

Chapter 1: Orientation into the Study

Introduction

This study focuses on final-year engineering undergraduate learning environments as legitimate and potentially effective educational spaces within which students' collective (team) creativity can be encouraged and developed. This mainly conceptual work encompasses the deconstruction of a pedagogic practice in relation to its capacity to shape and guide learning environments in ways that enable and limit certain classroom activities and actions as well as influence students' experiences of learning. The study goes on to reconceptualize and test, for purposes of illuminating the conceptual framework, a particular pedagogic practice in terms of whether it can support the development of students' creativity in engineering education. The study further focuses on investigating, for the same illuminative purpose, the existing engineering pedagogic practice in one University of Technology (UoT) in South Africa in relation to how it positions students on knowledge and how that, in turn, affects teachers and students' agency, autonomy and relations in the classroom which may either support or marginalize the fostering of students' collective creativity.

The investigation of these issues is vital because in more recent times in engineering education, there has been a growing interest in developing undergraduate students' collective creativity and other related social skills that grow out of "*joint thinking, passionate conversations and shared struggles common in meaningful relationships*" (John-Steiner, 2000: 3). One engineering educational challenge of our times is thus to conceive of the learning environment in such a manner as to develop learning conditions where creativity emerges out of patterns of social interaction where students are meaningfully, actively and collectively engaged in attempting higher designs of existing technologies.

According to a significant number of engineering education scholars, current curricular and pedagogic practices in engineering are driven by an overly-scientific approach and its teaching has largely been based on an obsolete and ancient epistemology of mimesis (Törnkvist, 1998; Ernst and Peden, 1998; Beder, 1999). The concept “mimesis” (the word is derived from the Greek root meaning ‘copying’, Kalantzis and Cope, 2008) as employed in this study to refer to curricular and pedagogic conditions that encourage the replication of existing learning content has re-entered 21st Century educational discourse through a 2008 book authored by Mary Kalantzis and Bill Cope called *‘New Learning: Elements of a Science of Education’*. According to Törnkvist (1998), the overly-scientific basis of engineering curriculum that tends to encourage mimesis serves more the purpose of creating academic respectability for engineering actors than it is a genuine attempt to meet the basic vocational demands of future engineers. The unintended consequence of this desire for academic respectability in engineering fields is that engineering curriculum especially at undergraduate level *“has become grossly overcrowded and dominated by science, to the detriment of other subjects”* and proceeds on the basis of *“tightly packed syllabus, full of science and maths and specialized technical subjects”* (Beder, 1999: 15). Kalantzis and Cope (2008) consider the epistemology of mimesis as culpable for content-driven traditions in curriculum and pedagogy in general. A mimetic curriculum, according to Kalantzis and Cope (2008), is a form of curriculum that advances the view that the world consists of definite facts which are not immediately accessible to students in formal educational settings. Given the general inaccessibility of these facts to students, these facts are then:

“Packaged into a digestible form, such as a textbook that covers the course. The textbook frames the reference point of learning, which is necessarily outside of the classroom – the facts of science...the formulae of mathematics” (Kalantzis and Cope, 2008: 195)

In this sense, a curriculum that is informed by mimesis posits the view that textbooks contain reliable explanations that aggregate what humans universally know and thus textbooks shape our models of reality.

A mimetic curriculum is a textbook-driven curriculum where textbooks inform students of 'things' of the outside world in a manner that is "*distant and distancing*" (Kalantzis and Cope, 2008: 195). These 'things' in the textbook, in terms of mimetic curriculum, are organized in the form of syllabi and the coverage of the course content which, in the modern temporality, focuses on content knowledge (facts and theories). However, in more recent times, an approach of essential learning has begun to shift focus towards delineating the kinds of learning outcomes that are expected in a specific area of curriculum and at a specified level of sophistication. In engineering education, these learning outcomes include the development of students' collective creativity and interpersonal skills which, materially, represents a shift in engineering education paradigm (Ernst and Peden, 1998; Kemnitzer, 1999; Beder, 1999; Bitcon, 1993).

