

Chapter 3: Advancing Systematic Creativity through Education

Introduction

In chapter 2, a broad overview of creativity conceptions and how they relate to the possibility of creativity being learned and enhanced within educational settings was provided. Chapter 2 thus dealt mainly with the theoretical underpinning and conceptual framework of this study. The study was thus set to be underpinned by a social creativity theoretical framework which posits that students' creativity emerges from collectively engaging in seeking new insights and ideas thus rejecting the cognitivist meaning of creativity as innate, individualistic and socially unaided. The social perspective on engineering creativity advances the view that engineering classroom settings can be arranged in such a manner as to encourage learning conditions where students can collectively achieve higher forms of cognitive success by collaboratively probing and examining existing technologies and using the gained insight to seek the higher designs of these technologies (Fischer, 1999). In this chapter, the feature of engineering creativity – that it is systematic and mostly conscious – is critically examined in relation to the alternative learning conditions that are advanced and deemed to encourage systematic creativity. These learning conditions are set to be facilitated by invitational pedagogy and thus are set to be collaborative and research-driven (questing for information across disciplines and sites to resolve real-life problems) as illuminated by Kohlrauschian pedagogy which was outlined in chapter 2.

Creativity Models as Aspects of Learning

Guildford (1950: 446) in examining the relationship between creativity and learning comes to the conclusion that “*a creative act is an instance of learning*” thus broadening the concept of learning so that a holistic approach to learning is the one that creates a balance between rigour and analysis on one hand and creativity and synthesis on the other hand.

In this study, engineering creativity is considered as guided by heuristic models so that the research problematic, as stated in chapter 1, is on how to conceive of the engineering learning environment in such a manner as to encourage a collective step-by-step search for novelty. Novelty is understood to mean the achievement of solutions to non-routine problems (Savransky, 2000). A non-routine problem, on the other hand, is a problem that has a critical step such that the problem will not be solved unless this step is adequately addressed (Savransky, 2000). This study proceeds on the basis that the problems of fostering creativity through educational settings are endless and require collaborative, concerted and sustained efforts among key classroom actors in respect of challenging the traditional institutional socio-cultural factors such as policies, management and administration which are outside the scope of this study. The study does not, therefore, pretend that these factors have no bearing on the issue but the study's approach is to attempt an alternative pedagogy to foster creativity in the context of accepted institutional factors.

I view novelty (as an aspect of creativity which refers to newness or unusualness of generated ideas) as central to the study and achievable through learning that has a growth focus, where students are not seen as deficient but are rather viewed as bringing 'something' into the learning environment. Such learning environments are grounded in a belief that such students' prior knowledges and insights can, with guided creative problem-solving, lead to the generation of new insights that can provide an intellectual infrastructure for seeking higher designs of existing technologies. In this sense, novelty has the meaning of ideality searching. The search for ideality of existing technologies refers to the systematic and collaborative investigation and generation of new or unusual ideas that may contribute in seeking the higher design of existing technologies which, in turn, implies a general dissatisfaction with its current state which may be understood to provide imperfect solutions to existing and known problems (Rantanen and Domb, 2002). The critical challenge for the learning environments is how to create an enabling learning ambience for the pursuit of such students' novelty in a research and group context. I believe that a growth focus in learning can lead to meaningful learning where novelty is systematically guided and collectively attempted.

However, it is important to note that creativity can either be systematic or random as well as operating at a conscious or sub-conscious level. This implies that creativity can either be guided by models or remain unguided, which makes it either a systematic or a haphazard process that either lends itself to a sequence or a randomness. For instance, Vinacke (1953) argues that creativity does not follow a sequential method especially in the Arts. Wertheimer (1945), a committed scholar of Gestalt philosophy, asserts that the creativity process is a generally integrated line of thought that rejects the segmentation that is implied in a step-by-step creativity model. However, engineering creativity has always proceeded with a step-by-step approach to problem-solving and, over time; a number of models, techniques and processes have developed that guide efforts toward solutions. Engineering creativity is, therefore, a systematic and mostly conscious process of problem-solving that is sufficiently flexible to allow users significant leeway and zones of discretion during implementation (Ghosh, 2000; Reymen, 2001). Engineering creativity thus eschews rigidity and rote prescriptions in ways that allow substantial deviation from the model or technique's steps, in given situations. Plsek (1996) suggests that such deviation from the model or technique's steps, under conditions where such a deviation is inevitable, does not render the model useless; rather it demonstrates the importance of flow in creative problem-solving which does not strictly demarcate where one step ends and the other begins.

