants who do not have a problem in this regard to become more creative to the same extent. It could, however, help participants who needed to be disinhibited.

7.7 RECOMMENDATIONS

7.7.1 The creative person

To help participants to increase their creativity involves more than just exposing them to steps in a process and /or letting them run through the process a number of times. It is not only the intellect of the person that needs to be involved, but also the whole person.

- One should take note of the need for disinhibition in some participants if creativity is to be encouraged. For these participants, especially those from African backgrounds, creativity needs to be modelled as desirable behaviour (*cf.* 2.4.3.4). This is, however, not needed and therefore not successful for all participants.
- For all participants challenge needs to be increased. These aspects may be improved by using more challenging projects and group compositions where participants with different creative strengths may join hands (and brains). The challenge needs to be open-ended. A link to real relevant problems in the community using community projects may be a way of enhancing the challenge and increasing motivation (*cf.* 5.4.3, 5.5.2.3).

7.7.2 The creative process

The difference in the outcomes of the creative abilities of the participants, who followed the basic programme and those who were exposed to the enriched

programme, makes one realize that creative process skills do not develop spontaneously, as one may easily assume when exposing participants to the technological process. Explicit attention must be given to creative process skills to get significant change (*cf.* 2.3.7)

Attention to a variety of different creative abilities should be made part of the requirements of a challenge given to students in Technology Education. Two creative abilities that stood out in this study as problem areas were elaboration and flexibility. To develop these abilities, explicit attention could be given to the planning phase of the technological process to add as much detail as appropriate to the designs (*cf.* 2.3.7). Detail could be added to the point of over-detailing and then even removal again of unnecessary detail. To develop flexibility, explicit attention could be given during the research phase of the technological process to view situations from different perspectives. Debate and role-play could be used. Students might even be placed in different roles from whose perspectives situations, products and problems, may be studied or the whole project could be followed through from the viewpoint of different groups or individuals. Even the other creative abilities could be developed further. Explicit stretching and techniques could be employed to get more ideas. Three ideas are too few, any ideas are not good enough, originality could be expected and techniques, using ordinary ideas as starting points for original ideas, could be taught.

In Technology Education one must take note of the observation that just “doing” technology is not necessarily helping to develop creativity. Special efforts and challenges are needed. Social and cultural aspects need to be taken into consideration (*cf.* 2.4.3, 2.4.4).

7.7.3 The creative context

Addressing the influence of the contexts to which the participants were exposed before they came to the university first of all involves acknowledging the differences. If one thinks that all students can start at the same place and level regarding creativity, one may disregard the needs of one group while regarding that of another. The participants, who were exposed to the basic programme, did worse regarding their verbal and figural creativity indicators after exposure to the basic programme. It may be that emphasis on process makes them lose their “spark”(table 6.9). The non-African students exposed to the enriched programme did not gain dramatically in creativity either. This indicates that their needs were not met regarding creativity

development. Similarly, disregarding the cultural disinhibition needs of African students may lead to a situation where all one's efforts may be in vain, as was seen with the African students exposed to the basic programme who showed no significant increase in creativity (table 6.10).

A point that stood out from this study is that while disinhibition may be important to unlock the creativity of some participants, greater challenges may be investigated as a way of getting more participants to increase their creative abilities (*cf.* 2.4.3.5). These challenges should be applied to participants, taking their level of readiness into account on a gliding scale, from structured and scaffolded for students who need the support, up to "chaos" in the case of students who are ready for it. Although starting in "chaos", namely with open-ended situations and by demanding an original answer, may be uncomfortable, even for students who are ready for it at first (because they are not used to it), greater challenges must "force" them out of their comfort zones.

7.8 IMPORTANT ASPECTS FOR TEACHING CREATIVITY

Creative potential: All people have creative potential. Creative styles, roles and levels differ.

Cultural inhibition: All cultures inhibit creativity to a certain degree. Some cultures inhibit creativity more than others. If creative output is expected of people from cultures that inhibit it to a greater degree, disinhibition (such as exposure to creative role models and creative thinking processes) should be addressed. Teaching the creative process alone will not be enough.