It is important to note that UoTs have traditionally been characterized by a content-overloaded curriculum and thus left very little time for the development of students' creativity (McKenna and Sutherland, 2006). It has also to be noted that in a content-overloaded curriculum, there is almost always a constant threat for 'rushing through' to complete the syllabus which tends to limit teachers' ability to commit to students and to develop classroom conditions that provide students with the intellectual challenge necessary to engage in meaningful learning. According to Runté (1995), the content-overloaded curriculum tends to compel teachers and students to engage in mind-numbing classroom work routines and it thus leaves teachers with little time to engage in reflective practice that could result in teachers problematizing, critiquing and improving their classroom practice towards engaging students in deep, meaningful learning. A content-overloaded curriculum tends to encourage students' surface engagement with curricular topics and rarely encourages students to seek connections in these topics. Thus students' cognitive gains are not geared towards generating new insights or ideas (Daniels and Zemelman, 2004; Arreola, 2006)). It is widely accepted that a content-overloaded curriculum proceeds on the basis of a post-epistemic condition where teaching and learning are separated from research and, the main focus in the classroom is on content delivery (Fuller, 2003).

According to Kalantzis and Cope (2008), content-driven learning environments tend to be characterized by pedagogic practices that thrive and proceed in a deficiency mode and are often closed systems that assume that students 'lack' something which learning should 'fill' and when learning fails to do so then students are labeled and 'discarded' from the system. These closed conceptions of pedagogy encourage passive acquisition of knowledge rather than active participation of students in the learning processes and thus distinguish clearly between the formalism of rote learning in the classroom and the outside social and cultural purposes to which learning ought to connect (Kalantzis and Cope, 2008). The key rationale in closed pedagogies is that the only legitimate source of knowledge and site of knowing are textbooks and formal educational settings. This study is grounded in another view.

This study is premised on the belief that pedagogic practices that are likely to encourage students' collective creativity should have a growth focus and a largely open-ended approach to learning. A growth focus on learning suggests an acknowledgement that students bring knowledges and experiences into the learning environment so that a curriculum framework that assumes that definite facts about the world exist and that the sources of definitive knowledge are mostly external to classrooms is problematized. I, however, accept that scientific knowledge has played a major role in human intellectual development to form the basis of human technological, organizational and infrastructural progress. I also believe that such knowledge is equally relevant as the basis of seeking new insights and ideas in a creative problem-solving process.

In this study, a social reconstructivist perspective on learning, given impetus by invitational pedagogy as a way of creating learning environments that can encourage and develop students' collective creativity, is assumed. Social reconstructivism, as used in this study and drawn from Freire (1970), refers to engineering learning that is critical to the impact of engineering work on sustainability of natural resources and on climate change and attempts to contribute positively and practically on these discourses.

Based on this position on framing learning environments, this study suggests that the curriculum arrangements that can better support our model of learning should be an outcomes-driven curriculum. Such a model of curriculum outlines the key outcomes of curricular efforts and provides sufficient space for teachers to ‘experiment’ with various models of learning as well as offering sufficient leeway for teachers to create extended opportunities for students to engage with learning content more meaningfully and actively. This study is intent on formulating a basis for the development of such conditions for learning and the outcomes-driven curriculum is one factor to be taken into account. While the key outcomes of curricular efforts are outlined, sufficient space is left for teachers to create learning conditions that promote students’ active and meaningful engagement with learning content (Pitso, 2000). This is what is, in this study, termed invitational pedagogical conditions. Invitational conditions refer to situations where the power to persuade others of the validity of one’s position is coupled with time and space for them to verify its veracity; all else represents a violation. Invitational conditions are essentially inductive and are thus based on students systematically investigating the truthfulness and factual information about claims that are being made in the classroom.

This study essentially attempts to test whether these invitational pedagogical conditions can promote students’ collective creativity development. Through a series of what I am calling “*learnshops*” (See, the last paragraph below for a brief elucidation and Chapter 5 for more details), students were given extended opportunities to collectively explore their institutional technologies that relate to water, paper and energy. It was anticipated that, through this exploration of existing technologies, students would be able to figure out the design and current operations of these technologies, current efforts on improving their limitations and hopefully provide some new insights. It was expected that such a learning effort would take students beyond the classroom and into the actual sites where these technologies are being used, refined or even retired.