Based on this understanding, it can reasonably be argued that the successful use of creativity models or techniques does not reside in the dogmatic following of its steps, but rather on the growing awareness and experience in its use in real-life situations or simulations. The use of creativity models or techniques facilitates knowing how to resolve steps in a creative problem-solving process through following the suggested steps and when to deviate from those steps based on available evidence and experience. Such an approach to creative problem-solving, making use of techniques or models to guide the creative process suggests, that the skillful use of these techniques or models can only come with experience, experimenting and learning what works under what conditions; it thus establishes a strong nexus between creativity models and learning as continuous processes that are generally self-correcting.

Martinsen (1995), probing this nexus between creativity models and learning, differentiates between learning based on replication and that which is premised on extension to explain the idea that students who tend to exhibit assimilation tendencies in learning (replication-oriented) tend to “*give priority to upholding cognitive economy*” (Martinsen, 1995: 292) and those who demonstrate exploratory propensities (extension-oriented) in learning grow into a tendency to “*seek new types of solutions and new ways of solving problems*” (Martinsen, 1995: 292). According to Martinsen (1995: 292), extension-oriented students tend to perform better than the replication-oriented students when “*there is a high level of novelty...in the task and low-level-of-experience condition*” whereas the assimilators show better results when “*they have a high level of relevant experience*”. In subsequent follow-ups, Martinsen (1995) found that replication-oriented students performed better in creative problem-solving when there is a “*high-level-of-experience conditions*” (Martinsen, 1995: 296) which means that these students can become creative only under conditions where they are given extended opportunities to gain experience in problem-solving activities, thus on guided creative problem-solving.

Martinsen (1995) concluded that both sets of students are capable of handling high task novelty under different conditions of learning. In chapter 1 under ‘Background and Rationale’, I provided evidence that the UoT under investigation has been pursuing replication in its curriculum so that our research participants (students) are drawn from the culture of learning that signifies replication. Hence it can reasonably be argued that the research participants are generally replication-oriented which warrants use of guided creative problem-solving. Guided creative problem-solving suggests the use of creativity models or techniques as integral aspects of fostering creativity through educational settings. Learning conditions that are mostly relevant for pursuing guided creative problem-solving through models or techniques are, first and foremost, concerned with building the confidence of students that they can successfully handle learning tasks with high levels of novelty (Martinsen, 1995).

Davies (1991) suggests that it is vital that conditions of learning that attempt to foster creativity are organized in such a way that students metacognitively make sense of creativity to attain a higher cognitive success, that is, students need to be aware of how they think about how they think about creativity. A higher cognitive success in creativity relates to better understanding the meaning of creativity which may lead to increased consciousness about how students think about what they think about creativity and thus contribute to demystifying creativity in their minds and leading to better prospects for tackling novel tasks. Davies (1991) was drawing from Guilford's position that students' creativity can be enhanced if *"the student be taught about the nature of his own intellectual resources, so that he may gain more control over them"* (Guilford, 1975: 240). Learning conditions that are likely to foster guided creative problem-solving would most certainly depend on learning theories that encourage students to actively construct knowledge in an environment that is guided by a creativity model or technique and provide conditions where students feel safe to try out new things without being judged dualistically in terms of the correctness or wrongness of the effort. Such learning theory would most likely be based on first, the principle of 'learning-how' to systematically investigate an existing technology collectively to gain insights on its current strengths and weaknesses. It is expected that such probing of existing technologies would include visits to actual sites where these technologies operate. It is assumed that by experiencing first-hand how the technology under investigation works, its current challenges and what seasoned practitioners of the technology have put in place in order to improve the technology, students may develop insights on the technology prior to attempting its ideality (higher design). Second, the suggested learning theory has to constitute opportunities for students to critically examine and explicate the existing technology in relation to what Stouffer, Russell and Oliva (2004: 1) call:

"...the complexity surrounding every engineering project mounting as natural resources dwindle, the world population increases, and the global infrastructure and economy grow ever more intertwined, the creativity and innovation necessary to address the big issues of civilization – maintaining the infrastructure, providing food, water, shelter and power to the

population and growing sustainably and safely – will increase in importance...thus the case that fostering creativity knowledge, skills and attitudes is vital for the future of engineering and engineering education”.

