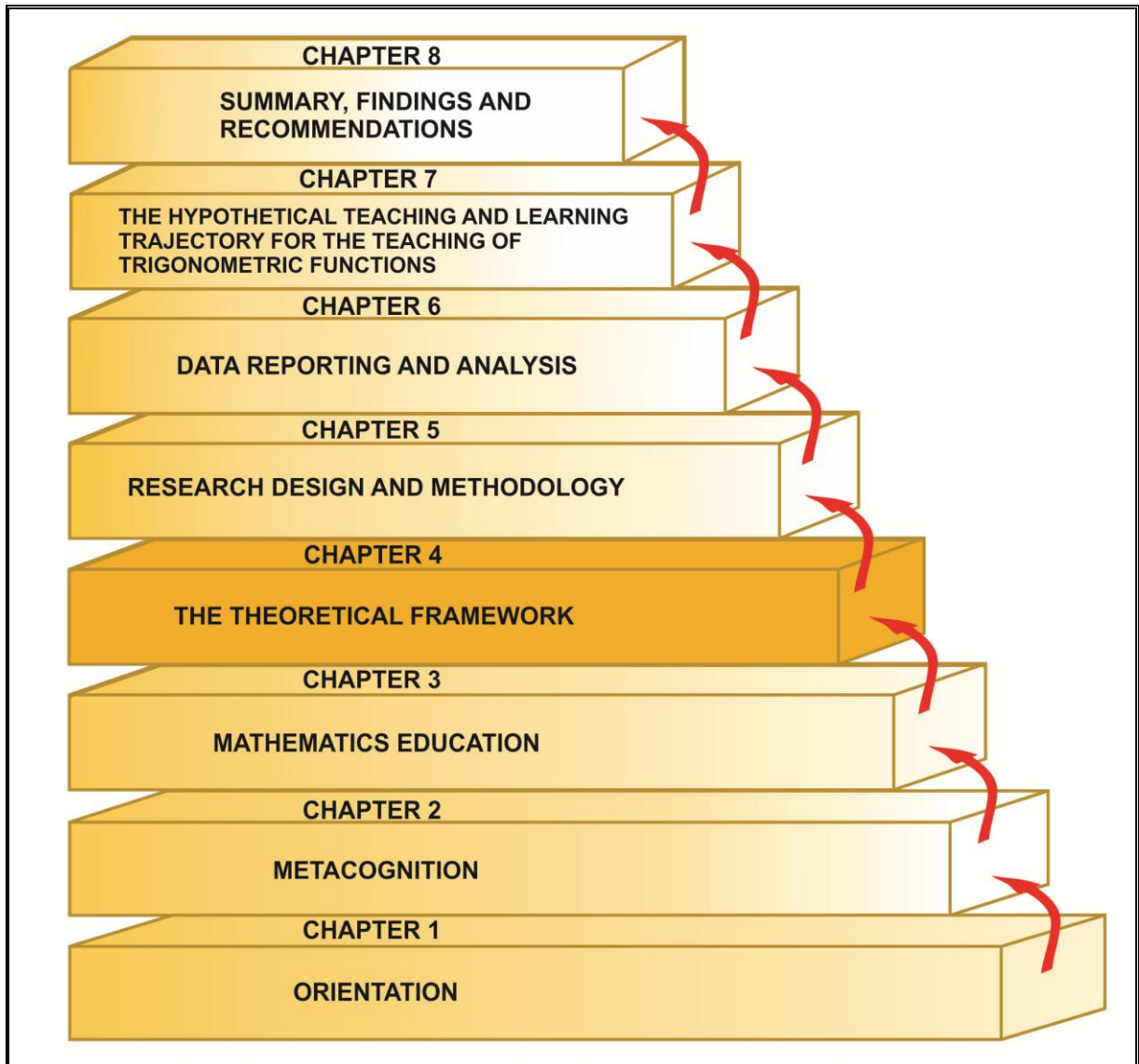