Knowledge acquisition: The following aspects regarding knowledge acquisition are important for development of creativity:

- Proper acquisition of basic knowledge
- Exposure to a variety of knowledge
- Storing the knowledge in chunked form
- Emphasis on knowledge re-use for both reproduction AND for innovation

Cognitive skills: The following aspects regarding cognitive skills are important for development of creativity in the light of this study:

- Development of working memory capacity enabling a person to juggle with information
- Development of specifically elaboration and flexibility skills
- Giving opportunity to start in chaos and to create own order when ready for it

Motivation: Intrinsic motivation and perseverance are key factors in creativity. The following may help to develop intrinsic motivation:

- Challenging tasks slightly above the current level of the student
- Stimulating physical environment
- Access to stimulating resources
- Visualising the end product and desire to have the problem solved
- Scaffolding, where and when needed, to make task manageable
- Encouragement with input when impasse is reached to challenge student and keep him/her on track and motivated

Time: To allow time for preparation (conscious knowledge acquisition and processing) and incubation (subconscious knowledge acquisition and processing), time is essential. Assignments expecting knowledge re-use for innovation must be given in advance.

7.9 IDEAS FOR FURTHER STUDIES

From the groundwork in this study, a number of further studies could be conducted.

- A study regarding the conceptions of creativity and creative processes in the different cultures represented in South Africa.
- Design of tests to test creativity according to African conceptions of creativity.
- Products can be evaluated as outcomes of the creative process and as evidence of creativity, instead of using a test.

- The effects of different programmes and different periods of exposure can be investigated. The programmes in this study were inexpensive in terms of time and period: less than 1 ½ hour per week for one semester.
- The sustainability of gains in creativity over time could be investigated in longitudinal studies.
- A true experimental study with equivalent groups, although difficult to organize, could be attempted.
- New experimental situations could be set up, such as situations where participants are grouped together in such a way that the group consists of individuals with different creative roles. This may be compared with situations where individuals with similar creative roles are put in one group. The emotional and intellectual experiences of the participants in the different situations may be described and the creative output measured.
- The effects of making challenges bigger as student's progress through the course or for students in different years of study could be researched.
- The effect of different methodologies and techniques in presenting Technology Education on creativity enhancement could be researched. Projects may include whole class projects, community involvement and varying mixtures of inductive versus deductive learning experiences.
- To stimulate the creativity of the participants to attain the creativity index average of the "norm population" could take an extra effort. A bigger challenge with less structure and more freedom might be an option. This may be especially true for the participants from the higher socio-economic and acculturation situations where the basic creative skills and perceptions of creative behaviour as acceptable are already in place.
- The enriched programme was designed with the assumption that some participants may have a problem to set their innate creativity free, due to cultural inhibition. The point was to try to "disinhibit" them and to try to create an atmosphere that encourages creative behaviour. For some participants this might not have been their problem; they may have been irritated with this kind of attempt. A needs analysis at the beginning, besides the testing of creativity, could have been a way of selecting those who for example needed cultural

“disinhibition” from others who needed stimulation of aspects like process skills, challenges, motivation or lateral thinking.

- An instrument to measure the degree of readiness of an individual to work independently (as proposed in the model in figures 3.9 and 3.10) could be developed. Such an instrument could be used as a diagnostic tool to help teachers in developing and assigning suitable tasks for different learners.
- Programmes consisting of different challenges could be developed. These challenges could differ so that they cater for students (and groups of students) with varying degrees of structuring, modelling and scaffolding needs. Students could be tested with the “readiness” tool, discussed above, and the tasks assigned accordingly.
- An instrument to assess the creative style of a person according to the model in figure 2.5 may be developed. This may help individuals in making career choices.
- One of the weak points of the programmes in this study is that they did nothing to stimulate originality. The creative skill that was the weakest in all the participants was elaboration: the skill to add detail. The second weakest was flexibility: the ability to look at a situation from different perspectives. One can design situations or programmes that work specifically on these aspects.
- Case studies of participants who were identified as highly creative or participants who showed significant increase (e.g. from creativity level 1 to 4) could be done. Following the careers of these participants may make a valuable contribution.
- Seeing the very few participants who tested on high creative levels as a valuable resource, and encouraging and supporting them in directions such as curriculum developers, developers of learner support materials, and so forth, could help to apply them sensibly.
- Similar studies as the present one could be done with participants from the same kind of population (pre-service teachers) or different populations such as in-service teachers, students in other courses, from different backgrounds etcetera. The results of this current study could then be compared with the results of the new study.

