Enculturation Process: What does it mean?

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ENCULTURATIO N PROCESS: WHAT DOES IT MEAN?

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DECLARATION

I declare that the mini-dissertation hereby submitted to the University of Limpopo, for the degree of Master of Education in Mathematics Education has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

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This mini thesis is dedicated to my mother Fridah and my late grandmother Emmah

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To Dr RS Maoto: Thank you for the exposure and believing in me.
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To my wife: Your love, support and patience helped me a lot as I worked through this study.
To my kids Mpho and Lethabo: Your being in this world complete who I am.

ABSTRACT

Culture has become a household name in research circles mainly due to different interpretations that people come up with. How one defines it is relative to the discipline from which one is reasoning from. My engagement with literature in trying to define culture was limited to what happens in the mathematics classroom. What comes out as the operating definition in this study is that culture evolves.

Classroom is about learning. As with culture, there are different interpretations of what it means. In this study my discussions on this issue were limited to those that use constructivism as a referent to learning. However, there are still a lot of debates within constructivism in terms of what it means to learn. My discussions were then confined to what it means to learn from a sociocultural perspective. From this perspective learning is accounted for on social and cultural processes. In contrast from a constructivist perspective the individualôs cognitive processes and the classroom culture are reflexively related. The evolving classroom culture does not exist apart from the teacherôs and studentsô attempt to coordinate their individual activities (Cobb and Yackel, 1998).

Initially the study was aimed at collaborating with an intermediate mathematics teacher in creating a constructivist classroom learning environment. However, the nature of data I had was such that I developed interest in what constitute enculturation process. I had moved between my classroom experiences and experiences with literature to establish what constitute enculturation process. The following constructs emerged as attributes of what enculturation process for both classroom and mathematics culture entails: **language, learning, and negotiation of meaning.**

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CHAPTER 1

INTRODUCTION

Introduction

In this chapter I give an overview of the study by explaining what it means to me to do research in mathematics education, and the structure of the mini thesis.

Doing Research

One of the modules that I had to do as part of my Bachelor of Education Honours Degree (B.Ed Honours) was introduction to educational research methodology. In this module we were taught about general issues on research. More emphasis was on how to decide on a good researchable topic, contextualising your study by going through literature, deciding on how best to collect data, and finally how to analyse data.

There were two issues that for me came out as very important in doing research. One was on what it means to do research and other is on developing theories through research. On the first issue, as I indicated in chapter 2, I was made to believe that research is a systematic process of collecting and logically analysing data for some purpose (Masha, 2004). In this conception of research, a researcher should come up with a clear detailed plan of what he is going to do. This include coming up with ways in which data will be organised and analysed. I wrote my masters research proposal using this understanding and I have to acknowledge that at that time my level of questioning issues pertaining to research was very low.

I suppose it was a blessing in disguise that already I was working with my supervisor on an ACE (Advanced Certificate in Education) programme as a facilitator. The established relationship was and still is such that I can freely have discussions with him without any fear and also that we shared an office. As such this made my consultations with him easy. However, it was his questioning about my plan of how I intended (planned) to carry out my study that changed how I view research. In our first meeting he asked me a question in relation to how I had planned to organise and analyse my data. His comment at that stage was that it seems as if already I know what the results of my study are and if it is the case then there is no point for me to continue with the study. He asked me to read articles on doing

quantitative and qualitative research. I had an idea what the difference between the two is and honestly I avoided collecting qualitative data during my honours project because I found it easy to analyse quantitative data. There is this cabinet in our office that at that time for some strange reasons I never opened it though it is right in front of my desk. He opened the last drawer and selected a few articles and put them on my table. He then said that I should feel free to use the documents that are in that drawer.

Almost all the articles in that drawer were talking about constructivism. Well, I had an idea what constructivism is and my understanding at that time was that it is a theory of knowing and that some people use it as a referent to teaching and learning. It was after I read an article by Guba and Lincoln (1989) that I had a different perspective of what it means to do research. Their arguments were on using constructivism as a referent for doing research.

I was fascinated by their arguments so much that I had to: (1) reshape my proposal (the initial intentions are explained in chapter 2) and (2) use the first part of the chapter on methodology to expand my knowledge on what it means to use constructivism as a referent in conducting research. Hence, I used constructivism as a referent for teaching and learning ï constructivist teaching experiment (see chapter 3 and 4), and as a referent for doing research (see chapter 2).

On the second issue, my understanding of research was that there are people who do research and develop theories somewhere. I only saw teachers as people who only implement theories developed by researches. It never occurred to me that teachers who are based at schools can do research. Partly I suppose this was due to my interpretation of the curriculum that was used by teacher training colleges. I had not seen a module that incorporated research. This for me contributed a lot to failure by teachers to implement some of the theories that are developed by researchers.

However, it was after I read an article by Paul Cobb (2000) titled ñConducting Teaching Experiments in Collaboration with teachersò that I developed a new understanding in terms of how problems and issues in mathematics education can be addressed through research. Two issues that stood out for me are on acknowledging the social and cultural aspects of mathematical activity, and the relationship between theory and practice (Nunes, 1992; Voigt, 1994). The first issue is discussed in details in chapter 3.

On the issue of the relationship between theory and practice, Schon (in Cobb, 2000) argues that there should be a reflexive relationship between theory and practice. His argument is that theory is seen to emerge from practice and to feed back to guide it. This for me suggest that teachers should be in the fore front in terms of doing research that addresses problems and issues of mathematics education more especially those that are very close to what happens in the classroom.

The structure of the thesis

Towards the end of chapter 2 I outlined three challenges I encountered when carrying out this study. The challenges are more on data collection and data analysis. At that stage of my study I thought those were the only challenges because I was already nearing the end of my writing process until I was about to conclude my introduction chapter where in I was supposed to outline the structure of my thesis. This led to the final challenge (not part of the challenges in chapter 2) ï conforming to the standard template of a traditional thesis.

The template (representation) in question subscribes to the positivist paradigm and is linear in nature. In this paradigm the thesis should comprise of the following in the order written: Introduction, Literature Review, Methodology, Results, Conclusions and Implications (Stapleton and Taylor, 2003). The structure suggests that all related literature should be reviewed during the initial conception of the research design; the research design should be fully formed prior data collection with all methodological aspects being cemented in place early to avoid invalidating the research process (Stapleton and Taylor, 2003). The purpose of reviewing literature as explained by De Vos, Strydom, Fouche and Delport (2002) becomes that of mapping out the main issues in the field being studied and pointing out where the study in question fits in. On the other hand, the first three chapters ï introduction, literature review and methodology are not in any way influenced by the ongoing processes of interaction with the data leading to the results of the study. This suggests that I can have these three chapters completed even before I start analysing data.

In contrast is a representation that is nonlinear and emergent in nature. On this issue Stapleton and Taylor (2003) contributed by saying:

> Contemporary qualitative research writing employs modes of representation that are judged in terms of their polyvocality, reflexivity, verisimilitude, pedagogical thoughtfulness, etc. And accompanying

> standards of legitimacy (or validity) include evidence of the emergence of the research design, the shifting nature of the methodology, continuous review of literature to establish significance of emergent issues, and the progressive subjectivity of the researcher. (p. 5)

This brings a different view of representation that allows the researcher to represent more authentically the processes of his/her qualitative inquiries (Stapleton and Taylor, 2003). The research report as presented would be very close to the true reflection of the processes that the qualitative inquirer went through as opposed to strict adherence to the predetermined modes of inquiry. Reflexivity, for example, suggests ongoing interaction and mutual influence of different aspects of the inquiry. Each phase of the process has a potential to influence and be influenced by other phases leading to an emergent research design, emergent research questions, emergent research methods and ultimately emergent research report. At the core of these shifting phases of the inquiry is a continuous process of interpretation. And it is this that demands a different view of the role of literature in the inquiry as that also becomes the subject of interpretation.

This study is entitled ñEnculturation process: what does it mean?ò The nature of this title again warrants a non-traditional approach to the representation of a research product. When the question ówhat does it mean?ô is raised, the answer cannot be a clean and finished product from some literature. Instead, the answer is likely to slowly emerge from different encounters that include literature itself, raw data, and ongoing reflections on emerging constructions of meaning. The different phases of the research process should continue to reflect this construction of meaning in compliance with the constructivist mode of inquiry underpinning this study.

Issues surrounding the acceptability of a different way of representation that does not conform to the standard template of representation can be addressed through an enculturation into a different way of doing research (qualitative research using constructivism as a referent to doing research). I elaborated more on this paradigm in chapter 2 where I accounted for the emerged research methods.

It was the latter way of representation that put me at ease regarding my last challenge as I found it to better capture my experiences throughout this study. There are five chapters in this mini thesis. The order of appearance does not suggest the order in which they were written.

For example the chapter on methodology was the last to be completed but it is chapter 2 in this submission. In chapter 1, I explained what research is and what it means to me to do research. This was done so as to make the reader to make sense of my study from my perception of what it means to do research.

In chapter 2, I provided a detailed explanation of the methodology used when doing this study. I also gave an overview of what happened from the beginning to the end of my study. The first part was interactive as I was trying to make sense of issues that are at the core of using teaching experiments.

In chapter 3, I provide my personal experiences as I attempted to make sense of what culture and enculturation is, and what the enculturation process entails from literature. It should be noted that literature in this case was not used to put my study in context but was used as data in making sense of the enculturation process. I had to, because of this way of engaging literature, deviate from the conventional thesis format.

In chapter 4, the focus is on the classroom within which this study was done. I am using two teaching experiments. The first teaching experiment was done in the second quarter of the first semester of the year and the second in the second semester of the year. The idea was to investigate or explore different issues that seem to me critical when taking one through an enculturation process ï either classroom or mathematical culture.

In chapter 5, I bring key issues from chapter 3 and chapter 4 together. The aim is to subject them to a further level of analysis to formulate for myself constructs that explain the enculturation process for both classroom and mathematical culture. These constructs that explain the enculturation process are discussed in details in this chapter.

Conclusion

In this chapter, I explained what it means to me to do research. I also gave an account of the research report template (structure) used and a brief explanation of what is entailed in each of the remaining 4 chapters.

CHAPTER 2

ACCOUNTING FOR RESEARCH METHODS

Introduction

This chapter is divided in to three sections: the introduction, accounting for research methods, problems inherent in using constructivism as a referent to research and lastly the conclusion.

I always had problems with what exactly are research designs. Most of the questions that were asked during my proposal presentation were on research designs. Almost everybody who was there was surprised when I failed to answer most of the questions asked on this issue. Out of all the questions asked, one question appeared to be the main reason why students (doing research in order to get a degree) were supposed to present their proposals before going to carry out the study. The main idea behind it, according to my interpretation, is to find out if students have step-by-step plan of exactly what they are going to do. Unfortunately I did not have that plan. What I had were ideas I was going to use to guide my study. It looked as if I did not do my homework thoroughly. I tried to explain, but still I could not find a way of explaining this plan that I had in mind.

My first experience of research was that it is a systematic process of collecting and logically analyzing data for some purpose (Masha, 2004). In this traditional conception of research, a researcher has to come up with a clear plan of what he is going to do. I had a plan but it had a lot of questions in it in the sense that it was not rigid. It was after one of the people present during my presentation talked about different paradigms to research that I started questioning myself about my beliefs and values on research. It is on this background that I decided to outline the location from which my study has emerged.