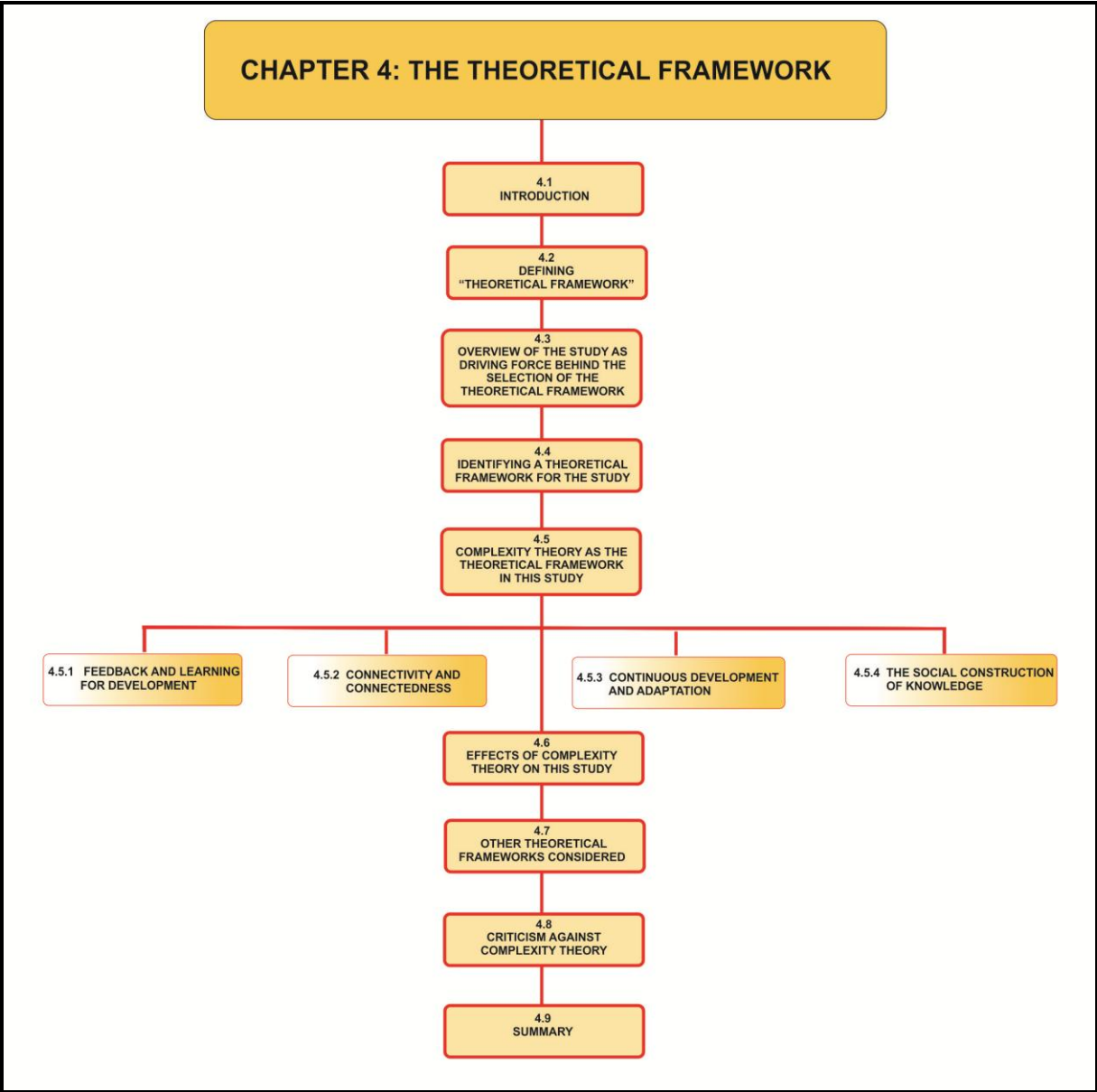