I make a point, above, that such a learning theory has to invite a highly systematic and structured quest for alternatives without compromising the principles of usefulness and relevance. Criteria for students' success can then be formulated not only in terms of their ability to come up with novel ideas but rather on how successful they have been in putting in place a research plan, its quality of execution, the information they have been able to elicit in relation to their research, the extent to which they succeeded in a group form to create safe conversations, align their intent and learn from one another. The assessment criteria can also include how well students handled suggested aspects of creativity in terms of their ability to exercise flexibility in each suggested step and their growing awareness around how inventive creativity with a strong novelty component works. The study assumes that given that creativity is generally marginalized in UoTs curriculum and pedagogy noted for strong classification and framing respectively which signify conservative/traditional approaches to these message systems (curriculum and pedagogy), the need to create safe learning environments in which students can grow into confidence in handling uncertainty, novel situations and inductive approaches to learning becomes more important than to pursue the ideal that students should come up with novel ideas.

I believe that such a quest for novelty is, at this stage, representing a higher form of cognitive effort that requires sustained and long-term engagement with current higher education curricular and pedagogic traditions, especially in UoTs known for replication of industrial processes. On a wider global scale, this view is supported by Magee (2003) who undertook a review of creativity in relation to education. Magee (2003) found that there is a fundamental misalignment between the goals of education and creativity.

This misalignment between goals of education and creativity is caused, Magee (2003) argues, by over-emphasis on deductively-driven learning, separation of principles from application in real-life situations, inadequate space and time within classroom conditions for students to pursue self-discovery learning, lack of opportunities for students to learn and grow from failure as well as lack of open-ended outcomes.

In the next section, I explore various learning perspectives fully cognizant of my responsibility to select one or a hybrid that can better fit the study's purpose – that of creating learning conditions that can offer students' extended opportunities to generate focused new insights or ideas that can contribute in seeking the ideality of existing technologies.

Exploring Learning Theories: The Quest for an Appropriate Learning Perspective for Fostering Engineering Creativity

In this section, I examine critically various learning theories in terms of the framework developed by Kalantzis and Cope (2008) and briefly outlined in chapter 1. I begin by looking closely at the school of thought that shaped the theory, the learning processes each perspective advances, the sources of such learning and the infrastructural opportunities each theory provides for students to learn new things which, in the case of this study, relates to enhanced abilities to tackle non-routine problems. Based on the analysis, I suggest a learning theory or a hybrid that is likely to positively impact students' abilities to resolve 'real-life', non-routine problems. It is important to note that invitational pedagogy attempts to develop learning conditions where students can learn collaboratively and in a research mode thus allows for certain explanations about the kind of learning that is made possible through its infrastructure. This section is about the search for such a learning theory.

The behaviourist perspective on learning originates from developments in the field of psychology where scholars such as Watson, Thorndike, Pavlov and Skinner popularized ratomorphism as a legitimate discourse of estimating human behaviour and potential. Ratomorphism is the view that there is no fundamental difference between how humans and animals learn thus through observing and affecting animal behaviour in laboratory settings; one can model such behavioural control over humans (Meyer, Moore and Viljoen, 1989).

This learning perspective has had an enduring and lingering influence on education since the middle of the twentieth century mainly because it was empirically tested that reinforcement – conducted through the transaction of reward and sanctions – facilitates the acquisition of desirable behaviour. Learning is thus conceptualized as change in behavioural pattern from the undesirable to the desirable behaviour which is set to be handsomely rewarded through learning progression eventually leading to future self-preservation.

The behaviourist conceptions of learning led to the teaching methods that emphasize acquisition, replication and mimesis in learning where programmed, sequential instruction is set to be the most effective means of advancing learning. Each conservative step of the carefully designed learning path has an embedded reinforcement strategy that rewards successful completion of sets of classroom activities and punishes any deviations or unsuccessful completion of prescribed activities through meting out a pain (failure, labeling as underachieving, corporal punishment) or withdrawal of a benefit (no progression to next step, no praise, prize or other incentives) (Jordaan and Jordaan, 1989). Reinforcement is thus the key source of learning under behaviourism. The learning infrastructural opportunities for students to actively engage in resolving real-life problems and seek information that can lead to solutions to non-routine, complex problems beyond the confines of learning environments are necessarily thwarted in such highly conditioned learning environments.

In these learning environs, committed knowledge forms made available in textbooks and; didactically and passively transmitted to students by a largely authoritarian teacher (Kalantzis and Cope, 2008) mean that students are mostly not expected to generate new insights or ideas to resolve real-life problems. Thus, behaviourist notions of learning in relation to creativity become conceptually flawed and of no further relevance to the study. That is not to exclude, however, that positive reinforcement which largely remains a legitimate means of keeping students interested and motivated to complete creativity-related tasks.