I will also look at the problems inherent in doing this kind of study, as I will be reflecting on some of the challenges I experienced during my study. I tried as much as I can, not to provide solutions because teaching occurs in particular, what had

happened in my classroom might not happen in oneôs classroom. However, there are common problems that one is likely to encounter when doing this kind of a study.

Theoretical Paradigm

As I mentioned at the beginning of this chapter, my first encounters of research were those in which research is considered as a systematic process of collecting and logically analyzing data for some purpose (Masha, 2004). In that context, the research design should be finalised (completed) before the commencement of data collection, analysis, and reporting. The implication here is that one has to deal with issues of methods and methodology first (Masha, 2004). With regard to issues of ontology, the researcher predetermines how the reality should be like instead of looking at the emerging reality. Hence, the approach in this case is commensurate with positivistsô conception of knowledge.

In contrast to the positivist paradigm is the constructivist paradigm. It is in this latter paradigm that I found my study located. According to Guba and Lincoln (1989) constructivist approach is an inquiry, which is nonlinear and not closed. It is an approach in which it is impossible to be very specific about anything. This, according to Guba and Lincoln (1989),

> é whereas positivist begin an inquiry knowing (in principle) what they donôt know, constructivists typically face the prospect of not knowing what it is they donôt know. (p. 175)

However, as the design proceeds, a constructivist seeks continuously to refine and extend the design to help it unfold (Guba and Lincoln, 1989). In this kind of study, they advise, one should look at issues of research design and systematization as an emergent process. This is a complicated process that is not amenable to descriptive procedures that are inherent in positivist paradigm. As mentioned by Masha (2004), with regard to constructivist approaches ñsystematization is something that though one can tell when it is there, it remains difficult to explainò.

Constructivism has its origins in how reality is perceived. Instead of ontological reality, constructivists work with experiential reality. It is on this that Masha (2004) wrote:

> Constructivists reject the notion of reality as accessible and interpretable outside our own experiences and instead ascribe our knowing to experiential reality. In this context it is unimaginable to think of the possibility of casting into stone oneôs research design prior the commencement of an inquiry. Doing so would be like locking researcherôs current and future experiences out of the inquiry itself.

It was these kinds of views that better explain and account for my initial dilemma with regard to the nature of research proposal. Throughout this research process, I never had a sense that my methodology chapter was complete. In fact, even during the report writing stage I continued to reflect on how and what I did in collecting and analyzing data, I had to and from movements between my writings and literature in such a way that it became difficult to isolate different stages of the research process.

Research Design

As I have explained in the latter section, I am using constructivism as a referent to this research and therefore I adopted constructivist methodology. In terms of this method, Guba and Lincoln (in Masha, 2004) point out that:

> The moral imperative of the responsive constructivist evaluator is continuously to be on the alert for ï indeed, to seek out ï challenges to the prevailing construction (however much it may be supported in consensus), and to stand ready to refine, change, or even reject that which is currently believed in favour of something else that, on examination, seems reasonable and appropriate to those in the best position to make a judgment. (p. 47)

In such a perforated process it is easy to get lost. As a novice researcher such experiences of continual reflections that sometimes lead to termination of some leads, are discomforting and unsettling. In order to survive this process, I came to realize that the broad research questions that one pursues should be clear so that they can be used as a reference during the study. As Denzin and Lincoln (1998) indicated, research design is something that involves a clear focus on the research question, the

purpose of the study, what information most appropriately will answer specific research questions, and which strategies are most effective for obtaining it.

This subsection is intended to cover the following issues (i) my research question and the purpose of the study (ii) research strategies that I have used in trying to find answers to my questions.

Research question and the purpose of the study

After registering for a masterôs degree, one of the modules that I had to do required me to write a mini research proposal as preparation for a research project (mini thesis). One of the issues that are central to our educational system is Outcomes-Based Education and I wanted to find out the extent to which this approach was being implemented in schools. I was supposed to submit that mini research proposal as an assignment.

The title of that mini research read as follows: Assessment of OBE Learning Environment in a Mathematics Classroom: Hindrances and Development. I planned to use Constructivist Learning Environment Survey (CLES) to assess the abovementioned learning environment. The reason behind was that OBE has its underpinning issues on constructivism. I thought by using CLES I will be in a position to tell whether the environment is consistent with OBE epistemology or not.

It was at the time when I was preparing for the presentation of my proposal that I, with persistent questioning from my supervisor, realised that I do not know what I was going to assess. I started asking myself questions with regard to constructivism and its application in the classroom. I came to realise that for me to be able to assess something I should be in a position to can create that something. I decided to change my title to creating a constructivist classroom learning environment. The reasoning behind choosing constructivist learning environment over OBE learning environment was that I realised that issues underpinning OBE have their roots in constructivism.

The questions that were at the core at the beginning of this study were:

- What does it mean to create a constructivist classroom learning environment?
- Is CLES viable (usable) in the intermediate phase (grade 5 to be specific)?

I decided to establish the viability of CLES in order to avoid doing a pilot test and to use it to guide my classroom observations and interviews. It was the first question that required elaborate attention. In trying to respond to that question I initially set out the following objectives:

- Establishing the viability of CLES in the Intermediate Phase.
- Assess learnerôs perceptions of both actual and preferred Constructivist Learning Environment in an intermediate mathematics classroom.
- Document teacherôs practices that influence and are influenced by learnerôs perceptions in the process of creating a constructivist classroom learning environment.

Intentionally, the study was aimed at assisting an intermediate mathematics teacher in creating constructivist classroom learning environment (teacher development of a teaching approach that uses constructivism as a referent). On the other hand I had hoped that it will help me as a researcher to construct my own meaning on issues relating to constructivism and to also improve on my teaching practices especially those that uses constructivism as a referent.

However, during the process of collecting data, the focus changed. There was this learner who always struggled to respond to our practices (instructional approaches). In almost all our lessons we always encouraged learners to share ideas in their groups in responding to activities as we believe in social construction of meaning but this learner was always quite. I did not want to make assumptions and as a result I always made follow-up questions in trying to find out if she was involved in the activities. At the beginning she was not responding but as time progressed she started opening up though in most cases the answers given were wrong.

It seemed to me, during the initial stages of my analysis that this learner was struggling to adjust to how things were done in this classroom (classroom culture) and also with understanding mathematical concepts (mathematical culture). It was at this time of my study that the following questions emerged:

1. What is classroom culture?
2. What does it mean to **enculture** one into an evolving culture?
3. What attributes constitute an enculturation process?

It is through my interactions with literature in chapter 3 that question 1 and 2 were answered. Chapter 4 respond to question 2 and 3 based on my classroom experiences. Chapter 5 responds directly to question 3.

Research strategies that I used

Traditionally teachers were seen as implementers of research. We had researchers doing research and publishing their results, and teachers were expected to implement those findings. In almost all the researches that were carried out people were striving to generalise their findings. Teachers found it difficult to implement the theories developed mainly because of different environments or teachers do not understand the theory that is to be implemented.

On the same issue Cobb (2000) contributed by saying:

> In traditional approaches that embody the positivist epistemology of practice, theory is seen to stand apart from and above the practice of learning and teaching mathematics. Then teachers are positioned as consumers of research findings that are generated outside the context of the classroom. (p. 308)

In support of Cobb, Confrey and Lachance (2000) write:

> é research frequently was confined to out-of-school laboratory settings (Kilpatrick, 1992). This allowed theories to be tested in a fairly controlled environment. However, results and findings from these types of studies have been criticised for being of limited applicability to classroom instruction (Romberg & T.P. Carpenter, 1986). (p. 231)

I find this very true in the sense that there are a lot of issues involved in doing research and those issues in many ways affect the results of the study. How do I then as a practicing teacher in a different environment with different resources be expected to implement those results? For me the answer is that it will not be easy to do it. In trying to bridge the gap Cobb (2000) writes:

> é theory is seen to emerge from practice and to feed back to guide it. This view, it should be noted, provides a rationale for transformational research that has as its goal the development and investigation of theoretically grounded innovations in instructional settings. (p. 308)

Teaching experiment methodology was found to be useful in studying studentsô mathematical learning and reasoning (Cobb, 2000; Steffe & Thompson, 2000). According to Steffe, Thompson and von Glasersfeld (2000) ña primary purpose for using teaching experiment methodology is for researchers to experience, firsthand, studentsô mathematical learning and reasoningò (p. 267). I found this relevant to my study in the sense that in the process of creating a constructivist classroom learning environment, what becomes the core is the construction of mathematical meaning by learners. I decided to elaborate on this methodology so as to provide a framework within which my study should be understood.

Teaching Experiments methodology

The primary purpose of conducting teaching experiment methodology is, according to Steffe, Thompson and von Glasersfeld (2000), ñfor researchers to experience, firsthand, studentsô mathematical learning and reasoningò (p. 267). Although in this methodology, the researcher is often doubling as a researcher, in this study I collaborated with the practicing teacher. Cobb (2000) outlined the following three as elements of a teaching experiment methodology: planning of a teaching experiment; ongoing experimentation in the classroom, and retrospective analysis.

The Department of Education in South Africa provides the schools with the teacherôs guide and the Learnerôs guide at the intermediate phase. What appears in the Learners guide are the activities that learners should go through whereas in the Teachers guide are possible solutions to those activities. In planning for the teaching experiments

what we did was that we followed the activities as they appear in the Learners guide but providing additional activities in cases were we felt that the concepts to be developed was not well understood. In some cases we had to, during the lesson, plan activities on the spot in response to what was happening. The data was collected by means of recording the daily experiences including samples of learnersô work.
When using teaching experiment methodology it is critical that the researchers be present in the classroom every day while the teaching experiment is in progress (Cobb, 2000). This makes it easier to understand learnersô social processes within the classroom. As such learning trajectories can be revised frequently to inform new thoughts experiments. Although as a researcher I was unable to attend every class, the practicing teacher had an understanding of what should happen as we shared more or less the same goal. She was recording the experiences as they happened and we would have debriefing sessions to reflect and plan for the next teaching experiment.

In trying to understand the classroom events in a broader theoretical context (Cobb, 2000), I used retrospective analysis. Steffe, Thompson and von Glasersfeld (2000) write that ñthrough retrospective analysis, we attempt to bring to the fore the activity of model building that was present throughout the teaching episodesò (p. 297). Further details of how the process unfolded are in chapter 4**.**

Actual and preferred forms of CLES were used at the beginning of the study to find out how learners perceive their environment and how they would like it to be. The actual form of CLES was administered at the end of the study to establish how learners perceive their learning environment after going through the teaching experiments and the whole processes that took place to guide the teaching experiments. The other reason for administering CLES was to establish its viability.

Looking back at what happened

What I outlined above remained the guiding framework of what happened during the entire period of this study. I administered the actual form and the preferred form of CLES at the beginning of the study and the actual form at the end of the study. I documented our (educator and researcher) practices and learnersô reactions to those practices. Though not easy, what I actually did was capturing what happened during

the lessons as they served as the basis for our day-to- day reflections. Everything happened as planned until such time when I was supposed to analyse data and write a report.

I could not help it but focus on data that talked about Sarahôs struggles during my analysis of data. It was at this stage that the focus of my research changed from what I intended to look at, the attributes of creating a constructivist learning environment, to what the attributes of enculturation process are. This meant that I had to rewrite the chapter on literature review.

This time my engagement with literature was more interactive. This allowed me to expand my knowledge on culture and enculturation process, and to also use it as data during the final stages of analysing of data.