# CHAPTER 4: THE THEORETICAL FRAMEWORK

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## 4.1 INTRODUCTION

Any researcher approaches a study field “with some orienting ideas” (Doll, 2012, p. 17) and very few researchers can claim that they enter the field “tabula rasa” (clean slate) (Dede, 2005). One of the main contributions of the theoretical framework is that it enables a new and different perspective on the seemingly familiar and ordinary (Jansen, 2013). In this study complexity theory was selected as main theoretical framework, and this chapter explains the theoretical framework as follows: First and foremost, the concept “theoretical framework” is defined (§4.2), followed by an overview of the study (§4.3), including its purpose, research questions and methods employed as basis for the discussion of the particular framework that was used. Next, an explanation of how the theoretical framework was found (§4.4) as well as a discussion on what convinced me that I should use this particular framework follows. Subsequently the theoretical framework is described in detail (§4.5) as well as the discipline in which it originated. This description is then followed by a discussion on the effects the framework (§4.6) had on the research question, the design and the analyses that were obtained in this study. Lastly other frameworks (§4.7) that were considered and discarded as well as a critique (§4.8) of the theoretical framework that was employed in the study are addressed before a summary (§4.9) of the chapter is offered.

## 4.2 DEFINING “THEORETICAL FRAMEWORK”

The ideas of a researcher are to a great extent informed by the perspectives, experiences, biases and assumptions of the researcher, but also by the particular field of study or discipline in which the study is positioned (Creswell, 2009). But these by themselves do not constitute theory. Anfara and Mertz (2006) explain that it all starts with experiences and sensations which can be seen as events put into words and then called concepts. Concepts, in their turn, are then clustered into higher-order units to form constructs. Lastly, relationships drawn between these constructs are then called propositions which finally constitute a theory (Anfara & Mertz, 2006). For Merriam (1998, p. 46) the “concepts, terms, definitions, models and theories of a particular literature base and disciplinary orientation” constitute the theoretical framework. Although existing literature is in agreement that there is no clear-cut definition for a theoretical framework, Anfara and Mertz (2006, p. xxvii) define a theoretical framework as:

*Any empirical or quasi-empirical theory of social and/or psychological processes, at a variety of levels (e.g. grand, mid-range, and explanatory), that can be applied to the understanding of phenomena.*

Some theorists, e.g. Merriam (1998), use theoretical frameworks interchangeably with conceptual frameworks or align the conceptual context of the study with theory, e.g. Schram (2003), or relate the theoretical framework with the methodology when they refer to paradigms and methods when they speak about theory, e.g. Lincoln and Guba (1985). I aligned myself with the definition proposed by Anfara and Mertz (2006) because it expresses the key role the theoretical framework plays in framing and conducting every aspect of my study. In this study I am making a distinctive divide between a theoretical framework and a conceptual framework because for me the theoretical framework constitutes the theory on which my study is based and frames my study the same way a portrait frames the picture within, while the conceptual framework is the operationalization of both the concepts and theory within my study.

#### **4.3 OVERVIEW OF THE STUDY AS DRIVING FORCE BEHIND THE SELECTION OF THE THEORETICAL FRAMEWORK.**

This study seeks to understand how the metacognitive skills and mathematical language of mathematics teachers teaching trigonometric functions in townships schools could be enhanced using adapted lesson study employing a design-based research approach. The research questions (§1.5) required a theoretical framework that would not only explain the thinking done by teachers about their own thinking (metacognition), during the lessons but also had to deal with the messiness of real-time classrooms in the teaching of trigonometric functions. Such a framework furthermore had to enlighten the mathematical language used by the teachers when trigonometric functions are taught to learners in the mathematics classroom. The design-based approach that was subsequently identified as methodology to be employed in the study further dictated a framework that could explain what transpired during the lessons as well as the focus group discussions as vehicle in order to design a hypothetical teaching and learning trajectory for the teaching of trigonometric functions.