7.10 LIMITATIONS OF THIS STUDY

The problems that were encountered in the quasi experimental part of this study were related to the use of convenience sampling. It was done on a group of students as they were participating in the first year courses offered by the school of educational sciences at the university. It was therefore not a random sample from the population as a whole. The groups were further taken as they were: divided on the basis of language-of-instruction. So there was not any random sampling from the first year population.

The participants used in this study are a specific and unique subgroup of the population opting for teaching as a career, coming to a specific university, often living with their parents in the geographical area of the Vaal Triangle. They, like other students opting for teaching at other universities, all passed the country-wide matriculation examination on a sufficient level to gain entrance or provisional entrance to the university.

The research was done in a real-life classroom with the restriction of having to reach the same module outcomes with the participants in the different groups, as well as with the participants on the other campuses of this university.

This study, as explained, is therefore not a true experiment. There are variables that cannot be directly linked to cause and effect. There are, however, 'flow'-patterns that emerged in the basins of strange attractors (*cf.* 2.4.2.1) that may shed light on some educational practices and cultural values and that may be investigated further.

These above-mentioned restrictions necessitated specific adjustments and care in data handling that, if it could have been avoided, would have made the statistical analysis more straight-forward and would have reduced the threats of this situation to validity of the study. The results can therefore not be generalized to the South African population as a whole, but give insight into creativity and the factors affecting it in a specific subgroup, namely students enrolled at a university with the aim of becoming teachers.

The ATTA test that was used, tested certain abilities through the mode of writing and drawing. Language skills and artistic abilities may have advantaged some individuals. Some researchers combine tests to counter for this kind of problem. It was not done in this case, as it was assumed that the skills tested and the modes through which they were tested are most relevant in the classroom situation.

Although many limitations and shortcomings may be present in this study, it could provide the basis for further studies on the creativity of South African students opting for teaching as a career. It could further provide a springboard for the development of Technology Education programmes that may make provision for the enhancement of creativity within the diverse cultural context in South Africa.

7.11 SUMMARY

In this chapter an overview was given over the different chapters, the results of the literature study and of the empirical study. Findings regarding the aims of the study and the rejection or acceptance of the hypotheses were given. Recommendations, ideas for further studies flowing from this study, important aspects that should be attended to when teaching for creativity and, in conclusion, restrictions of this study, were discussed.

Creativity can and should be enhanced. To expect of teachers to do creative work and encourage creativity in the learners without equipping them for it, is an unfair demand. Teacher education institutions could take note of the need for enhancing creativity in teachers and the opportunities provided by Technology Education to do so.