How I analysed data

During the study we could see a number changes in how learners behave and participate during the lessons. Most satisfying was to see how they engaged themselves and shared ideas when doing the activities. When I reflected back on the whole process and in particular the developments of different environments created, I could see a culture that evolved. And there was one learner who struggled to adapt to that evolving culture. It was at this stage that I developed interest in understanding the factors or elements that led to that classroom culture.

I had to engage with literature with the view of understanding what culture is and what enculturation is. However, my engagement with literature was an interactive one. As explained in chapter 3, I used literature to expand my knowledge on culture and enculturation issues as opposed to using literature to guide or give shape to the study. Issues that emerged from this chapter were then put aside to be subjected to another level of analysis in chapter 5.

The second set of data was collected from two teaching experiments that were taken at two different stages of the year. Each teaching experiment was subjected to an analysis in order to identify emerging issues. I then took the analysis for the two

teaching experiments and subjected them to another level of analysis. It was at this stage that I identified constructs that explain the enculturation process from our interactions with learners in the classroom. This constructs were then taken to chapter 5 for further analysis.

Issues that emerged from chapter 3 and 4 were then subjected to another level of analysis in chapter 5. At this stage I came out clear in terms of the constructs that I find to better explain the enculturation process for both the classroom culture and mathematical culture.

Problems inherent when doing this kind of study

There were a number of challenges I came across as I carried out this study. Partly due to the fact that it was my first time doing this kind of study and also that this time my level of interrogating research issues was better compared to my first experience of doing research. The following challenges stood out from the rest: (a) loosing focus as a result of continuous planning, (b) problems with documenting while being an active participant and (c) making sense of the data collected.

Loosing Focus

When conducting teaching experiments, each session ends with reflecting on what happened during the session. This is done in order to identify those things that went well and those that need to be improved. In addition this is done to prepare for the next session. This becomes a cyclic process. My challenge during the process was that I got carried away with discussing issues that emerged from the sessions. At the end of the teaching experiment I could not tell what I intended to look for. As a novice researcher I got very frustrated by this. It was as if the data that I had was irrelevant to what I intended to do. I was comforted by my supervisor when he reminded me about what it means to use constructivism as a referent to doing research (discussed on page 7).

Documenting while being active participant

The nature of my study was such that I had to put on two hats; one being that of a researcher and the other being a co-facilitator during the learning sessions. During the initial stages of data collection I would focus on classroom interactions and forget about documenting the interactions. When I document the classroom interactions, I missed opportunities to be part of the interactions. For some time this was frustrating until I decided to use a tape recorder. With time I could relive the moments after the sessions backed by the tape recorder.

Making sense of data collected

The most challenging aspect of using constructivism as a referent to doing research for me was on accounting for what it means to deal with emerging reality. I had guiding questions for collecting data but they became meaningless during the process. As a novice researcher I thought that I had reached a dead end and I have wasted time collecting data that will not help me respond to the questions I had. Dealing with qualitative data can be a nightmare if proper supervision is not given.

Conclusion

In this chapter I accounted for the methodology used for this study. I gave an overview of the process as it unfolded and lastly the challenges that I came across during the process.

CHAPTER 3

ENCULTURATION

Introduction

Culture has become a household name in the research circles. This is the case purely because there has been and still there is a struggle in trying to come up with a clear cut definition of the word. Some researchers (Bauersfeld, 1998; Cobb and Yackel, 1998) see culture as a relative word. How one defines it is relative to what one wants to achieve. However what offers hope in the whole debate is the fact that they agree that culture evolves.

In this chapter I focus on two issues namely: classroom culture and an enculturation process. I start by drawing meaning of what culture is from the sociocultural and constructivists theories. However, much emphasis will be on the constructivist theory as used in carrying out this study. I must indicate that literature in this case is not used to guide or give shape to the study but used as another way of experiencing and expanding my knowledge on classroom culture and an enculturation process.

Making sense from literature

My engagement with literature did not help me to define culture. Consequently, it became more difficult to define classroom culture. However, interesting about the debates around this issue is how theorists from different perspectives defend their arguments. The debates start by explaining what it means to learn.

As put by Cobb and Yackel (1998), from a sociocultural perspective individual learning takes place as a result of social interaction and culture. The underlying theoretical assumption in this case is that classroom culture should be accounted for based on the school culture or the culture of the wider community within which the school is located. Meaning that individual experiences do not constitute a *classroom* culture but these individual experiences can be accounted for based on the social and cultural processes within which a particular individual is located.

However, they (sociocultural theorists) offer a variety of explanations for the process by which students gain access to mathematical practices carried in conventional mathematics symbol (Cobb and Yackel, 1998). Rogoff (in Cobb and Yackel, 1998) views a learning process (gaining access to mathematical practices) as a process of internalization, and Newman, Griffin and Cole (1989) characterize it as a process of appropriation wherein the symbols become psychological tools for thinking. In contrast, Lave and Wenger (1991) view learning as increasing participation in communities of practice. Cobb and Yackelôs comparison of these views explain the emerging role of the teacher in each case as ñan enactor of established mathematical practices whose role is to guide studentsô learning by initiating opportunities for increasing participation in these practicesò (1998: 180).

In comparing these possible sociocultural accounts, I noted that, except for Rogoffôs view, the emphasis is on social and cultural processes with a little account on individual studentsô cognitive processes. As indicated in the second paragraph of this subtopic, individual studentsô cognitive processes are better accounted for based on the social and cultural processes.

In contrast, constructivists are concerned with the quality of individual studentsô interpretive activity and with the teacherôs and studentsô interactive constitution of classroom norms and practices (Cobb and Yackel, 1998). Constructivistsô contention is that individual studentsô cognitive processes and classroom culture are reflexively related and that individual students and the teacher together actively shape the evolving classroom culture (Cobb and Yackel, 1998). In contrast to sociocultural theorists, constructivist theorists argue that individual studentsô cognitive processes and classroom culture have the same priority and the evolving classroom culture does not exist apart from the teacherôs and studentsô attempts to coordinate their individual activities (Cobb and Yackel, 1998).

However, Waschescio (1998) argues that these theories have not provided an explanation for the occurrence of learning and for the orientation of development in the classroom. I find this statement confusing after going through Cobb and Yackelós paper on social and cultural processes. As indicated earlier their argument is that it is through social interactions that individual students construct knowledge. The state of

mind made me to dig deep into constructivism to make sense of what it really means to learn.

Learning

My engagement with literature on constructivism in this case was to try and make sense of what it means to learn in social interactions but avoid getting lost in the complex debates on constructivism itself. I shall concentrate on the analyses made by Cobb and Yackel (1998) on the approaches proposed by Voigt and Cobb.

In their analysis Cobb and Yackel (1998) indicate that Voigt uses the concept of negotiation as a mechanism of explaining the development of mathematical meaning in the classroom. Their analysis is at two levels ï namely the individual level and the classroom interaction level. On the first level Cobb and Yackel said,

> é meaning is conceptualized as the result of individual sense-making processes. It is the individualôs attempt to cope with the different elements of a task. When the individual student is confronted with an empirical object or event, she or he will use her or his background knowledge to create an interpretive context. In the realm of this context, the individual student makes sense of the object or event and ascribes mathematical meaning to it. This process, called mathematical modelling, results in individual mathematical meaning constructed by the individual student. At the same time, this process is influenced by the studentsô expectations regarding what is an accepted answer. (1998: 223)

In bringing in the teacherôs role, they continued by saying,

> If the studentôs way of mathematical modelling is rejected by the teacher, she or he will modify this construction in line with the assumption she or he has about the teacherôs intentions. This process continues until the student gains the impression of sharing with the teacher a meaning of the problem at hand. (1998: 223)

The emphasis of this approach is that each student constructs his or her own individual mathematical meanings and establishes its viability through interpretation of othersô views. According Cobb and Yackel (1998) Voigtôs intention in this instance was to locate and account for an individual mind within a social interaction. The

second level tries to explain the mathematical meaning constructed during classroom interactions. On this issue this is what they had to say,

> In the course of classroom interaction, another process of meaning construction is added to this model of individual sense-making. On this interactional level, meaning is conceptualised as the result of negotiation. Since background knowledge differs between students and certainly between teacher and students, it can be assumed that different mathematical modelling processes occur. These probably result in different mathematical meanings. These different meanings may or may not conflict with each other. In order to prevent or solve conflicts, a process of negotiation of meaning takes place. As a result of this process, a kind of official or collective meaning is established: a meaning taken-to-be-shared. (1998: 224)

On the first level, I would have loved to hear more on how students build up their assumptions about the teacherôs expectation, how these assumptions relate to studentsô mathematical constructions, and ways in which a teacherôs rejection of a construction leads to its modification. The specifications in terms of how the process unfolds were not further explored.

On the second level, I still find it difficult to see how the socially constructed mathematical meaning become part of individualôs cognitive structure. Hence I thought the answer lies in what it means by meaning taken-to-be-shared. The collective established meaning (meaning taken-to-be-shared) referred to remains at the level of social interactions. Cobb and Yackelôs contention on this aspect is that:

> Meaning may well be the product of social interaction, but in order to achieve the status of knowledge, it has to become part of the individual. Otherwise we cannot speak of learning. (1998: 225)

However, Voigt (as mentioned by Cobb and Yackel, 1998) agree that processes of negotiation of meaning can be very valuable for the development of mathematical thinking, but only under the condition that negotiated meanings become part of the conceptual structure of the individual student (Cobb and Yackel, 1998). On this approach, the relation between interaction and learning remains unspecified.

Cobbôs, as mentioned in Cobb and Yackel (1998), conception of the function of social processes for conceptual development is different from that of Voigtôs. He concedes that

> ...the studentsô constructions have an intrinsically social aspect in that they are both constrained by the groupôs taken-as-shared basis for communication and contribute to its further development. (p. 26)

Cobbôs claim is that social constructivist approach is characterized by a reflexive relation between individual and social processes. Meaning that social processes should reflect individual constructions and these, in turn, should reflect social interactional processes (Cobb and Yackel, 1998). Though cautious, Cobbôs conclusions from the case studies that he did in trying to establish the reflexive relation between social and cognitive aspects is that for him

> The central notion that characterises the relationship between the cognitive and social aspects of small group activity is that of constraints. (1995b: 103 in Cobb and Yackel, 1998:229)

All he is saying is that the particular type of interaction may have a facilitating effect on constructing mathematical concepts. The important thing to note from his approach is that social interaction is not the origin of learning, and may or may not provide learning opportunities. According to me his claim makes sense when one considers different interpretations or experiences that individual students have within the same learning environment. Again the interpretation of the meaning taken-to-be-shared by individual students will vary depending on the level at which each individual student is on the topic in question.

Given the differences presented by two approaches, it is clear that the main function of social interaction in social constructivist theories is that of providing opportunities for a student to develop further in his or her autonomous individual constructions (Cobb and Yackel, 1998). The social interactions characterises an evolving classroom culture. During the process social norms of interaction evolve. The following social norms of interaction are common and considered to be important for productive relationship in a classroom that constructivism is used as a referent to teaching:

> Explaining oneôs mathematical thinking to the partner; listening to, and attempting to make sense of, the partnerôs explanations; challenging explanations that did not seem reasonable; justifying interpretations and solutions in response to the partnerôs challenges; and agreeing on an answer and, ideally, a solution method. (Cobb, in Cobb and Yackel, 1998: 228)

The Enculturation Process

As I was going through literature, I had hoped to find articles that deal directly with an enculturation process from a constructivist perspective. I did not find one. I am not saying there is none. Constructivists are concerned with construction of mathematical meaning and how that becomes knowledge to individual students. It is a theory of knowing that explains the development of studentsô cognitive structures (Pirie and Kieren, 1992).