## 4.4 IDENTIFYING A THEORETICAL FRAMEWORK FOR THE STUDY

Not only teaching is a complex activity (Hiebert *et al.*, 2002) but learning also (Davis & Sumara, 2008; Davis *et al.*, 2006). The complexity theory was selected as theory in this study because of its applicability to investigating the dynamics that emerge during mathematics learning/teaching activities in *messy real-time classrooms*, focusing specifically on how teachers come to learn *collectively* through teaching but also through reflecting on their own, as well as observing how other teachers are teaching. Furthermore, in identifying a suitable approach for this inquiry, it was also important to select a theory that favours pragmatism:

*Complexity theory embraces a deep-seated pragmatism, justified only by (perhaps selfish) survival and suggests that what is right at any moment is that which works at the time, to ensure survival (Morrison, 2002, p. 8).*

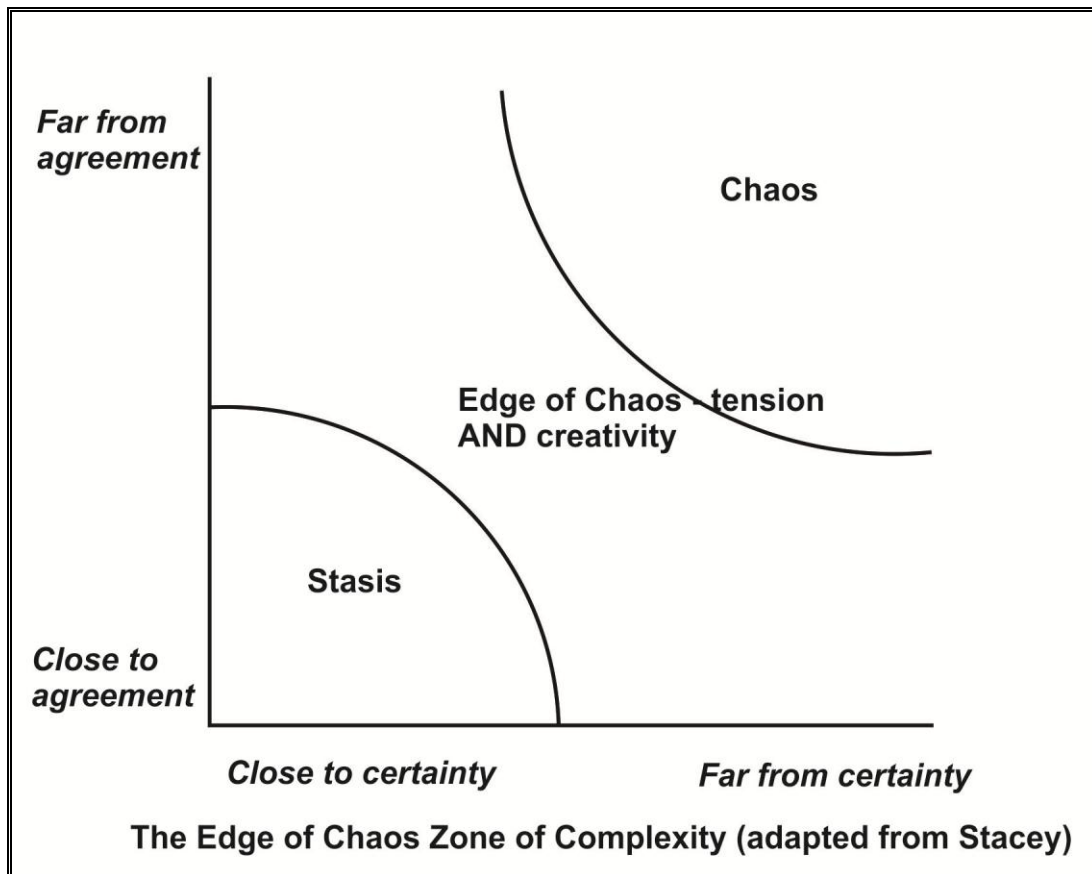
Metacognitive instructional practice is not the easiest to observe and therefore complexity theory was employed in order to illuminate not only the thinking of the teachers, but also how teachers were learning from each other in the context of the adapted lesson study and focus group discussions, both at the individual level and the collective level which Davis and Sumara (2008) alluded to in complexity theory. Furthermore, Pollard *et al.* (2008, p. 1) is of the opinion that complexity theory not only provides a new lens through which to examine existing teaching methods, but it “also shine[s] light on places to look for better approaches to education than conforming to pre-selected methods”. Learning through teaching trigonometric concepts and their application in solving problems is seen as a multi-layered happening in the context of adapted lesson study in the two rural township schools. Where Davis and Sumara (2008) see the learner as a learning system, this study viewed the teacher as the learning system whose learning evolves as a sum of all the parts (the knowledge of the teacher, his experience, the community in which he lives and works, the learners whom he teaches, fellow teachers, lecturers, the learning culture within the school and the curriculum) that contribute to the learning and subsequent professional development of the teacher. Complexity theory focuses on experiential and exploratory learning (Morrison, 2006) and emphasises the process (Doll, 1993) rather than the content.