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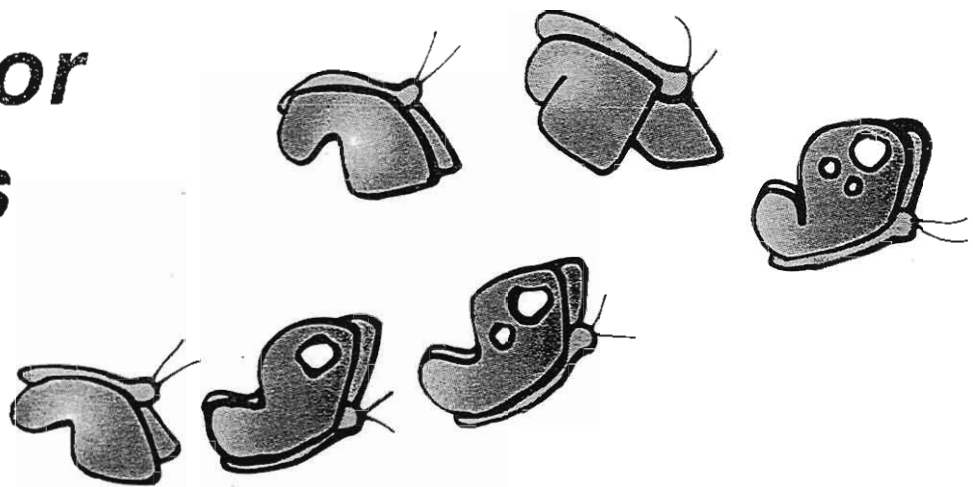
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APPENDIX A

ATTA TEST

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Abbreviated Torrance Test for Adults



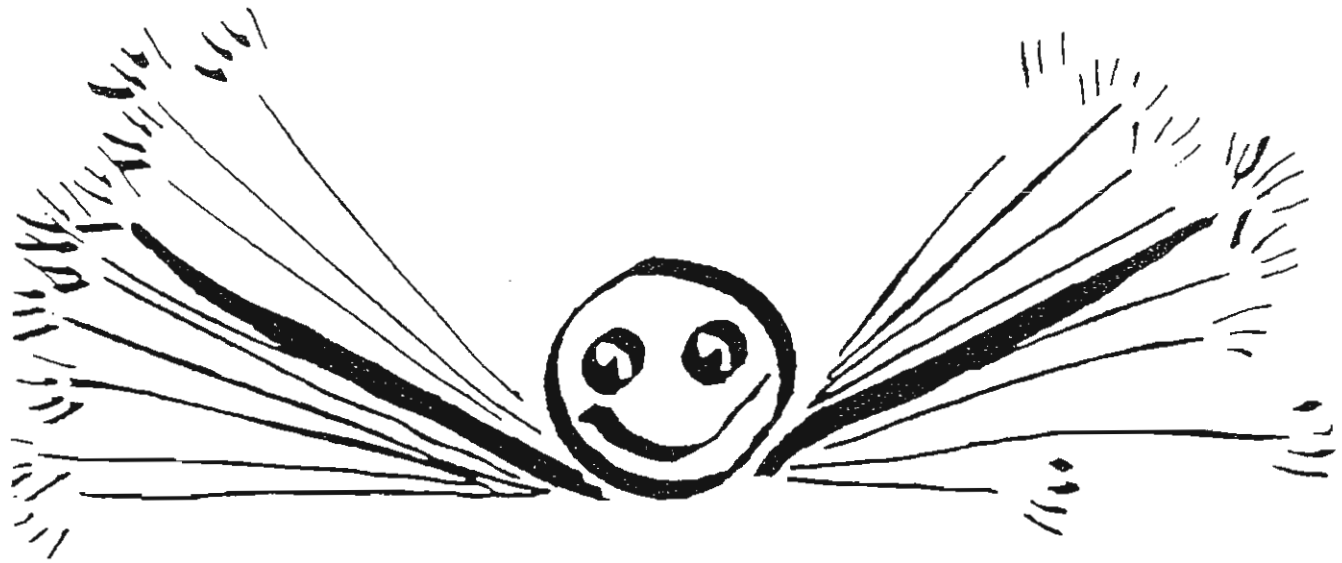
by
Kathy Goff, Ed.D. and E. Paul Torrance, Ph.D.