In this way, it was expected that students would modify their assumed dualistic viewing of things towards more relativistic terms where knowledge is provisional and useful to the extent of its utility and relevance in assisting to resolve critical steps in a problem-solving process (Perry, 1970). *Learnshops* were, thus, designed in such a way as to encourage students' active and collective engagement with engineering problem-solving efforts around environmental sustainability within the context of global warming, greenhouse gas emissions and depleting natural resources. In this sense, it was important that students' ideas generation conversations around these issues in the *learnshops* were premised on invitational dialogues that have the potential to first facilitate students' new ways of seeing the world of engineering within the sustainability discourses. Second, to engendering questioning attitudes in students, promoting students' research projects designs and inculcating increased awareness of how students could interact productively with others in the problem-solving efforts. Third, these dialogues were intended to encourage students to develop frameworks to deal with their creative experiences. Invitational dialogues draw from invitational rhetoric and refer to the view that communication is essentially a shared and egalitarian project which is generally free from the intentions of persuasion (Foss, 1993). *Learnshops* were designed as workshops of a special kind with the specific aim of facilitating students' learning that was likely to develop their creativity and other related capabilities. These *learnshops* also gave rise to the study's data which assisted with clarifying some of the salient aspects of the conceptual framework as further developed in Chapter 2 and 6.

It is also important to note that students' creativity development within engineering undergraduate education has been so significantly marginalized over time (Törnkvist, 1998; Ernst and Peden, 1998; Beder, 1999) that curricular and pedagogic research efforts that attempt to tackle this challenge can achieve such a feat through mainly conceptualization and testing of alternative curricular and pedagogic practices. The empirical data mainly serve to illuminate some of the key aspects of the conceptual framework.

This is how this study was conceived – as a conceptual work – with data collection intended to reveal the context of the study and classroom actors’ meanings of creativity as well as to develop (design and test) an alternative pedagogy that had better prospects of encouraging the development of students’ creativity.

Background and Rationale

The disconnect between goals of engineering education and creativity has, in more recent times, become a sustained global discourse framed as efforts on reforming engineering curriculum and pedagogy to better serve the 21st Century economy and society (Ernst and Peden, 1998; Kemnitzer, 1999; Beder, 1999; Bitcon, 1993; Mitchell, 2004). However, such an educational reform may have to tackle entrenched traditions, attitudes and practices that have shaped engineering education over many years. My belief is that in order to genuinely attempt to make sense of the general marginalization of creativity in traditional engineering curricula, it is important to demystify the role of the industrial economic paradigm in shaping the form of formal education in the twentieth century. In the middle of the twentieth century, education was modeled around the Fordist industrial images with their, as Runté (1995) points out, strict timelines, parochial task units and hierarchical task management so that mass-institutionalized education closely resembled Fordist workplaces. According to Kalantzis and Cope (2008: 54), educational settings during this period became:

“Places where teachers and students worked in conditions not dissimilar in their general social arrangement to the workplace of the modern industrial system. The state determined the syllabus, the teachers led their students through the textbooks; and the students were assessed against the correct answers, which had been centrally determined by the educational bosses. From a managerial point of view...modern schools...had a command structure in which teachers had little scope to teach anything and in any way beyond what they had been ordered to do by the education system, and students had to learn what they were told.

The classroom was a place of surveillance and discipline, where students were taught to take orders uncritically to respect authority”

These educational arrangements signaled an era where teachers were under tremendous pressure to complete prescribed content in the syllabi and assess it through tests and examinations. The use of tests and examinations results as measures of curricular success meant that teachers:

“Feel pressured to teach to the test, rather than to respond to student interests...Mathematics and science teachers retreat into rote memorization of the basics, rather than encouraging critical thinking (and creative thinking), because they know that most standardized examinations are incapable of measuring such higher mental activity” (Runté, 1995: 14).