## 4.5 COMPLEXITY THEORY AS THE THEORETICAL FRAMEWORK IN THIS STUDY

The etymological roots of the word ‘complexity’ can be found in the Latin expression ‘complexus’ and modern French words ‘cum’ and ‘plectere’ meaning encompassing, surrounding, embracing, encircling, comprising or comprehending (Ricca, 2012). Complexity theory (also referred to as complexity thinking or complexity science) gained prominence in the 1600s as a breakaway from the idea that everything can be described in terms of mechanical organizations towards the belief that the universe is a grand ‘clockwork’ and hence everything can be understood by breaking it down (Davis *et al.*, 2008: 76). Although complexity theory originated in domains like chemistry, physics, cybernetics, systems theory and information science (among other domains), it has also been applied in studies spanning across a broad range of social areas, including studies of health, family research, psychology, business management, economics and politics (Davis & Summara, 2008). Lately complexity theory is increasingly being used by educationists, although to a lesser extent. Complexity theorists (Batttram, 1999; Bohm, 1987; Davis & Sumara, 2006; Morrison, 2002; Stewart & Cohen, 1997) describe complexity theory in education as a theory of change, evolution and adaptation, often in the interest of survival, and often through a combination of cooperation and competition which involves *learning in non-linear terms*. Hence, complexity theorists see the clock as the predicable sum of its parts and therefore the whole can be predicted, provided that there is a thorough knowledge of the motions of the pieces (Davis *et al.*, 2008). Although Davis and Summara (2008) contend that complexity theory refuses tidy descriptions and clear-cut definitions, Davis *et al.* (2008) argued that:

*For educationists, complexity research might be productively understood as the study of learning and learning systems—a notion that encompasses individuals, social groupings, bodies of knowledge, cultures, and species as well as the contexts that are implied when such “agents” are specified.*

In this inquiry the learning of the teacher is envisaged as a complex learning system with several agents, viz. learners, researcher, lecturers and other teachers and the ideas they create. For Batttram (1999) complexity is concerned with the nature of innovation, emergence, adaptation and learning. Ricca (2012), referring to the difficulty of planning without reference to the students in the class and the subsequent potential for fragmentation and disconnectedness, maintains that complexity theory recognizes the importance of improvisation, reflection, mutual influence, and acculturation in education.