Representing a way forward and a palpable antidote to the over-simplification of the complexity of human learning by behaviourist scientists, the constructivist perspective on learning suggests that students are active participants and meaningful role-players in the construction of knowledge so that students make their own individual interpretations of science knowledge (Kearney, 1992). The key exponent in this area was Piaget who modeled learning as an adaptive process of accommodation and assimilation. However, constructivism today is considered as providing better prospects for advancing students' learning in an active and more meaningful way for the learners (Kearney, 2002). Learning does not come automatically, under constructivism, but involves students efforts on matching perceived 'things' in the social world with their "*existing conceptual framework in the internal mental world*" (Kalantzis and Cope, 2008: 148). Students thus achieve higher cognitive success which builds, over time through persistence, into a sophisticated intellectual infrastructure that they can use to negotiate the external real-world. The sources of learning, under constructivism, are mostly based on the complex interaction between the individual who is in a growth trajectory, and the accommodation of newness from the external world; thus learning is mostly a function of mental activity where students construct knowledge through experience (McCown, Driscoll and Roop, 1996). Constructivism, in its deeper essence, provides learning infrastructural opportunities for students to engage in meaningful tasks in which they own the knowledge content they themselves consciously construct. Students, consequently become active agents in their learning which enables them to construct meaningful cognitive representations of a phenomenon or concept.

Constructivist notions of learning depends, largely, on authentic activities and situated learning where tasks are drawn mostly from the world outside the classroom, thus bringing connections between these 'things' in the textbook and real-life experiences. The key advantage of constructivist learning is that 'things' in the textbook are facilitated in such a manner as to be applied in real-world contexts and problem-solving is epiphantic as it cannot state in advance what the real solution could be. The solution, itself, is also outside the purview of the teacher's knowledge thus enables the teacher to participate in the problem-solving exercise.

While the teacher can also participate in the problem-solving efforts of complex and authentic problems given to students, the teacher also serves as the guide and one who models strategies and processes of creative problem-solving (Leinhardt, 1992). Constructivist learning is not entirely irrelevant in this study but seems to emphasize individualistic understandings of cognition. It does however provide invaluable information that can guide the study.

In more recent times, social constructivism adds another dimension on how the learning environment can be organized to better serve the students. Social constructivist conceptions of learning consider learning as inherently social thus leaning more towards the 'nurture' side of an old debate on whether nature (pre-determined) rather than social conditions (nurture) determine human ability. The social constructivist perspective on learning is underpinned by the work of Vygotsky who suggested that learning occurs among humans within the 'social context' they find themselves in, as they influence and shape one another's conceptual thinking or cognitive development (Vygotsky, 1978). Vygotsky's theory, as applied to adult learners, focuses on scaffolding, which refers to the degree of support needed or given to facilitate their learning. Social interaction, under social constructivism, fundamentally shapes individual's cognitive development.

The learning environments, seen from the perspective of social constructivism, need to be organized in such a manner as to encourage peer collaboration, since “*full cognitive development requires social interaction...all higher functions originate as actual relationships between individuals*” (Vygotsky, 1962; 1978: 57). The source of learning, in this perspective, is the broad scope of the learning environment (Kalantzis and Cope, 2008). Learning here does not come automatically but depends on the affordances generated within the learning environment, including the interactions between actors there. The infrastructural opportunities that social constructivist conceptions of learning provide relate to the fact that learning should, out of necessity, occur collaboratively among peers or through guidance from the teacher, or both. Social constructivist learning represents an important way forward in this study as it bears explicitly on peer collaboration and the rebalancing of agency in learning.

However, social learning is limited to a particular range and scope at any given time and thus ignores the value of broader social networks; it is silent on the broader aspects of the learning environment, beyond the confines of the ‘proximal’ social context (classrooms). Social constructivist learning has also been linked to Lave and Wenger’s notions of situated learning and learning within communities of practice (Lave and Wenger, 1991; Wenger, 1998) which are conceptualized within the theoretical framework of an apprenticeship model of teaching and learning. The concept of learning in the apprenticeship model is significantly shaped by social constructivist traditions, and involves the acculturation of novices into the cultures and social systems of meaning of a particular community. Learning proceeds from students’ position of being barely recognized as a player of significance (peripheral), to a level of some recognition (legitimate peripheral participation) and to full recognition and acceptance as a player of some substance (legitimization of full participation) (Lave and Wenger, 1991). This kind of learning is strong on mentorship and is fundamentally based on a deficit-model where students (novices) lack the praxes of the community of practice and requires a seasoned member of the community from whom to learn the ropes, thus accentuating acquisition at the expense of self-discovery, probing and examining critically these praxes and practices.