According to Pirie and Kieren (1992) it is the role of the teacher to create an environment that allows for the development of studentsô cognitive structures. The two have suggested tenets of beliefs that should be held by teachers if they are to create constructivist environment for mathematical learning and understanding as follows:

- Although a teacher may have the intentions to move students towards particular mathematics learning goals, she will be well aware that such progress may not be achieved by some of the students and may not be achieved as expected by others.
- In creating an environment or providing opportunities for children to modify their mathematical understanding, the teacher will act upon the belief that there are different pathways to similar mathematical understanding.
- The teacher will be aware that different people will hold different mathematical understandings. The teacher cannot think that his or her own understanding, the understanding of a given mathematician, the understanding underlying the writing of particular texts and materials, and the studentsô understanding will all be the same for any particular mathematical topic.
- The teacher will know that for any topic there are different levels of understanding, but that these are never achieved ñonce and for allò.

Their argument is based on the belief that a constructivist environment for mathematics learning is not a product of a particular program of classroom or individual activity (Pirie and Kieren, 1992). Such an environment is created by a teacher through a set of constructivist beliefs in action including the four tenets mentioned above. The actual process of how the teacher and the learner relates in the process is addressed later on in this chapter.

On the other hand, Cobb (in Cobb and Yackel, 1998) described social norms that guide social interactions in such environments. These social norms were discussed on page 20 and 21. It is believed that it is the teacherôs intentions and studentsô response to the environment created that constitutes the evolving classroom culture. As such the enculturation process would involve learners playing their roles as discussed on page 21 in response to the environment created by the teacher.

It is Bishopôs (1991) perspective on enculturation that offers a holistic approach. The approach focuses on two issues namely the mathematical curriculum enculturation and mathematical enculturation as opposed to classroom enculturation (enculturation in to the classroom culture). For the purpose of this study I will focus on mathematical enculturation as I believe that it will expand my knowledge on issues that relate directly with what happens in the classroom.

According to Bishop (1991) mathematical enculturation is a shaping process ï a process whereby concepts, meanings, processes and values of mathematics are shaped in trying to develop in each individual learner a way of knowing. In trying to make the process clearer, he gave a definition of what enculturation is and said:

> Enculturation isnôt done by one person to the other, culture isnôt a óthingô which is transmitted from one person to another, nor is the learner merely a passive recipient of culture from the enculturator. Enculturation is an interpersonal process and therefore it is an interactive process between people. Mathematical Enculturation is no different in that respect from any other type of enculturation. (p. 125)

From his definition it is clear that educators should not see themselves as transmitters of knowledge (concepts from mathematical culture) rather as active participants

during the enculturation process. His argument in this case is that it is the role of the educator, representing the mathematics culture, to shape learnersô ideas. However, cautious of many interpretations that might arise; he explained what it means to shape learnersô ideas by saying

> At first sight it may appear that the teacher is the one who does the shaping, but recall what is being shaped. It is not a lump of clay nor is it a piece of material. Concepts, meanings, processes and values are what are being shaped, and these belong to the learner, owned by the learner, and therefore of course, shaped by the learner. (p. 126)

At this moment it became very difficult for me to understand how the shaping takes place and how the educator does the shaping. I will look in to this issue towards the end of this chapter. However, Bishop identified three foci which help in clarifying the nature of the mathematical enculturation process and offering principles which should guide the development of this process. The three foci are: asymmetrical process, intentional process, and the ideational process (Bishop, 1991).

Asymmetrical Process

This aspect, as put by Bishop (1991), gives an enculturation process its dynamic quality. It is more concerned with the roles being played by both the teacher and the learner during an enculturation process. In any normal classroom situation the teacher and learner do not have equal roles to play, nor do they meet on equal terms. As explained by Bishop (1991), it the teacherôs task to create a particular kind of social environment for the learner. On the other hand, it is the learnerôs task to construct ideas and modify them in interaction with that environment.

The asymmetry referred to in this case is of power and influence, with the teacher being in the more powerful, influential position. The basis for the teacherôs power lies in the appointment by the culture of the teacher as enculturator. The mathematics culture requires the teacher to act as the mathematics enculturator, and it is to that culture that the teacher is answerable and accountable (Bishop, 1991). The power gives the teacher the authority to influence the learner, and legitimises the teacherôs various influential acts (Bishop, 1991). It is clear that more than anything else it is the

teacherôs use of that power which determines the quality and success of an enculturation process in the classroom. Success of the enculturation process in this case should mean learners succeeding in being part of the culture.

However, Bishop (1991) has identified three principles within this aspect which have influence on the success of the mathematical enculturation process. The first principle is that the teacherôs power and influence must be legitimately used. An example used by Bishop is that of the teacher choosing easy topics to teach, or teaching in style that benefits the teacher more than learners, or blaming learners for failing to understand.

The second principle is that the teacher should use her influence to achieve a constructive and collaborative engagement of the learners in the enculturation process (Bishop, 1991). The argument in this case is that if learners do not construct ideas then there is nothing to shape and the only way the teacher can tell if construction is occurring is to seek contributions from learners. In turn these contributions shape the teacherôs influence on learnersô ideas. The contributions should be offered in a constructive and collaborative spirit (Bishop, 1991).

The third principle is that the teacher should use his/her influence facilitatively, and in particular that he/she should not impose his/her mathematical knowledge on the learners (Bishop, 1991). The main issue in this principle is that the teacherôs role is to lead learners in to worthwhile mathematical experiences and avoid becoming mathematical authority (Bishop, 1991).

An Intentional Process

The second aspect of the mathematical enculturation process as described by Bishop (1991) is an intentional, purposeful, goal-directed process. The goals relate to both the nature of the mathematical activities and the values and attitudes embedded within the mathematics curriculum. The initial intentional nature of the enculturation process is manifested through the selection by the teacher of particular activities to be engaged in by the learners (Bishop, 1991).

This process also emphasises the importance and the role of the teacher within the broader spectrum of the education system. The first stages of the enculturation process, as described by Bishop (1991), are established by the government or the school. It is at this level that decisions on what should constitute a mathematical curriculum are taken before the teachersô decisions come into effect. The curriculum should provide a framework and structure that should guide the enculturation process. This suggests that the intentionality of the enculturation process starts with the mathematical curriculum. However, the framework and the structure of the mathematical curriculum should not be restrictive to allow the teacher to operate adaptively. According to Bishop (1991) it is more appropriate for the classroom teacher to make the micro-curricular decisions and adaptations within the macro ï curricular framework. He goes on to say that the teacher as an adaptive person needs to be able to respond creatively and purposefully to the dynamic classroom environment created by himself and his learners. Therefore, this implies that the teacher has a responsibility for selecting particular mathematical activities to be offered to learners.

Bishop (1991) identified what he considers knowledge environments that are important for the intentional process. The mathematical activities that a teacher engages learners in should create the following three environments: the Concept-Environment, The Project-Environment, and The Investigation Environment.

The first environment focuses on concepts, connectedness of concepts, and the processes of developing and relating them. Within this environment, the emphasis should be on:

- the phenomena to be explained
- the derivation of models, concepts, explanations
- the search for similarity in disparate situations
- the attention to structure, not detail
- the representations of similarity
- the generalisation and logical extension of concepts
- the objectification of abstractions
- the logical relationships between concepts and conceptual structures.

However, for this environment to be successfully created the language of discussion should be shaped accordingly, as should be questions asked of the learners, and the answers offered to learnersô questions (Bishop, 1991).

The second environment focuses on projects which are meant or concerned with relationship between mathematics and society. This environment allows learners to shape their ideas using projects that are about issues within their societal context in which they live. On the other hand, the problem facing the teacher in creating this kind of an environment as described by Bishop (1991), ñlies in making satisfactory connections between the level of mathematical conceptual knowledge possessed by the learners and the simplicity/complexity of the societal/contextual situations to be exploredò (p. 143).

The third environment focuses on the teacherôs creation of an investigation environment. In this environment the main source is the learnerôs own creative potential which the teacher should work on (Bishop, 1991). As mentioned by Bishop (1991) the challenge for the teacher in creating the investigative environment ñlies with the fact that the mathematical work may proceed in a direction which the teacher has not investigated herself, and therefore that the learner will know more about this work than the teacherò (p. 151). However, the education that seeks to enculturate learners into ideas and values of the mathematical culture must include the possibility of the learners developing their understanding above and beyond that of their teachers (Bishop, 1991).

An Ideational Process

The third aspect of mathematical enculturation as described by Bishop (1991) is about a way of knowing. The focus is on mathematical ideas and the shaping of those ideas. However, at the core of this process (ideational), is a concern about the meaning of mathematical ideas (Bishop, 1991). Bishop and Goffree (1986)ôs interpretation of mathematical meaning is that it is ñachieved by establishing connections between the particular mathematical idea under discussion and the remainder of the individualôs personal knowledge. A new idea is meaningful to the extent to which individuals can connect it with their existing knowledgeò (p. 346).

According to Bishop (1991) meaning is ñpersonally achieved and is an integrating response by the learner to a new and potentially disturbing phenomenon in her environmentò (p. 152), and as such the mathematical enculturation process is a way of encouraging individuals to experience and to reflect on ideational contrasts in order to develop a particular way of knowing (Bishop, 1991). He, however, in agreement to the constructivists stresses that ideas are contrasted in an interactive and interpersonal engagement. Meaning that it is through social interactions that ideas are shared and individuals construct meaning from those interactions.

However, it should be noted that it is the responsibility of the teacher to create an environment that allows for learners to share and critique ideas. During the process the teacher, representing the mathematical culture, should offer learners an opportunity to shape ideas so as to enculturate them in to the mathematical culture. One important issue that comes out as very important is that if a learner does not contribute ideas then there will not be anything to shape.

The shaping as explained by Bishop (1991) does not mean moulding something in order to have an artefact. On the other hand, it should be clear that it actually the learner doing the shaping not the teacher. According to Bishop (1991) if knowledge is individually constructed, then it is the individual learner with the teacher continually creating a collaborative environment, who does the shaping. He emphasises the fact that it is the learner who comes with the idea, it is the learner who construct meaning in response to environment and it is the learner who owns or develop mathematical meaning as a result thereof.

What does enculturation mean?

It is evident from the arguments presented in this chapter that enculturation can be better explained if the culture in question is clearly defined. In this chapter the focus was on mathematics culture and to some extends on classroom culture. But what came out as key to my sense making was how learning was used to explain or describe culture and enculturation.

From a sociocultural perspective, learning takes place as a result of social interactions and culture. In this case the individual experiences can be accounted for based on the social and cultural processes within which a particular individual is located (Cobb and Yackel, 1998). The emphasis is on social and cultural processes with a little account on individualôs cognitive processes, which I find very strange. This is purely because their contention is in contradiction to my understanding of the learning process. For me the learning process can be better explained by what happens in the individualôs cognitive domain, of course influenced by the social and cultural environment. Not the other way round.

On the other hand, constructivists argue that there is a reflexive relation between individual and social processes. Their arguments seem to suggest that the two processes are at the same level. Social processes should reflect individual constructions and these, in turn, should reflect social interactional processes (Cobb and Yackel, 1998). From this perspective individual constructions play a major role in shaping the emerging social processes (emerging classroom culture).