Name: _____ Date: _____

Sex: _____ Year of Birth: _____ Group: _____



SCHOLASTIC TESTING SERVICE, INC.
BENSENVILLE, ILLINOIS 60106-1617

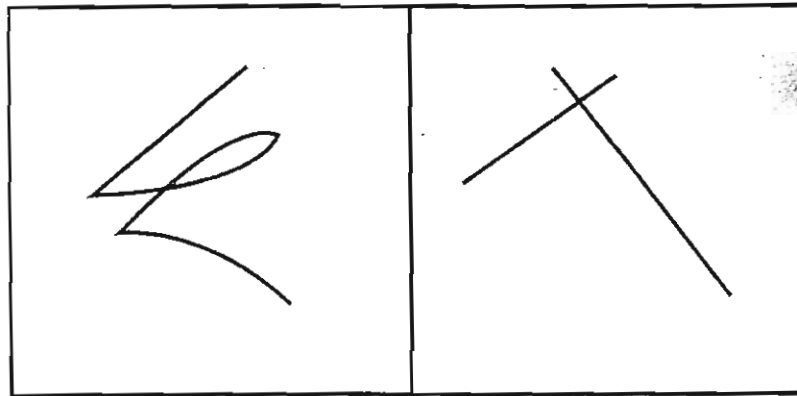


JUST SUPPOSE you could walk on air or fly without being in an airplane or similar vehicle. What problems might this create? List as many as you can.

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Activity 2

Use the incomplete figures below to make some pictures. Try to make your pictures unusual. Your pictures should communicate as interesting and as complete a story as possible. Be sure to give each picture a title.



Activity 3

See how many objects or pictures you can make from the triangles below, just as you did with the incomplete figures. Remember to create titles for your pictures.



Abbreviated Torrance Test for Adults (ATTA)
Scoring/Interpretation Worksheet

Name _____ Age (yrs.) _____ Group _____ Date _____

Norm-Referenced Measures

Creative Ability	Raw Scores				Scaled Scores									Scaled Scores
	Activity			Total Score	11	12	13	14	15	16	17	18	19	
	1	2	3		Corresponding Raw Scores									
Fluency					1-6	7	8-9	10	11-12	13-14	15-16	17	18+	
Originality					1	2	3	4	5	6	7-8	9-10	11+	
Elaboration	X				1-3	4-5	6-8	9-11	12-14	15-18	19-23	24-27	28+	
Flexibility	X	X			-	1	-	2	3	-	4	5	6+	
Creative Roles:					Collaborator			Contributor			Accelerator			
Total Scaled Score														

Criterion-Referenced Creativity Indicators

Verbal Responses (Activity #1)

Tally	Rating	Raw Score	
_____	_____	_____	1. Richness and Colorfulness of Imagery
_____	_____	_____	2. Emotions/Feelings
_____	_____	_____	3. Future Orientation
_____	_____	_____	4. Humor: Conceptual Incongruity
_____	_____	_____	5. Provocative Questions
Total		_____	

Figural Responses (Activities #2 and #3)

Tally	Rating	Raw Score	
_____	_____	_____	6. Openness: Resistance to Premature Closure
_____	_____	_____	7. Unusual Visualization, Different Perspective
_____	_____	_____	8. Movement and/or Sound
_____	_____	_____	9. Richness and/or Colorfulness of Imagery
_____	_____	_____	10. Abstractness of Titles
_____	_____	_____	11. Articulatness in Telling Story
_____	_____	_____	12. Combination/Synthesis of Two or More Figures
_____	_____	_____	13. Internal Visual Perspective
_____	_____	_____	14. Expressions of Feelings and Emotions
_____	_____	_____	15. Fantasy
Total		_____	

Composite Measures

_____ Total Scaled Score
 + _____ Total Indicator Score (Count 1-point for each "+" and 2 for each "++")
 = _____ CREATIVITY INDEX (CI)

<i>Creativity Index*</i>	1-50	51-59	60-67	68-73	74-77	78-84	85+
<i>Creativity Level</i>	1	2	3	4	5	6	7
<i>Verbal Assessment</i>	Minimal	Low	Below Average	Average	Above Average	High	Substantial
<i>% of Adults in Level</i>	4%	12%	20%	26%	20%	12%	4%

*Interpretive Aid—Find Creativity Index in top row score range. Use information in that column to help understand the CI.