Drawn from contemporary philosophy, social reconstructivism views education as a legitimate means of effecting societal change and social reform. It has an explicit agenda of improving and reconstructing existing societal structures and systems through seeking their higher designs and retiring those that cannot be rehabilitated. Social reconstructivist learning was brought to wider attention by Paulo Freire (1970) who posited that society can be improved and reconstructed through conditions of learning if they can be arranged in ways that are critical of existing societal structures and systems which have been leading to increased poverty and inequality.

Freire (1970: 52) is critical of existing educational settings which “*seek to ‘fill’ students with a reality that is motionless and static and as a result, disconnects students from the ability to act with those ideas and give them significance*”. Freire (1970) suggests that ‘critical pedagogy’ is the way forward in students learning as it builds ‘critical consciousness’ around the key causes of poverty and inequality in society and thus creates conditions where students can deconstruct the layers of oppression and attempt to challenge them. However, social reconstructivist learning is not limited to raising consciousness around oppressive systems of the society but equally focuses on turning students into active agents of social change who can feel comfortable in exploring controversies and illuminating injustice. In this case, social reconstructivism is framed within the social justice discourse.

The social justice discourse in education attempts to deconstruct the relationship among politics, economic liberalization and education (McLaren, 1999) and focused on how learning conditions can be arranged in such a manner as to emphasize shaking comfort zones which can translate into creative tensions that tackle injustices and can eventually lead to self-actualizing students. The key advantage of social reconstructivism in education is that it has a growth focus and elevates education from its traditional deficit-driven model where students are passive participants in the learning processes, and thus mostly have a superficial engagement with the learning content, to a level where there is critical or meaningful engagement with learning content.

The perennial problem that weakens the case for social reconstructivist learning as a learning theory is on the difficulty of creating real infrastructural learning opportunities that shift “*from critical thought to critical practice*” (McLaren, 1999: 30). Furthermore, the sources of social reconstructivist learning are real-life problems that are huge and appear to be practically insurmountable especially given the fact that modern education is still very much mediated through industrial images to reproduce the very inequalities the learning environment seeks to challenge.

However; social reconstructivist learning is not without merit and, in the context of this study, has another role to play which has not been adequately examined in education. Social reconstructivist learning can, I argue, serve the purpose of creating learning conditions where students can explore the controversies that relate to sustainable development which is a view that suggests that world’s natural resources are dwindling fast and may not, in the long term, sustain the current unfettered consumption (Korten, 1995; Suzuki, 2009; Pitso, 2008). A key aspect of the sustainability discourse that has gained global ascendancy is the issue of climate change and the framing of meeting human needs in a postanthropocentric perspective which suggests a responsible way of living with nature. That such learning has a growth focus gives impetus to the logic that education has to view itself beyond survivalism and exorcise itself from the adult needs framing of education which links education mainly with self-preservation in lieu of focusing on a greater good and posterity. The social reconstructivist learner at work is more likely to build upon existing technologies, structures and systems and adapt them to the prevailing discourses of sustainability through deconstruction, recombination or recontextualization. The overall goal of social reconstructivist learning is to create learning conditions where the vitality and originality of meaningful engagement with existing technologies reawakens a sense of the world we live in and how it can be improved for posterity. Students that operate under the social reconstructivist learning are more likely to slow down and engage in genuine dialogical reconstruction which eschews mindless protest or conformism in ways that represent an honest effort to seek the higher designs of these technologies in order to better serve humanity.

Social reconstructivism in education thus encourages meaningful engagement with learning content and generation of creative insights. Within engineering educational infrastructure, social reconstructivism is more likely to compel the achievement of a higher cognitive success collectively which entails thorough knowledge of the technology under investigation, including both its design and operations, in respect of its current strengths and limitations.

Through a process of research, students are likely to inductively identify areas for improvement and systematically seek relevant information that may lead to the generation of new insights and possible higher designs of the technology. This approach to learning is premised on peer collaboration, creative problem-solving and research. In such educational settings, it would happen that neither the lecturer nor the students would know what the ultimate solution to the problem might be which brings together the freshness of anticipation with the excitement of tentativeness and the allure of the rewards that await at the end.