Taking a closer look at these two arguments, they both value the importance of social interactions in the process of individualôs construction of mathematical meaning. The only difference for me is on the value (emphasis) attached to the social aspect of the individualôs construction of mathematical meaning (learning process). They again agree that the social processes and the cultural processes constitute or contribute towards the evolving classroom culture.

However, my remarks above seem to suggest that socialization and enculturation have the same meaning. As much as I do not want to suggest that they mean the same thing I cannot differentiate the two. Mead (1963) tried to differentiate the two in her article titled ñsocialization and enculturationò from an *anthropology* perspective. In differentiating the two this is what she said ñenculturation- the process of learning a culture in all its uniqueness and particularity- socialization - the set of species - wide requirements and exactions made on human beings by human societiesò. As a way of clarifying her statements above this is what she said - socialization is ñabout learning as a universal processò and enculturation is ñthe actual process of learning as it takes place in a specific culture.ò I am not going to try to analyze her interpretations as I

might not do justice to anthropologists. However, what comes out of her paper is that it remains a serious challenge to anthropologists to come up with a general framework of how to use socialization and enculturation without contradictions.

Looking back at what is presented in this chapter, there are five constructs that emerge as key in understanding enculturation process. Those are: role play, shaping of learnersô ideas, learning (what it means to learn), negotiation of meaning, and the intentional process.

The first construct has to do with roles that teachers are expected to play. It is the responsibility of the teacher to create an environment that allows for learning to place. The type of environment to be created depends largely on the beliefs that the teacher has in terms of what it means to learn. The other role is that of representing the mathematical culture. This role involves coming up with intentional activities that are meant to initiate the learning process. The teacher is expected to, through questioning, help learners to shape their mathematical ideas. On the other hand, learners are expected to respond to the environment created and positively contribute to the emerging classroom culture.

The second construct is shaping of learnersô ideas. This is as a result of learners sharing ideas and critiquing them. It is believed that during this process learners are able to develop mathematical meaning. It should then be very clear that it is the learner who does the shaping not the teacher.

The third construct is about what it means to learn. For me this serves as the basis for what we as teachers intend to do in the classroom. It is our (as teachers) understanding or perception of what it means to learn that guide how we prepare the activities we give to our learners, how we engage learners in the discussions during the negotiation of meaning process (this include the shaping process), and the learning activities that we create during the learning process.

The fourth construct talks about the importance of the process of negotiation of meaning in a social classroom. Though the meaning developed during this process

remains at social level, it plays a big role in helping students when they individually interrogate issues as they shape their ideas.
The fifth construct is more concerned with how teachers plan for their lessons. It is the intentions of the teacher that give shape to the kind of issues that are brought forward by students during the interactions.

These constructs will be subjected to another level of analysis in chapter 5.

Conclusion

In this chapter I tried to make sense from literature of what culture is and by so doing tried to make sense of what and how the classroom culture comes to exist. It is the social interactions and how learning occurs that characterise the evolving classroom culture. Subsequently, I looked at the enculturation process for both the classroom culture and mathematical culture using sociocultural and constructivistôs theories as the basis for my sense making.

However, the issues discussed in this chapter were at a level where the enculturation process was more on the mathematical culture. The next chapter offered me with an opportunity to experience and make sense of an enculturation process in an evolving classroom culture but also taking issues of mathematical culture in to consideration. A classroom culture that evolves during the process of learning mathematics operates within a mathematical culture. It also gave me an opportunity to look at issues surrounding an individual learner who was trying to fit into a group of learners who have been together for a number of years.

CHAPTER 4

ENCULTURATION OBSERVED

Introduction

In this chapter, I reflected on two teaching experiments, which were taken at different times of the academic year. The first taken during the second school term and the second taken during the third school term of the same year. The two teaching experiments gave me an opportunity to see how Sarah (a case) adapted to the new environment and her enculturation process in to her new class. I also looked at Helen (Sarahôs class mate) with a view of comparing how learners respond to the culture created in the classroom

Environment created

Our intention, as guided by our beliefs on how mathematics should be learned, was to have an environment where learners get to share mathematical ideas with the hope that during the process they will construct mathematical knowledge. As such, our actions during the process were such that they encourage learners to share ideas. As indicated by Bauersfeld (1994),

> teaching should be an attempt to organize an interactive and reflective process, with the teacher engaging in a constantly continuing and mutually differentiating and actualizing of activities with students, and the establishing and maintaining of a classroom culture. (Bauersfeld, 1994, in Bednarz, 1998. p.53.)

It was this understanding of what it means to teach that guided us throughout the two teaching experiments. Of greater importance was our beliefs of how mathematics should be learned as it also affect our actions during the learning process. We believe that mathematics should be learned through social interactions. As indicated by Masha (2004) it is through social interactions that learners, including us, get opportunities to assess their constructs from different perspectives that they would not have had in their solitary endeavours. This allows individual learners to critique new experiences in accordance with their own prior knowing systems resulting in the generation of new scenarios that enrich all other participantsô perspectives.

On the other hand, it was Lermanôs view of mathematics as a social construction that guided our teaching. With this view each learner is seen to re-create mathematics for her/himself, with the constraint of social interaction as the medium for the development and limitation of those personal creations.

It was against these ideas that the culture created in our classroom was such that learners work on the activities in their various groups and later have a whole class discussion where we try to negotiate for a common understanding. We did that whilst acknowledging the fact that each learner will develop his/her own constructs.

All learners in this classroom have been together from previous grades except for Sarah who joined them during the year this study was done. From the two teaching experiments it was evident that she struggled to become part of the existing culture. One of the emerging reasons why she had problems in getting used to how things were done was English as a language used during lessons and also as a medium of instruction.

The Teaching Experiments

This section has two teaching experiments labelled Teaching Experiment 1 and Teaching Experiment 2. Each teaching experiment has a background, learning episodes and its analysis. The teaching experiments were drawn from two different times of an academic year. The first teaching experiment shows variations of interactions as learners get used to each other with special focus on Sarahôs enculturation process as a new learner at this school and the class. The second teaching experiment shows a different stage in the process of settling into a new class and also the progress made by the whole class in interacting with one another.

Teaching Experiment 1

Background

This teaching experiment is taken from the 2004 grade 5 learners classroom experiences. The teaching experiment arises from the second quarter of the year. Prior this, I had spent a week with the class in the first quarter of the year in order to get a

feeling of how they interact with each other and to find a way in which I can be part of the setting. It was during this week that I had a discussion with the educator in trying to establish a way in which we will continue to work with learners.

The activity given to learners was a follow up on the one they did on counting and addition, and to introduce multiplication. The idea was for the learners to use their prior knowledge on counting and addition to carry out this activity.

Episode 1

This activity is taken from the textbook: Maths for all, Grade 5

Activity 2. Buying Herbs

1. For their new herb garden, Mr and Mrs Gordon bought the following: 3 boxes of rosemary, 6 boxes of thyme, 8 boxes of origanum and 10 boxes of coriander.

   (a) How much did they pay for the rosemary?
   Complete: R4 × 3 = □
   (b) How much did they pay for the thyme?
   Complete: R8 × 6 = □
   (c) Now work out how much they paid for the coriander and origanum. Write number sentences for your answers

2. Their neighbor, Ouma Mentoor, bought 4 boxes of thyme and 7 boxes of origanum. Ouma had R80,00 before buying her plants. How much money did she have left?

This is what happened in the classroom:

Teacher: Do activity on page 27 from your textbook (Maths for All) on buying herbs.

About five minutes after learners started working on the activity the educator looked a bit more frustrated.

Teacher: Hey, you need to write down what you are doing. We need to see that on paper.

Learner A: Môam do you mean that I should write down what I was explaining to you.

Teacher: Exactly, you need to present those ideas using numbers.

They continued working on the activity. During the process I would go to Sarahôs group to see how she is interacting with other learners and also to find out if she was working on the activity. They were asked to work in pairs and Lazarus has been working with Sarah for the entire quarter and their educator was not satisfied with their interaction. So, Helen (a friend to Sarah) was asked to team with Sarah for this activity. From what the educator told me the three learners (Merlyne, Anneline and Helen) volunteered to help her with mathematics. As I was observing Sarahôs team from a distance I could see her only nodding her head. This prompted me to get closer so as to make sense of her participation. Upon closer inspection I noticed that the two had responded to question 1a and 1b as follows

a) $R4 \times 3 = R4 + R4 + R4$
$= R12$

b) $R8 \times 6 = R8 + R8 + R8 + R8 + R8 + R8$
$R8 + R8 = R16$
$R8 + R8 = R16$
$R8 + R8 = R16$
Then $R16 + R16 = R32$
$R32 + R16 = R48$

But the responses as is did not tell me or give a picture of Sarahôs understanding. In my attempts to probe Sarahôs understanding, this is what happened.

Researcher: Sarah, explain to me what you did here (referring to 1a)

She kept quiet and looking very scared.

Helen: I can explain sir. Here we are multiplying R4 by 3, this is the same as when we add 4 and 4 and 4, and we get R12.

Researcher: What if you have $R4 \times 100$?

Helen: I am going to write R4 tse 100 and add them one by one. Potsiso ya bobedi le yona ke e dirile ka wona mokgwa wo (I did the second question in this way). Because it is R8 × 6 ke a tseba gore ke swanetse ke ngwale R8 tse 6 and add them one by one (*because it is R8 × 6 I know that I should write down R8 six times like I did here, pointing what she wrote in her book and add them one by one*).

Researcher: Do you think this method will always work for any multiplication problem?

Helen: yes, it will work (looking very confident).

Researcher: Explain what you did to Sarah on the first two problems.

From the extract, it shows that Helen did the questions on her own. Sarah did not utter even a single word to me. Instead of pestering her with questions I decided to let Hellen to explain the responses to her. I had to be sensitive here. She looked scared and did not want to make the situation worse than it was. On the other hand, the confidence shown by Helen forced me to let her explain. I wanted her to continue working hard.

When I checked the other groups they did the same thing as Helen except Annelinôs group and Merlinôs. In their case, both groups wrote the answers for 1a and 1b as follows:

R4 × 3 = R12
R 8 × 6 = R48

But their explanation was the same as Helenôs. It was time up and they did not finish the activity. We asked them to go and complete the activity at home so that they will discuss the answers the following day.

Analysis of episode 1

In this episode we expected learners to work in their groups as they usually do. There were a few learners who were not taking part in the group discussions. At this stage it was difficult for me to tell what the reason might be. But those learners who were not taking part (including Sarah) looked scared. This became a challenge to us in the

sense that we anticipated that learners would share ideas on the activity that they were doing and that this would also improve the social interaction in the classroom.
Majority of learners felt at ease to share what they have got with us except a few that I mentioned above (including Sarah). It was interesting to see how learners realized their mistakes as they explained their answers to us. From the episode given Helen did not have a problem in coming up with the answers. What I see would become a problem is when she is supposed to multiply a three digit number by a one digit number or multiplying bigger numbers. For the given activity her strategy works. Merlin and Annelinôs groups got the answers right but when asked how they got there their response was that they know that: in 1a 4 taken three times is 12 and 8 taken 6 times is 48. But most learners felt at ease in using repeated addition to find the answers.

During discussions I noticed that Sarah was always quiet. In most cases she would talk to Helen but just asking for a pencil or rubber. For the whole two periods, she seemed withdrawn, out of place and scared. When we try to talk to her she becomes more scared and in most cases she would not say anything. At this stage the problems that came out are more into English as a language and of greater importance her learning of mathematics.