**Source: Anfara and Mertz (2006, p. 1)**

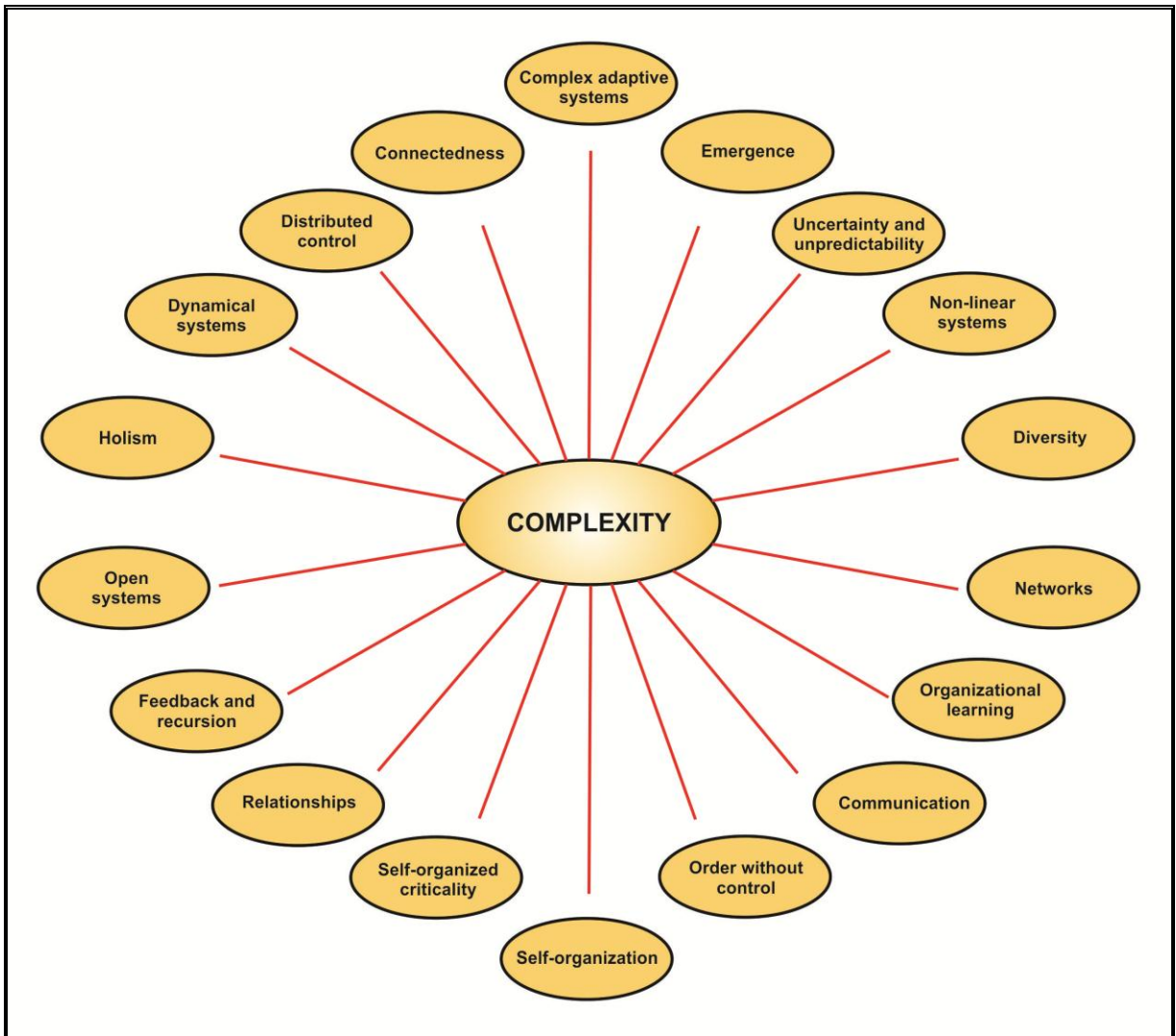
**Figure 4.1: Zone of complexity**

Anfara and Mertz (2006, p. 1) makes the following suggestions for Complexity theory when applied to educational practice:

*We might:*

- accept that we are not in control
- stop and inquire any time we were tempted to try to 'make' students behave a particular way
- explore how to design learning systems on 'minimal structures' of simple principles
- promote 'connectivity' and creativity among the agents in the learning system (students and staff and...)
- have ways of inquiring critically into our own 'theories in use' of teaching and learning, and programme management
- seek ways of valuing emergent learning and encouraging education 'at the edge of chaos'

Stewart and Cohen (1997) and Davis and Sumara (2008) do not regard complexity theory as a frame that can be simply adopted, but an emergent conversation that compels participation. Complexity theory is seen as a non-linear and holistic approach, in which relations within interconnected networks are the order of the day (Cilliers, 1998; Wheatley, 1999; Youngblood, 1997). According to Lewin (1993) and Morrison (2002), complexity theory provides a useful lens through which educational research can be viewed. The different elements of complexity theory are shown in Figure 4.2



**Source: Cohen, Manion, and Morrison (2007, p. 2)**

**Figure 4.2: Elements of complexity theory**

Following the work of Morrison (2006) in which it appears as if only some of the above elements can be elected and applied in an inquiry to explain phenomena, I have selected four of these elements for the purpose of crystallizing understanding in this design-based research study, viz. (i) Feedback and learning for development, (ii) Connectivity and connectedness, (iii) Continuous development and adaptation and (iv) The social construction of knowledge. I am of the opinion that these four elements are the most relevant for my inquiry and have been selected based on the extent to which they are relevant to the pragmatic and complex nature of my study. These four elements, which characterize complexity theory and in some cases are interrelated, are subsequently discussed in more detail.