Creativity Models for Guided Creative Problem-solving in the *Learnshops*

I need to indicate from the outset that I do not seek overly-rigid, pre-determined models or techniques of creativity to guide students' creative processes during the *learnshops*. I rather believe that an effective creativity model or technique is one that assists students to demystify the design and operations of an existing technology, interrogate its ideality (current limitations and causes) and gain insights into its higher designs. I briefly explore some key models and techniques of creativity that are presented in the literature, extract some commonalities and attempt to develop a composite framework that integrates these commonalities which would form the basis of chapter four. Various models and techniques for engineering creativity can be categorized as either algorithm and heuristic.

These types of engineering creativity models are noted for their systematic step-by-step methods of problem-solving and their use of mainly mathematical concepts to model the systematic achievement of a resolution to a problem. Algorithmic techniques delineate well-defined instructions for completing a task and are noted for using a finite sequence of instructions (Jordaan and Jordaan, 1989). Algorithmic techniques are effectively and widely used in engineering especially in mathematical and computing models of problem-solving. For example, in computer systems an algorithm refers to an instance of logic written in software for the intended users of computers in order for the software in the target machine to perform specific functions (Bolter, 1984; Harel and Feldman, 2004).

There are many other classifications of algorithms such as those that pertain to a field of study, including geometric algorithms and complexity algorithms which deals with the time required to complete a set of tasks (Burgin, 2005). These are not immediately of any further relevance to the study except to outline this area of systematic creativity. However, I find algorithms as used in engineering in computer fields as too prescriptive and rigid to be of any further use to the study however relevant they are in computer science. The educational settings I investigate and the focus of this study, which is on setting up engineering undergraduate learning environments in such a manner as to encourage collective creativity, may not be malleable to algorithmic forms of problem-solving. Heuristic techniques or strategies are characterized by the fact that, on the basis of available evidence that include knowledge and experience; a problem-solver attempts the solution that shows better prospects of success first (Jordaan and Jordaan, 1989: 443). Heuristic techniques or strategies are often used in creative problem-solving where the problem is most likely to be complex, involving the dialectic of vagueness and solutions leading to innovations, inventions or ideality (Altshuller, 1984; 1989; 1996; Savransky, 2000). The typical problems that the heuristic techniques or strategies attempt to resolve include first, problems that lack clarity where there is either a commencement of or continuation of opacity. Second, heuristic techniques or strategies can be used where there are more critical steps to be resolved in order to find a solution to a problem.

The heuristic problems based on multiple critical steps typically involve temporal constraints and sensitivity, phase effects and dynamic unpredictability (Beckman and Guthke, 1995; Bhaskar and Simon, 1977; Brehmer, 1995; Broadbent, 1977; Sternberg and Frensch, 1991; Groner, Groner and Bischof, 1983; Altshuller, 1973; 1994).

Heuristic problem-solving also includes processes that can lead to effective but often ephemeral solutions that require constant search and improvement. Fogler and LeBlanc (1995) describe a problem-solving strategy that involves five typical blocks of the heuristic – problem definition, generation of solutions, decision on the course of action, implementation of the solution and evaluation of the effectiveness thereof. I find heuristic approaches such as those of Fogler and LeBlanc as described above fit for our purpose as they collate the key aspects of creative problem-solving processes as gleaned from literature. These key aspects of heuristic problem-solving form the basis for creating; through educational settings, guided systematic creative problem-solving where conditions of learning provide students with opportunities to gain insight and experience on the use of creativity models to resolve non-routine problems. It can be concluded that with continuous and sustained use of these models, students may gain confidence and self-efficacy that may lead to greater exercise of flexibility and discretion when using these models where self-efficacy is defined as the nurtured belief that students build over time that they can use creativity models or processes as part of the intellectual infrastructural capacity to resolve ‘real-world’ problems. In the next chapter, I elaborate on the creativity model I developed for use in the *learnshops* as part of creating invitational learning conditions for students to grow into guided, systematic creativity. The model I develop draws heavily on the composite framework of heuristics that summarizes the critical steps in the creative problem-solving processes and TRIZ theory.

Summary

This chapter attempted to provide a more focused framework for the use of educational settings to encourage the development of systematic creativity. I set out to demonstrate that engineering creativity is systematic and mostly conscious and linked such creativity with social reconstructivist learning, once various learning perspectives were evaluated. My take was also that systematic creativity can mostly be based on algorithms or heuristics and opted for the latter to take our study forward. In the next chapter I describe how I developed a TRIZ-based Creativity Model.