From this episode two major issues stand out as serious challenge to us. Firstly learners feel comfortable using repeated addition in solving problems that involves multiplication. We wanted them to come up with a strategy that will work even for bigger numbers but they continued using repeated addition. The negotiation in this case did not allow us to impose what we think would work. As Bishop (1991) indicated, though educators should be seen as mathematical leaders in the classroom, they should avoid being the mathematical authority figure.

The second issue is on Sarahôs enculturation process in the classroom. According to Bishop (1991) enculturation demands that both learner and social environment play a strong role. The learner should in response to the environment construct ideas. Furthermore the environment must promote negotiation, while the learner must respond to that kind of feedback and become more involved. As evident from the episode, Sarahôs response to the environment has not been what we expected. She

seems not making any sense of what is happening in the classroom. The challenge in this case is how we then help her construct and shape her ideas if she is unable to express her thoughts. In this situation it is difficult to have an idea of how she is dealing with issue under discussion as her inner thoughts remain inaccessible to us. That there is a lot going through her mind is not disputed. We know that she is internally actively engaging with all that is going on around her.

In the next episode I will look at enculturation in two ways. The first one is the enculturation of learners to the mathematical culture-the induction of learners into the symbolization, conceptualizations and values of mathematical culture. Secondly, I will continue monitoring Sarahôs enculturation process (to the classroom culture and mathematical culture).

Episode 2

This was a continuation of the activity the class was engaged with the previous day. We asked them to complete the activity at home so that when they come for todayôs class they should start with the group discussion. Having realized the problem we had the previous day in terms of their interaction among themselves, we allowed them to choose members of the group. Sarahôs group remained the same.

As they were discussing, we realized that they were comfortable using repeated addition when given a multiplication exercise. Realizing that it was easy for them to respond to question 1c and 2 we decided to give them two questions still on multiplication but this time a bigger number and a small number. We wanted to see if they would still find repeated addition the only way to do multiplication.

We asked them to do the following sums:

(a) $20 \times 8 =$

(b) $19 \times 12 =$

(c) $100 \times 70 =$

As we expected, all the groups used repeated addition for all the questions. For example, this is how almost all the groups wrote question (a)

$$\left.\begin{matrix}20\\20\end{matrix}\right\}40$$
$$\left.\begin{matrix}20\\20\end{matrix}\right\}40$$
$$\left.\begin{matrix}20\\20\end{matrix}\right\}40$$
$$\left.\begin{matrix}20\\20\end{matrix}\right\}40$$

$$40 + 40 + 40 + 40 = 160$$

They followed the same procedure for the other two questions. Interesting was to see how happy they were and asking for more questions. We decided to give them bigger numbers just to see what will happen. For now the purpose was not see if they can answer problem based questions but to see if they can multiply numbers.

Question: find the product: 100 × 100

As they were working on the given question I went to Sarah to check if she was able to respond to the first set of questions. This time I did not involve other members of her group. I was prepared to go some length to try to figure out her thoughts. This is what transpired:

Researcher: Show me how you would multiply 20 by 8.

She kept quiet and she did not look as if she is even thinking about my question. I then resorted to using her mother tongue.

Researcher: Ok, Sarah o na le bagotsi ba bakae mo sekolong (*how many friends do you have here at school?)*

Sarah: Ba four.

Researcher: Ge ele gore o mongwe le o mongwe wa bagotsi ba gago ba go fa R10, go ra gore

ba go file bokae ka moka ga yona (*if each one of them gives you R10, how much will you have in total?*).

Sarah: Ke R40.

Researcher: o ehweditse bjang? (*How did you get that?*)

Sarah: Ke a tseba gore di R10 tse four ke R40 (*I know that four R10 equals to R40*).

At least at this time Sarah is talking though still reluctant in giving details. In the interaction that follows I am trying to establish how she arrives at R40 but in a way she just knows that four R10 equals R40.

Researcher: Ge nka go botsisa gore 10 multiply by 4 ke bokae o tla reng? (*If I ask you what the product of 10 and 4 is, what would you say?*)

Sarah: Ga ke tsebe (*I do not know*).

Researcher: O a tseba gore bagotsi ba gago ge ba go fa di R10 tse o tla ba le bokae. (*But you the total amount you will if each of your friends gives you R10*)

Sarah: Ee (*yes*)

Researcher: Ge re re ba go fa R13, o tla ba le bokae? (*If each one of them gives you R13, how much will you have?*)

Sarah: (Very quick to respond) Di R13 tse four diswana le R10 tse four le di R3 tse four. Ke a tseba gore di R10 tse four ke R40 and di R3 tse four ke R12. Ge ke tlakantsa R40 le R12 ke hwetsa R52. (*Four R13 is the same as four R10 and four R3. I know that four R10 is equals to R40 and four R3 is equal to R12. When I add R40 and R12 I get R52*)

Researcher: 3 multiply by 4 ke bokae?

Sarah: Ga ke tsebe (*I do not know*).

What we came to realize is that Sarah is comfortable working with money. The numbers make sense to her if put in the context of money. Going back to check how other learners were responding to the question (100×100) we realized that they still used repeated addition. But most interesting was that they were complaining that it

takes them a lot of time to write down all the hundreds and add them one by one. It was almost time up and in a way we were satisfied that, though they use repeated addition, they understand what it means to multiply. But somehow Merlyne was excited and we asked her why that excitement. This is what she presented at the board.

Marylane: Sir and Môem let say I multiply 28 by 8. I know that 28 is the same as 20 + 8 and this is what I will write $(20+8)\times 8 = (20\times 8)+(8\times 8)$

$$= 160 + 64$$
$$= 224$$

Teacher: Marylane why do you separate 28 into 20 and 8

Marylane: It is easy for me to multiply numbers that end with zero by a single number and it is also easy to multiply a single number by a single number.

It was already time up and most learners were no longer paying attention.

Analysis of episode 2

Analysis of this episode takes the same shape as the first episode. However more emphasis is on how Sarah copes in terms of sharing ideas with other group members and the understanding of mathematical concepts involved. The analysis is done at two levels in relation to Sarahôs well being in class.

For this lesson we allowed learners to choose group members but surprisingly most of the groups stayed the same. This was because of the problems we encountered the previous day in terms of how they interacted. Since it was a continuation of the previous lesson they started by discussing amongst their groups.

The interaction for this lesson was better as compared to the previous lesson in episode 1. They were able to share ideas and each group made sure each member of the group understands the answers before moving to the next question.

During this episode we wanted to see if they could not find a way of multiplying numbers without using repeated addition. We gave them bigger numbers to work with and still they continued to use repeated addition except for Marylane and Helenôs

group. We asked Marylane to explain her method to the whole class hoping that they would use that method if given bigger numbers. They told us that though it takes time to find the answers, they find the method (repeated addition) to be making sense to them. I came to realize that there is no way in which we can push them to using Marylaneós method. After all we were happy that they understand what it means to multiply and they have a way of doing it.

However, Sarahôs struggle in terms of understanding or making her thoughts accessible to us in terms of what it means to multiply continued. The problems appear to be two fold. She is struggling with the language being used during classes. Secondly, she seems to be struggling with understanding mathematical concepts. As such these problems affect her interaction with other learners in the classroom.

As I mentioned in the paragraph above, Sarah finds it difficult to understand English as a language and English as used in mathematics. From time to time I will go to her group and discuss the activity in Sepedi. She opens up and starts responding to questions. However, I have to break down the questions and provide a context that will make it easier for her to respond. I used money as a context in episode 2 and she was able to give meaningful answers. But when I use English she keeps quite and sometimes she would say that she does not know the answer. She does not perform well in written assessment.

The problem in this episode seems to be more on symbolization and conceptualization of mathematical concepts for Sarah. The word multiplication does not make sense to her but if the question is asked differently not using that word she is able to work on it. On the other hand, she can only work on it if the question is verbally explained to her in her mother tongue. More interesting was to realize that numbers do not make sense to her if they are not used in context. For example the number 10 does not mean anything to her but you talk of 10 oranges or 10 people then she is able to make sense.

In terms of her interactions with other learners, she has been struggling and the language comes out as the main reason. She does not have confidence to share with others her ideas and still the language seems to be a key problem. I tried to engage her using Sepedi. This time she was able to respond but there was little understanding in

what she was saying. In general, she still finds it difficult to adjust to the culture being created in this class and what came out at the end of this episode was her lack of confidence. I will still look at her interactions with other learners and her understanding of mathematical concepts in Teaching Experiment 2

Analysis of Teaching Experiment 1

The analysis of this Teaching experiment will be on learnersô enculturation in to mathematical culture and Sarahôs enculturation process as arising from the two episodes. I will, however, look at the following issues as contributing factors to the enculturation process: (i) language, (ii) sharing of ideas, (iii) learnersô response to the environment created, and (iv) negotiation of meaning.

According to Bishop (1991) shaping of learnersô ideas can only be possible if they share their ideas with each other and the educator. If nothing comes from learners then there is nothing to shape. As evident from the two episodes Sarah has been struggling with English as a language and as such it made it difficult for her to share ideas with other learners. One has to also acknowledge the fact that she is new to this school.

As for other learners, language was not a problem because it is used at the school as a medium of instruction. However, it is normal for learners at their age to struggle with a few words they come across. It was interesting to see them sharing ideas and it made things easier in some instances for us to help them as they shape their ideas. The environment created allowed them to freely interact with each other. In a way the culture created in this classroom is such that learners work in small groups and they are free to find out from each other (group to group) how certain things are done.

One issue that came out strongly from the two episodes is that learners do not react the same to the environment they find themselves in. Within environment learners create their own environments. As a result, learners operate at different levels within the same classroom. Helen and Marylyne found the environment allowing them to freely express themselves and seeking for different ways of solving problems. In Sarahôs case the environment was threatening to her and in most cases she looked

scared. Her enculturation process to the culture of the classroom has not been a smooth one thus far.

However, the environment created allows learners to socially interact in sharing mathematical ideas. This implies that it is through social interactions that each learner constructs meaning about the mathematical concept that is being dealt with. On the other hand, this implies that the educator and learners go through a process of negotiation of meaning. The role that we played as part of the classroom culture, and representing the mathematical culture, was to help learners as they shape their ideas in a negotiated way. As defined by Leontôev (1981) negotiation is a process of mutual appropriation in which the educator and learners continually co-opt or use each otherôs contributions.

The negotiation process has not been a smooth one. As highlighted in *episode 1*, the negotiation did not allow us to impose what we wanted them to do. We had anticipated that they will reach a stage where they are able to multiply bigger numbers without using repeated addition. Through our interactions with learners we came to realize that they are comfortable with using repeated addition. We could not impose some of the strategies that would have helped them to multiply bigger numbers. Although we are seen as mathematical leaders in the classroom, we tried to avoid being the mathematical authority figure (Bishop, 1991).

Teaching Experiment 2

This teaching experiment was done in the third quarter of the year. At this time learners were already used to the way we are doings things in the math classroom. However, I was not with them most of the time but just after the first teaching experiment the educator and I sat together to see how best we could encourage learners to actively participate during group discussion. I am not implying that group discussion is the only way in which we could improve learning but we were using it to get learners talking about what they think about mathematics concepts.

We decided to contextualize their activities to suit their environment. In this way we hope that learners will find math as being accessible and more interesting. By now the assumption was that they are used to working in groups. But more interesting was to find out how Sarah has adapted to the environment. More focus for this teaching experiment was to see how Sarah responds to the environment created and how she responds to the activities.

For this teaching experiment learners were working on data handling. The activity was on reading the graphs.