In such educational settings, thought and time spaces of teachers and students are often significantly curtailed thus limiting the potential of educational settings to promote students learning that can collectively lead to first, students’ capacity to contribute meaningfully in the challenges of the 21st Century world which relate mainly to depleting natural resources and climate change, calling for sustainable innovation (Kalantzis and Cope, 2008; Suzuki, 2009; Pitso, 2008), and second, to students’ ability to act, adapt, respond and exercise flexibility in collaborative social learning environments that are defined by diversity and change (Kalantzis and Cope, 2008). Furthermore, collaborative social learning environments tend to develop students’ resilience that connects with the complex sociability of collaborative learning, teamwork, emotional empathy and a holistic comprehension of the global and local consequences of their actions (Kalantzis and Cope, 2008). Increasingly in the 21st Century, the entrenched educational practices that have been underpinned by the industrial images of the modern past are being strongly challenged. The era of ‘*informationalism*’, a term Castells (2001) has coined to define the alternative mode of development, refers to the new dependence of productivity upon its ability to generate, process and apply knowledge-based information. This alternative mode of development subsists on the consistent balance it maintains between economy, society and culture (Castells, 2001).

The 21st Century economic model thus shows increased dependence on the triple focus on responsible production (action on nature to meet a demand sustainably), power (actions taken on others to a particular end) and experience (action on the self or self in-relation). As Castells (1998: 360) suggests:

“A new society emerges when and if a structural transformation can be observed in the relationships of production, in the relationships of power, and in the relationships of experience. These transformations lead to an equally substantial modification of social forms of space and time, and to the emergence of a new culture”

Over the last two decades, the impact of these changes in engineering education has begun to be felt globally. Informationalism impresses upon engineering education to create educational conditions that allow students to seek new knowledge or insights that can be generated and applied in some specific context to produce some human convenience in a sustainable way (Suzuki, 2009).

These alternative educational settings turn time into the pillar for periods of incubating promising ideas and providing thought spaces for students to attempt the generation of novelty and new insights (Pitso, 2009). Educational settings that create conditions for novelty and the generation of new insights often challenge traditional discipline and site boundaries and expand zones of learning and knowing beyond the strictures of academia and its entrenched traditions.

The Fordist mode in education similar to industry naturalized and epitomized “*the commoditized, linear and divisible conceptions of time*” (Birth, 2004: 74) as a necessary condition for organizing learning environments. This economic mode illuminated fallaciously, in the view underpinning this study, the fundamental essence in the relationship between classroom practice (analogous to production process) and commoditized time in lieu of accentuating the functional nature of such a relationship.

The emphasis on the functionality of such a relationship between learning and time illuminates the perennial conflation of the temporal-spatial metaphors that are used to represent time and space and actual time and space. Fordist-influenced educational settings naturalized this time and space conflation which encouraged the urge to think in absolute and dualistic terms and created a curriculum framework that divides the world into subjects that assume the appearance of being self-sufficient (Kalantzis and Cope, 2008).

With the 21st Century world changing so rapidly, the disconnect between textbook content and this new world grows ever greater thus signaling a need to treat time and space in learning as nothing more than tools that assist us to make sense of our world. In order to keep up with the new world order, educational settings may benefit from emphasizing the functional nature of the relationship between time and learning and, expand the space of learning beyond absolutized bodies of content knowledge and traditional boundaries of discipline content. This way, alternative learning environments may be created that move teaching towards new modes patterned around active interaction and new configurations that are more integrated and reflective of our rapidly changing world.

I believe that such alternative learning arrangements are likely to rebalance agency in the classroom and lead to a more active engagement with curricular topics among classroom actors beyond the authoritarianism that beset traditional learning environments in engineering education. Such alternative engineering educational settings become more “*a set of experiences of learning in and for a world whose future shape we cannot predict*” (Kalantzis and Cope, 2008: 8) and thus demand more than just textbook-based knowledge content.

The “*perpetual edufog*” (Fritz, 1994: 80) of replication that hangs ominously over 21st Century learning ensures that our curriculum and pedagogy, especially in Universities of Technology, proceed on fundamentalist orthodoxy because UoTs rarely seek evidence that may serve as a bulwark against ancient and obsolete traditions of teaching and learning.

It is my belief that alternative educational settings, similar to those outlined above, compel learning in a research, collaborative and creative problem-solving mode thus may lead to significant modifications of current engineering undergraduate learning environments and hence to a possible new culture of learning upon which a new society may emerge.