### **4.5.1 Feedback and learning for development**

In the logic of complexity theory and learning communities promoted by Davis and Sumara (2008) through feedback, Morrison (2006, p. 3) illuminates this learning for development by stating that:

*Higher levels of complexity and differentiated out-of-equilibrium systems and behaviour emerge from lower levels of complexity and existing forms which, themselves, are different from, and cannot be comprehended simply in terms of, the initial forms or lower levels.*

### **4.5.2 Connectivity and connectedness**

Complexity theory puts emphasis on 'connectivity', the quality of relationships and connections between the agents in the system. Although Davis et al. (2008) mention connectivity; they also make distinctions on an individual level. For Ricca (2012) there is a challenging difference between connections within complex systems and connections within non-complex systems:

*Complex systems exist with connections that are different from non-complex systems. It is usual to think about various systems in a hierarchical fashion, with a top-level and various sub-levels leading to the bottom. In these situations, it is very true that the whole is the sum of the parts.*

Connectivity and connectedness finds exposition in the notion that agents within a complex system should be thought of as a collective and not a collection of agents. So for example is a class of learners not thought of as a collection of learners, but rather as a collective group of learners (Davis et al., 2008).

### **4.5.3 Continuous development and adaptation**

Development, and for that matter, continuous development should be considered as a process of recursive elaboration in which people are moving while adapting to more sophisticated ways of interpreting experience, rather than a linear and predetermined progress consisting of clearly defined stages (Davis et al., 2008). Lewin and Regine (2000) alluded to the notion of adaptation as the "zone of creative adaptability", a notion that can be compared to Vygotsky's (1978) 'zone of proximal development' in that both ideas refer to possibilities for development.

#### **4.5.4 The social construction of knowledge**

For Davis *et al.* (2008) one of the fascinating features of the construction of knowledge is the frequency of notions of bodies, like a body of knowledge, a social corpus, embodied knowing, and so on. The social construction of knowledge “argues for participatory, collaborative and multi-perspectival approaches to educational research” (Cohen *et al.*, 2007, p. 34). Zohar (1997, p. 110) puts a lot of emphasis on this dynamic interaction with others in order to understand one’s own self when he unequivocally states: “I am defined by my relationships”. Zohar (1997) uses his relationships with others to construct his understanding of himself and how he identifies with himself.

### **4.6 EFFECTS OF COMPLEXITY THEORY ON THIS STUDY**

The effects of complexity theory on this study are subsequently addressed in relation to what Mcmillan and Schumacher (2001) and Anfara & Mertz (2006, p. xvii) posit as accomplishments of good and useful theory in a study: A theory:

- (1) Should provide a simple explanation of the observed relations relevant to a phenomenon;
- (2) Should be consistent with both the observed relations and an already established body of knowledge;
- (3) Is considered a tentative explanation and should provide means for verification and revision;
- (4) Should stimulate further research in areas that need investigation.

Firstly, complexity theory could crystallize the understanding how relations were formed in the data-analysis process using ATLAS.ti focusing on the use of metacognitive skills and mathematical language in a real time classroom.

In the second place the constructs that comprise the noteworthy substance within the existing two metacognitive instruction frameworks (§2.7) used in the study were identified in the observed relations formed in networks using ATLAS.ti and made possible the forming of a new framework (§2.7.4).

Thirdly the prototype of the hypothetical teaching and learning trajectory (§3.9.6) was verified and revised after each iteration.

Lastly complexity theory as theoretical framework in this study illuminates avenues for further research in that the hypothetical teaching and learning trajectory can now be further researched using different methodologies in future research endeavors.