The Activity: Picturing hairstyles

Selaeloôs school made a table and graph of the childrenôs hairstyles at their school.

Style	Bob	Baby dreads	Freeze wave	Braids	Number 1	Other
Number of children	93	79	70	87	35	51

Hairstyles

Hairstyles

1. Compare the picture graph and the bar graph.
    a) How are they the same and how are they different?
    b) What does each face show on the picture graph? Where does it tell you this on the graph?
    c) The numbers on the vertical axis of the bar graph are in groups of how many?
2. Answer the following questions by reading off the graphs:
    a) How many children have their hair in a freeze wave? From which graph did you read this information?
    b) How many children have their hair in baby dreads? From which graph did you read this information?
    c) What do the three and half faces in the ñNumber 1ò column of the picture graph show?
    d) What is the least common hairstyle shown?

End of activity

Episode 1

From the previous lessons we had problems with learners not willing to work in groups. The major problem was that some learners do not make inputs during the discussions and some feel that they are doing work for others. It was during the discussion we had with learners about this problem that one learner suggested that if they have to work in groups it should be in such a way that everybody within the groups takes part and that before moving to the following question the group should make sure that each member of the group can explain the answer. The agreement was if one member of the group fails to explain the answer that you have agreed on, you have to go back to the same question again. This might sound as if we are forcing learners work in groups but it was after we realized that it was easier for most of them to explain their ideas to their classmates.

Learners started doing the activity on picturing hairstyles. This is what happened:

Marylane's group: Sir, we do not understand number 1b.
Researcher (sir): Read that question again.

Question b: *What does each face show on the picture? Where does it tell you this on the graph.*

Sir: How many parts are there in that question:
Rotandwa: it has two parts and we understand the first part.
Sir: what is your understanding of the first part?
Marylane: we are supposed to tell what each face represents on the picture graph.
Sir: What is your answer to that question?
Jackson: 10 children.
Sir: How do you see that on the graph?
Marylane: oh, now I understand what the second part is looking for. It wants us to tell where we see the answer to the first part on the picture graph.

Almost all the groups had a similar problem. Marylaneôs group took a lead in helping other learners to understanding that question. They continued with the activity. As we

were moving around the groups we realized that they do not understand question 2d. At this time they stopped working in groups and we discussed question 2d as a class.

> *Sir*: What is your understanding of question 2d?
> *Hellen*: It means the hairstyle that is done by small children.

Most learners supported Helenôs view and we also saw it as we were interacting with them in their various groups. Instead of continuing they started talking about this question and we realized that the problem was more in to English. As we were still trying to figure out how we can help we saw Marylane raising her hand

> *Teacher*: Yes Marylane.
> *Marylane*: Can I use Sepedi môam
> *Teacher*: It is ok.
> *Marylane*: E ra gore ke hairstyle efe yeo elego gore e dirilwe ke bana ba bannyane (*it means which hairstyle was done by small children*).

Although I did the interpretation I knew that she might be meaning that which hairstyle did few children do. We interpreted it this way simply because we saw that their responses meant which hairstyle was done by small children. My interpretation caused a lot of noise. What I could gather from the noise is that it is not what they are saying yet their answers say a different story. They all wanted to say their understanding. Rotandwa did not bother to raise his hand and he stood up and started talking

> *Rotandwa*: Sir le Môam, e ra gore ke hairstyle e fe yeo ele go gore gase ya dirwa ke bana ba bantshi (*it means which hairstyle was not done by many children*).

They seemed happy with Rotandwaôs explanation and they continued on the activity. I went to Sarahôs group to see how she relates with other group members and also how she responds to the questions. But what was surprising was that learners stop discussing when we visit their groups but as soon as we leave they start discussing again. We would stand a bit far from the groups but still listen to what say.

Back to Sarahôs group

Researcher: Between the two graphs, which one is the bar graph and which one is the picture graph?

Doreen: The first graph is a bar graph and the second one is the picture graph

Researcher: Why are you saying that? What tells you that the first graph is the bar graph and the second one is the picture graph?

Helen: Because in the first graph they used bars and in the second graph they used pictures and the pictures are faces.

Researcher: Kagiso do you see the difference between the two graphs?

Kagiso: Aowa (*no*).

Researcher: Tshepiso

Tshepiso: Graph ya mathomo ke bar graph ka gore ba somisitse dibar and ya bobedi ke picture graph ka gore ba bontsha dipicture. (*The first graph is a bar graph because they used bars and the second one is a picture graph because they used pictures - faces*)

Helen: Sir, go to another group I will explain to them.

It was time up and most of them were still on question 1.

Analysis of the Episode 1

My analysis of this experiment will be focused on how Sarah reacts to the environment within which she finds herself in. I will look at how she interact with her group members, how she responds to questions as opposed to how other learners find the environment like. In this case I will look at Helen who is member of Sarahôs group, Merlyne and Annelin who together with Helen volunteered to help Sarah with mathematics activities.

The whole two periods were used to clarify questions as most of the things were new to them e.g. Representation of data.

By this time learners were already used to the way we were teaching and they knew what we expected from them in terms of responding to the activities. However, Sarah still finds it difficult to freely express herself within the group and also during whole class discussions. Focusing on Sarahôs interaction with other group members, she still finds it difficult to freely interact with other members of the group thus making it

difficult for Helen to assist her. The contributing factor might be that she is unable to read or communicate in English. In trying to help Sarah in this regard, we would explain the questions to her in Sepedi and see if she would be able to respond to the activities.

Contrary to how Sarah expresses herself, her group members were able to get access to the activity given and were able to discuss possible solutions to the questions. Although Helen seemed to be having an upper hand in terms of sharing ideas, Tshepiso, Kagiso and Doreen seemed interested and not shy to express themselves.

In trying to get Sarah involved the group would ask her to make presentations during whole class discussions. The groups would agree that it is the responsibility of the group, not of the learner presenting, to respond to questions that might be asked. However, it was going to be interesting to see how she would respond to questions asked. But what she did was to present the answers as they are written and let other members to respond to questions. Interesting was to see how she got motivated and willing to present again. However, my worry in this case was that she was only presenting answers that she does not understand.

The whole scenario takes me back to what I explained in the analysis of teaching experiment 1 about what learners make of the environment they found themselves in and how that affect their experiences. In this case Sarah is struggling to adjust to how other learners are working and on the other hand Helen, Merlin and Annelin find the environment interesting and thus making it easier for them to freely express themselves. This is evident from how they respond to questions and how they carry themselves during the lessons.

Episode 2

This episode was a follow up on the previous lesson. By now the understanding was that they are able to differentiate between the two types of representations given on their activity. Most of them were supposed to start with question 1c. My focus for this period was on Sarahôs group. However, I did visit the other groups but I spent most of the time with Sarahôs group.

This is what happened:

They were now working on question 1c and Helen was taking the lead asking the group members to explain.

Helen: Gare ga diline tse tse pedi vertical axis ke efe and horizontal axis ke efe? *(Between the two lines which one is the vertical axis and which one is the horizontal axis?)*

Sarah: Ke tse tse pedi (*pointing the two axis*).

Helen: Gape they are not the same. O swanetse o kgethe ye tee ya tsona (*you must choose one between the two options*).

Sarah was pointing at the first and when Doreen said no she pointed on the other one because there were only two options. I decided to ask the whole class to differentiate the two axes to make sure that they are able to differentiate them.

Researcher: Class can you differentiate between the vertical line and the horizontal line?

Learners(as a whole): Yes sir.

Teacher: Who can explain that to us? Yes Lele.

Lele: The vertical line is the line that is standing upright and the horizontal line is the line that is lying down.

Teacher: can you explain that using the graph?

Lele: yes maôam. The vertical line is the line that represent the number of children and the horizontal line is the line that has types of hairstyles.

Teacher: Can you all see what Lele is talking about?

Learners (as a group): Yes maôam

Researcher: Sarah, do you understand what they are talking about?

Sarah: Yes sir

Teacher: can you come and show me the vertical and the horizontal lines on this graph (pointing on the graph drawn on the blackboard)

She pointed on the correct lines

Teacher: Sarah, which line is this one? (Pointing the horizontal line)

Sarah: Hozontal line. (She could not read it properly and other learners corrected her)

Teacher: Ok, continue with the activity.

Back to Sarah's group. Still working on 1c

Helen: Sir I understand the answer to 1c but when I ask them they donôt know it.

Researcher: Ok, vertical axis le horizontal axis le a ditseba. (*Do you know the vertical and the horizontal axis?*)

Sarah's group: Yes sir (pointing them)

Researcher: vertical axis e representa eng on the graph? Helen let them to respond. (*What does the vertical axis represent on the graph?*)

They kept quiet

Researcher: Look at the graph carefully. Do you see the vertical axis?

Sarah's group: yes sir

Researcher: What is written on the vertical axis?

Kagiso: numbers sir

Researcher: do you agree with him?

Sarah's group: yes

Researcher: what are those numbers representing?

Tshepiso: they are representing number of children.

Researcher: Sarah do you see what they are talking about?

Sarah: No sir.

Researcher: Sarah, o tshogile (are you scared)?

Sarah: Ga se ka tshoga(*I'm not scared*)

Researcher: Ok, vertical axis ke efe mo? (*Which one is the vertical axis?*)

Sarah: Ke ye ya goba le dinomoro. (*It is this one with numbers*)

Researcher: Dinomoro tse di emetse eng? (*This numbers represent what?)*

Helen (feeling neglected): Can I explain to them Sir?

Researcher: Ok, go ahead.

Helen: vertical axis e re bontsa gore ke bana ba bakae ba ba dirilego mohuta o itsego wa moriri and horizontal axis ere bontsa mehuta ya dihairstyle

Researcher: Sarahôs ke bana ba bakae ba go dira Bob Hairstyle? (*How many children did Bob Hairstyle?*)

Sarah: 90 children

Researcher: why o re ke 90? (*Why are saying that it is 90?)*

Sarah: ke ka lebaka la gore bar ya Bob hairstyle e fihla go 90. (*It is because the bar representing Bob hairstyle ends at 90*)

Researcher: Do you agree with Sarah?

Other members of the group: No.

Researcher: Why are you saying no?

Tshepiso: I am saying no because bar ya Bob hairstyle e ka godimo ga 90. Nna ke re ke 93 or 94. (I *am saying no because the bar representing Bob hairstyle is above 90. So, I am saying that the number of children who did Bob hairstyle is 93 or 94*).

Other members except Sarah: He is right.
Researcher: Please explain that to Sarah.

It was time up. We were happy with how learners were engaging themselves in the activity. During the facilitation we realized that there were learners who had answers for all the questions (Helen, Marylane, Lele, Rotandwa, Doreen and Lazarus). I could see from how they contribute ideas within their groups that they really gave themselves time to do the activity.

The following week was reserved for third term tests and I was also involved in evaluating student teachers doing practicals at the university where I work as a tutor. This meant that I could no longer continue visiting the school for the remaining part of the year. The educator and I agreed that she will give them a project to do on data representation and she will invite me for presentations of the project. However, my aim of attending will be to see Sarahôs group presenting.

Analysis of episode 2

The focus was more on Sarahôs group for this episode. I wanted to see the progress she has made in terms how she relates with other learners during discussions and how she copes with mathematical concepts. I also looked at Helen in trying to understand the effect of the learning environment on learners.