This study is thus linked to studies that focus on entrenched traditions in engineering education and how those educational traditions have been inimical to the development of creativity and other related social skills. In a powerful critique of engineering education traditional classrooms, Rugarcia, Felder, Woods and Stice (2000: 16) have this to say:

“When we walk into an arbitrarily chosen engineering classroom...what do we see? Too often the same thing we would have seen in 1970 and 1940. The professor stands at the front of the room, copying a derivation from his notes onto the board...the students sit passively, copying from the board...once in a while the professor asks a question: the student in the front row feels compelled to answer every question...others simply avoids (sic) eye contact...at the end of the class students are assigned several problems that require them to do something similar to what the professor just did or simply to solve the derived formula for some variable from given values of other variables. The next class is the same, and so is the next one, and the one after that”.

Similarly, Effert (1998) argues that the nature of knowledge itself and the knowledge about the nature of the postindustrial work designs are vital in any attempt on transforming engineering educational settings to promote creativity. Chang and Hsiau (2002: 64) consider engineering classrooms as:

“Indoctrination of domain knowledge...most problems given to students in class are well defined with only one correct solution. Under current engineering training, students are asked to solve these ‘textbook’ problems, which are simple, well formulated in particular forms, and have standardized approaches and answers”.

This study is also directly linked to studies that seek to develop alternative educational settings in the form of programmes or other interventionist approaches that attempt to encourage and enhance creativity that emerge out of collective creativity (Baillie and Walker, 1998; Mathews and Jahanian, 1999; Lewis, 2004; Pitso, 2009).

This study takes place at one University of Technology that evolved from being a College for Advanced Technical Education in 1966 to a Technikon that awarded certificates and diplomas in a range of vocational programmes by 1979, to a degree-awarding institution by 1994 and finally into a UoT that adopted OBE as a curriculum framework in 2004. It also gradually developed from being an Afrikaans-medium technical college with 189 white students to an English-medium UoT comprising close to 17000 mostly African students by 2008. Almost the entire students’ body has English as a second language and recent preliminary tests on English Proficiency conducted by the Counseling Department show that the English Proficiency levels of most of the students is averaged at Grade 10 level.

Against this background, an alternative pedagogic practice has been developed and implemented with a Process Instrumentation lecturer and his twenty-four, final-year undergraduate students. Intensive sessions called “*learnshops*” – workshops for learning – were designed and implemented to introduce notions of creativity in an open and invitational mode, aimed at supporting a creative, collaborative and research-like approach to dealing with issues of sustainable development in industrial processes.

This study is undertaken fully cognizant that UoTs curricular mission, post-apartheid, was left untouched as the assumption that UoTs prepare highly competent students for the intermediate level of the economy persisted (Ensor, 2004).

In this way, the post-apartheid era disconnected goals of education in UoTs and creativity, since the curricular mission of UoTs was left unchanged. I believe this was a mistake in general as the country's economy was experiencing a de-industrialization – lack of productive entrepreneurship – (Mbeki, 2009) at the time when most developed and developing countries were moving towards post-industrialism with a strong innovative and entrepreneurial focus both of which subsist on creativity. The economy was also experiencing a reduced absorption rate of new recruits down to less than 4% by 2001 (Davies, 2001). As a result of this low intake of new graduates by the economy and high levels of graduate unemployment even among UoTs engineering graduates despite the fact that the economy was experiencing acute shortages at an intermediate level (Howitz, 2007) which is a claimed niche of UoTs, reconnecting UoTs curricular mission and creativity has become inevitable. I have reason to believe that the apparent contradiction in retaining UoTs' curricular mission of replicating industrial processes at the time when those industrial processes were undergoing intense transformation to better serve the new economic paradigm of post-industrialism did not serve UoTs well.