## 4.7 OTHER THEORETICAL FRAMEWORKS CONSIDERED

Three other theoretical frameworks were considered as possible frameworks for this inquiry. Firstly and most strongly considered of the three possible frameworks, was the framework from Clements and Sarama which they call “Hierarchic Interactionism (HI)” (Daro et al., 2011). Daro *et al.* (2011, p. 34) define HI as:

*a synthesis of contemporary approaches to understanding how human beings learn and develop. It holds that cognitive development, both general and domain specific, proceeds through a hierarchical sequence of levels of concepts and understanding, in which those levels grow within domains and in interaction with each other across domains, and their growth also reflects interaction between innate competencies and dispositions and internal resources.*

HI was considered because of its affordances as cognitive developmental framework, but unfortunately I found it to be focusing on the learner’s cognitive development and as this study focuses more on the teacher, this framework was discarded. It must be acknowledged, however, that HI would also have illuminated the understanding of the conceptualization process which became more prominent as the study progressed, had it been used as theoretical framework in the study.

Constructivism and in particular social constructivism was the second possibility as theory that was considered to be used as theoretical framework in this study because of the social nature of knowledge and the belief that knowledge is constructed through social interaction and is a shared rather than an individual experience (Vygotsky, 1978). However, this theory was discarded because of the fact that it would not have provided insight into the dynamics and complexities of mathematics teaching in a real-time classroom.

Realistic Mathematics Education (RME) is the other important theory that was considered to be used as theoretical framework in this study because of its applicability in real time classrooms, not only as a route into mathematics but also as a means of developing students’ understanding (Schoenfeld, 2006). Unfortunately RME puts too much emphasis on

mathematics problem solving and did not provide theory that could be used to explain the social interactive learning that happens when teachers reflect on their teaching.

I agree with Davis and Sumara (2008) that the individual-focused emphases of imported frames anchored in behaviorist psychology or constructivist epistemology are simply inadequate for the multi-layered, intertwining happenings of a real-time classroom.

## 4.8 CRITICISM AGAINST COMPLEXITY THEORY

Although complexity theory can be used *prospectively* to prescribe actions and situations that promote change and development, it has been criticized as being in essence a theory which can only be used as “a *post hoc* explanation, with limited *prospectively* or *predictive* utility” (Morrison, 2006, p. 7). I have indeed used complexity theory in a *post hoc* capacity after each cycle but also *prospectively* in preparing for the consecutive cycles in this design-based study. Furthermore Morrison (2006) asks the question whether complexity theory is not merely “old wine in new bottles” and mentions to this effect the theory of structuration (Giddens, 1976; 1984), and Bourdieu’s ‘habitus’ (1977) and Bernstein (1975) ‘visible and invisible pedagogies (Morrison, 2006: 6). However, I found the reflective nature and the collaborative, collective learning within complexity theory in particular very useful in this study.

## 4.9 SUMMARY

Each of the stages in adapted lesson study requires the implementation of metacognitive skills and elements of mathematical language to be discussed. In this chapter complexity theory was outlined as a possible set of lenses to recognize and make sense of educational practices in the inquiry. This discussion leads to an analysis through reflection by the mathematics teacher in a design-based research. Trigonometric functions and their application in solving problems are used in the adapted lesson study and subsequent discussions of the lessons have a specific focus on how metacognitive skills and mathematical language can be employed for the most effective learning by learners. Complexity theory crystallized the understanding in the complexity of the above situation in line with what Doll (2012, p. 2) advocates:

*The interplay of these two, a dance of the analytic and the hermeneutic, provides for each culture an awakening of the new. From this new another new emerges. We not only learn from our differences, we need our differences, if we are to learn.*

Although Cohen *et al.* (2007) suggest the need for case study methodology or action research to address holism and other elements of complexity theory; I am of the opinion that design-based research holds promise as a useful research methodology for complexity theory because of the following reasons:

- (1) It looks at situations through the eyes of as many participants as possible, resulting in multiple perspectives, causality and effects.
- (2) It creates opportunity for the teacher to be a researcher.
- (3) The collaborative nature of design-based research requires teacher and researcher working hand in hand towards the solution of teaching and learning concerns resulting in the symbiosis of practitioner and researcher.

The next chapter outlines design-based research as methodology that was used in this inquiry and shows how design-based research rose to the challenge of being a valuable methodology for complexity theory in this inquiry.