The study is undertaken to make a contribution towards reconnecting UoTs' goals of education with creativity. It is further pursued to better understand how the participants in the study make sense of creativity and its role in improving classroom practice and their future effectiveness in the workplace. I further believe that by creating invitational pedagogic conditions in the classroom, learning that is informed by social reconstructivism will thrive and enable participants in the study to improve their creativity and, that this study may lead to suggesting learning conditions that can promote students' collective creativity and impact local pedagogic practice. I make no attempt to alter the context of investigation. The study is undertaken fully cognizant of the Engineering undergraduate curriculum global standing as a *"tightly packed syllabus, full of science and maths and specialized technical subjects"* (Beder, 1999: 15). I am also aware of significant efforts to reform the engineering curriculum to realize an alternative paradigm with a strong collective creativity and other related social skills focus (Törnkvist, 1998, Baillie and Walker, 1998; Ernst and Peden; 1998; Beder, 1999).

I also understand that creativity is a complex, multifaceted concept that assumes different meanings in different contexts (Forrester and Hui, 2006) and has been studied from a cognitive and social psychology point of view. This study moves closer to a sociological perspective that considers creativity in the context of society and its mode of development. I examine these conceptions of creativity closely in Chapter 2 to make a case that learning environments can be organized in specific ways to encourage collective creativity and other related social skills such as communication and cultural understanding.

Research Aims

1. To encourage the development of creativity within engineering undergraduate curriculum through:
 - 1.1. Deconstructing and making visible the key features (micro and macro) of a pedagogic practice to enable possibilities of analysis as well as reconceptualization and testing of the existing pedagogic practice.
 - 1.2. Investigating current engineering undergraduate pedagogic practice from the perspective of both teachers and students and how such a practice enables or limits the development of students' creativity as well as understanding better the ways in which both teachers and students make sense of creativity.
 - 1.3. Reconceptualizing and testing a particular pedagogic practice which attempts to develop learning environments where students' creativity development has the potential to thrive.

Research Questions

1. What are the key features of a pedagogic practice and how do the organization of these features affect the development of learning environments and students' experiences of these learning environments?
2. What is the current pedagogic practice in engineering undergraduate studies from the perspective of teachers and students, and what meanings of creativity do students and teachers hold?
 - 2.1. Which pedagogic practice is revealed and what curricular context informed such a practice in engineering undergraduate studies?
 - 2.2. What meanings of creativity do students and teachers hold and in what ways do students view creativity in relation to their future effectiveness in the workplace and role in improving classroom practice?
3. Can a pedagogic practice that is reconceptualized to constitute an invitation to undergraduates to collectively seek the higher designs of existing engineering technologies increase students' creative abilities as measured through the Torrance's Tests of Creative Thinking (TTCT) and shape students' understandings and relevance of creativity?

Responses to question 1 illuminates key features of a pedagogic practice, which are then used to analyze the existing pedagogic practice in one engineering undergraduate classroom within one UoT as well as contribute to reconceptualizing and testing an innovative pedagogy that is likely to increase students' creative abilities as measured through the TTCT. Question 1 will, therefore, be addressed in Chapter 6. Questions 2 and 3 will be addressed in Chapter 7 as the results of the empirical study I conducted over a period of a semester.

Research Design and Methodology

This study is grounded on pragmatism as it is concerned with designing and implementing alternative pedagogic practices in order to attempt the development of students' creativity. It is a study that is based on addressing a real, practical problem in engineering undergraduate classroom practices, which is a failure to encourage the growth and development of students' creativity. In order to attempt to solve this problem in one UoT engineering undergraduate classroom, a Design-Based Research approach was adopted because this approach to research allows for the development of innovative programmes that are likely to impact local practice positively and contribute a learning theory (Brown, 1992). Design-based researchers are involved in developing learning contexts, creating frameworks, designing tools and pedagogical models consistent with and to better understand emerging pedagogical theories or ontological commitments (Brown, 1992). In this way, research not only moves beyond simply examining learning, cognition and knowing as isolated variables tested within laboratory conditions but involves systematically engineering these learning contexts in ways that allow researchers to achieve certain outcomes and generate evidence-based claims about learning (Barab and Squire, 2004).

In this sense, the commitment to examining learning in naturalistic and authentic contexts, many of which are designed and systematically changed by the researcher, necessitates the development of a methodological toolkit for deriving evidence-based claims from these contexts. In its core essence, DBR involves both the engineering of particular forms of learning and systematically studying them within the context defined by the means of supporting them. The designed learning context is thus subject to testing, revising and successive iterations that play similar role as that of systematic variation in experiments. DBR is, *ipso facto*, interventionist and pragmatist as it seeks solutions and what works, and therefore focuses on applying innovative programmes in order to impact local practice and contribute in advancing a particular learning theory as alluded to above.

In the case of this study, invitational pedagogical conditions were developed to encourage students to learn in a research, collaborative and problem-solving mode. The designed pedagogical conditions were built on the assumption that such pedagogical conditions could foster engineering undergraduates' creativity and could then be iteratively studied and revised over time.

The Scope and Range of the Study

This study takes place at one UoT and focuses on the curriculum of one discipline – engineering – at the undergraduate level. It thus will most likely provide insights on the experiences of 24 students in respect of creativity and the challenges creativity poses when its fostering is attempted. The DBR findings are likely to carry the peculiarities and perturbations of the single, chosen unit of analysis and may be difficult to generalize to other contexts except to share insights on the learning theory that is likely to encourage creativity development. However, the use of pre- and post-testing as part of the study which involves measuring the creative abilities of students in line with engineering education trends in fostering creativity is more likely to inform a broader audience. The duration of the study which was one semester also provides an important input in respect of stimulating creativity within the strictures of engineering undergraduate curriculum.

Overview of Chapters

Chapter 1 provides a general overview of the study in terms of the general conditions that informed its undertaking, the aims and research questions that are pursued as well as brief ideas around the research design and methods of research that endeavour to elicit data that attempts to answer the study's questions.

Chapter 2 reviews related literature on broad conceptions of creativity as occasioned in various knowledge epochs in relation to the question of whether creativity can be learned and enhanced through educational settings.

This chapter is vital as it provides the theoretical infrastructure that makes analyzing data and fostering creativity initiatives within educational and organizational settings possible. It also sets a tone for the conceptual framework of the study. This chapter also demonstrates historical epochs that shaped and influenced creativity conceptions in more specific ways and its strong relationship with the prevailing economic paradigm. Furthermore, the chapter tackles the tensions, dilemmas and myths associated with socio-cognitive underpinnings of creativity as a separate theoretical underpinning to social creativity and argues that the socio-cognitive lacks theoretical precision and appears to be a social dimension of creativity which is the theoretical position the study takes.

Chapter 3 focuses on the correlation between creativity and learning thus makes a case that educational settings are legitimate sites where collective creativity can be learned and enhanced under pedagogical conditions that are informed by a Kohlrauschian pedagogy. The social reconstructivist theory informs the learning focus of the students. A social reconstructivist theory of learning encourages students to engage learning content critically by raising awareness around issues of social justice and poverty as direct consequences of existing societal structures and systems. However in this study, the social reconstructivist learning theory is used to inform the *learnshops* in ways that make students to engage learning content more meaningfully by relating it to issues around sustainable development and climate change. This case is argued in this chapter. The chapter also makes a case for guided, systematic and collaborative creativity and thus sets limits on what invitational pedagogy can reasonably achieve.

Chapter 4 delineates how the creativity model that is used in the study was developed and tested during the pilot phase of the study for refinement. This is related to what is known as the TRIZ method which is also briefly elucidated to provide the rationale for basing the creativity model on it.

Chapter 5 provides an overview of the study's methodological considerations as well as the methods of research used to collect and analyze data. Ethical and validity issues are also elucidated in this chapter.

Chapter 6 attempts to glean the core argument of the study which is that a better understanding of a pedagogic practice – its key features – is more likely to assist with the analysis of an existing pedagogic practice and such understandings are more likely to lead to efforts on searching for viable, appropriate and innovative pedagogies for meeting new educational demands such as the development of students' creativity. Chapter six thus makes the conceptual framework of the study visible.

Chapter 7 presents the results of the study in detail.

Chapter 8 focuses on some inferences and recommendations that were made for fostering creativity within the strictures of entrenched curricular and pedagogic practices as well as provides some direction for future research in this area.

Summary

This chapter provided a broad overview and the purview of the study and what the reader can expect in the body of this thesis. It further provided the basis for undertaking the study, a brief description of the learning environment under investigation and how it legitimizes the study's core focus, the aim and research questions of the study. The chapter also touched on the study's methodology and the general design of the study.