I have to start by indicating that I was surprised to see Sarah volunteering to make a presentation on behalf of the group. This is something that she would not do during the first semester. I realized that she now feels that she is part of the class and more interesting that the culture created requires of her to participate in the activities of the class

However, what she presented was what the group agreed on. It did not mean that she understood was she was presenting. This was evident when the group was asked question and instead of responding she would keep quiet. But by this time I could see that she is more relaxed in class and free to talk to the group members. However, what she talks about is limited mostly on general issues. This is largely due to the fact

that she is struggling with understanding mathematical concept and language used in learning the subject.

By this time I could tell that Sarah feels part of the environment and the culture created. However, the two aspects have different effects on individual learners. Individual learners within the same environment create their own environment and that in a way model how they behave and learn in class. I am not saying that this are the only two issues that affect how learners learn. There are a lot of aspects that affect how learners learn, for example, one of the factors that have an effect on how Sarah learns is language.

As compared to Sarah, Helen finds the environment and culture created very friendly. It allows her to freely express herself. She is not struggling with English as used mostly as a medium of instruction. The environment gives her a platform to share her ideas with other learners and indirectly clarifying her own understanding.

Looking at how Sarah copes with mathematical concepts, I think the problem has to do with her mathematics background. For example, during this episode her group was working on question 1c and she could not see that the bar representing Bob hairstyle was above 90 or it might be that she does not know that between 90 and 100 there are numbers because the numbering on the vertical axis was in multiples of ten. However, the other members of the group did not agree with her. They were able to see that the bar they were looking at was above 90 and their answer was 93 or 94. From this I could read that learners are able to interrogate the activity.

Analysis of Teaching Experiment 2

The issues arising from this teaching experiment centred on the following: English as a language through which mathematics is learned, and shaping of learnersô ideas.
I need to indicate that language plays an important role on how learners communicate mathematical ideas and how they learn. For learners who started schooling at the very same school that I conducted this research, it was easy for us to get them talking, sharing ideas and negotiating mathematical meaning. This is purely because in their

case they learned to communicate in English as it is used as a medium of instruction. The enculturation process into the mathematical culture became a bit easier because they were able to share ideas and thus making it possible to shape their ideas (Bishop, 1991).

As a result, the culture created (classroom culture) was such that learners have to interact with each other, share ideas and most importantly negotiate for meaning. What was important for us was that though not all learners were actively participating as indicated in the previous sentence, the understanding of what had to happen was understood and negotiated by learners and us.

On the other hand, Sarahôs enculturation process has not been a smooth one for both the mathematical culture and the classroom culture. The problem underpinning her struggles seems to be on English as a language. From the conversations that I tried to have with her I could see that she was not making sense of everything that I said in English. When talking to her in Sepedi she would respond and some of her responses were making sense.

As I mentioned earlier, English is used as a medium of instruction at this school. Learners are encouraged to use English when communicating to each other in the classrooms. However, educators can decide to use Sepedi in cases where they feel it will be important to. This resulted in a situation (culture) where in most conversation are in English. This makes it difficult for Sarah to talk to most of the learners except those that are aware of her problem. On the other hand it affects how she relates to other learners and thus making it difficult to get used to the culture of the class.

The problem also affects her learning of mathematics in class. As indicated by Bishop (1991) educators can only shape learnersô mathematical ideas if they contribute their ideas during classroom discussions or on one to one interactions. He went on to say that if nothing comes from learners then there is nothing to shape. It has always been difficult to get Sarah to say something during discussions. It was only when we communicated in Sepedi that she was able to say a few ideas but still what she said did not really show any understanding of what was happening.

In what way was enculturation encountered in the classroom: Reflecting on the two Teaching Experiments

The following issues emerged as key to the enculturation process of learners for both the classroom culture and mathematics culture: Language, Shaping of learnersô ideas, and Negotiation of meaning.

Language

It is through language that we get to communicate with one another and share ideas. As mentioned by Seeger, Voigt and Waschescio (1998) language, in its widest sense as communication, is the limit of what one can express and more importantly that language is culturally specific and learned as one develops. In this subsection I will look at language in two ways, not suggesting that it is limited to the two ways, namely: language as used in social interactions and language as used in learning mathematics.

From the two teaching experiments it has emerged that language plays an important role in teaching and learning. The classroom culture as it has evolved during the course of the year was such that learning occurs through social interactions. In this case English as a language was used during the interactions. In a way it meant that learners who are unable to speak in English would find it difficult to cope with the flow of activities as unfolding during the learning process.

An example of such cases was Sarah who was new in the school. She had to undergo an enculturation process in to the school culture and ultimately the classroom culture. I will however, talk about her enculturation process in to the classroom culture. As I explained at the beginning of this chapter, the culture of the classroom was such that learners are free to talk to each other, share ideas, and that they learn through social interactions. Sarah had a problem with English as a language used during discussions. She could not construct a single sentence and it resulted in her feeling inferior. The consequence of this being that she could not form part of the social interactions that were taking place. The same issue was indicated by Ernest (1998) when he said that

individual learners develop personal knowledge of language, mathematics and logic through prolonged participation in socially situated conversations of varying types.

In learning mathematics, sustained participation in conversations helps in generating, testing, correcting, and validating subjective representations of mathematical knowledge (Ernest, 1998). On the other hand, educators do not have direct access to learners understanding as knowledge can only be identified as the individualôs mental constructions. It is through interactions (not limited to) with learners that as educators we, in a way, get an idea of what learners know and understand. Looking at Sarah and Helen, it is evident from the two teaching experiments that Helenôs enculturation process in to the mathematical culture has been a smooth one as compared to Sarahôs. The main reason being that Helen did not have problems with English and that the environment allowed her to freely engage herself in classroom interactions.

On the other hand, what I came to realize to during the interactions was that it does not necessarily mean that a learner is passive if he/she is not actively participating. A clear example of this was Rotandwa who was quiet most of the time but his written work showed that he was coping with the activities. From a distance we would see him talking to other group members but when we go to his group he would keep quiet. In episode 1 of teaching experiment 2, Rotandwa decided it was time for him to share with the whole class what his thinking was. Somehow the whole class looked surprised more especially because he did not even raise his hand, he just talked. As nicely put By Masha (2004) ñdeliberations, though sometimes centred on few individuals, are not entirely confined to them as the silent ones may also remain actively engagedò. This shows that even though he was not actively involved, he was following the argument (mentally he was actively involved).

Shaping of learners' ideas

As indicated in the later section, it is through language that we are able to communicate and share ideas with other people. In a mathematics classroom where social interactions are being encouraged; it becomes even more important for learners to be able to communicate with each other. It is through this social interaction that individual learners make sense of what is being discussed. It becomes very difficult to

find out if learners understand or is making sense if they are not communicating their ideas (as we have seen with Sarah).

As I mentioned in the previous paragraph, it has been evident from both teaching experiment that Sarah found it difficult to adapt to how things are done in her classroom. Most importantly in this section, I will look at sharing ideas with other learners. The environment created or the culture of the classroom, as indicated in the introduction of this chapter, was such that learners learn through interacting with one another. Sarah found sharing ideas with other learners very difficult. She hardly contributed to the group discussions.

I came to realize that it is not only language that makes it difficult for her to interact with other learners, also the prior knowledge that she had in mathematics did not do her any favours. This resulted in a situation where she could not use mathematics in interacting with other learners. In accounting for this issue I used Bauersfeldôs argument on subjective reconstruction of societal means and models through negotiation of meaning in social interaction:

> Participating in the process of a mathematics classroom is participating in a culture of using mathematics. The many skills, which an observer can identify and will take as the main performance of the culture, form the procedural surface only. These are the bricks of the building, but the design of the house of mathematizing is processed on another level. As it is with culture, the core of what is learned through participation is when to do what and how to do it. (in Cobb and Yackel, 1998: 160)

However, it is the first sentence of the argument that is most significant for this section. Part of the mathematics classroom culture involves learners using mathematics during the interactions to learn about mathematics. As part of the enculturation process to this culture one should be in a position to be able to share his/her mathematical ides during classroom interactions.

On the other hand, not being able to participate in the processes of a mathematical classroom is more likely to affect how one learns mathematics in a social mathematics classroom (as was the case with Sarah). By saying out what you think helps in clarifying your understanding. I am not trying to say that if a learner is not

participating as I am putting it then it means that that particular learner is not actively involved in the lesson. My argument is that in saying out what you think helps also in listening to yourself and clarifying your ideas. This also allows other members of the class to help in modifying that idea.

Sarah found it very difficult to share her ideas with other learners and in this case my assumption was that somehow she was thinking about something in line with what was done during the lesson. On the other hand her written work proved that she had very little if no understanding of what was discussed during the lessons. So, part of enculturation process involves learners sharing ideas and during the process help each other in shaping those ideas and also that provide the educator with an opportunity to shape those ideas.

Negotiation of Meaning

In a classroom where social interactions are being encouraged learners come up with different ideas. The challenge becomes how to get to a point where the class agrees on the meaning of what is being discussed. This does not only happen as learners together with the educator exchange ideas. It also happens in the learnerôs mind. In this case the educator is seen as representing the mathematics culture within the classroom culture. The educator should during the discussions through questioning give direction in the process of negotiating for meaning. In this research negotiation of meaning is looked at as part of a culture that exists in a classroom and is used to explain the enculturation process as opposed to actual process of negotiating for meaning.

Negotiation of meaning in most cases from the two teaching experiment was done mostly during group discussions as opposed to whole class discussions. This provided us with an opportunity to engage learners in rigorous discussions. Most of my time was spent with Sarahôs group.

Conclusion

This chapter provided me with an opportunity to experience enculturation as it was taking place in a classroom with learners. This was done by reflecting on the two Teaching Experiments as outlined in this chapter.

The following constructs emerged as key in understanding the enculturation process: language, shaping of learnersô ideas, and negotiation of meaning. This constructs will be subjected to a further analysis in chapter 5.

CHAPTER 5

WHAT ENCULTURATION PROCESS ENTAILS

Introduction

The two chapters preceding this one provided me with two contexts to explore different ideas about an enculturation process. A number of constructs have since emerged from those experiences. In this chapter I revisit those with the idea of subjecting them to another level of analysis. Through this experiencing I hope to construct generic attributes that to me provide a viable view of what an enculturation process entails.

The chapter has three sections ï introduction, attributes of an enculturation process, and conclusion.

Attributes of what a process of enculturation entails

There were four constructs that I considered important in understanding the enculturation process in chapter 3, in which I expanded my knowledge on culture and enculturation process from literature, and those were role play, shaping of learnersô ideas, learning (what it means to learn), negotiation of meaning, and the intentional process (activities are hypothetical). Three constructs emerged from chapter 4, wherein I experienced enculturation in a classroom setting, and those constructs are language, shaping of learnersô ideas, and negotiation of meaning.

There are two issues that I find important to highlight before I deeply engage the constructs that emerged from the two chapters. Firstly, the arguments presented in chapter 3 and chapters 4 were discussed from a constructivist approach to the culture of mathematics classroom wherein social interactions form a basis for knowledge construction. In this approach learning is characterized by the subjective reconstruction of societal means and models through learnersô negotiation of meaning in social interaction environment (Bauersfeld, 1998).

Secondly, I find it important to also highlight that the attributes that will follow in this chapter consider both the classroom and mathematical enculturation. I have since realized that from the two chapters there is no way one can talk about the mathematics classroom culture without talking about the mathematics culture. In bringing the two together, Bauersfeld argues that

> Participating in the process of a mathematics classroom is participating in a culture of using mathematics. The many skills, which an observer can identify and will take as the main performance of the culture, form the procedural surface only. These are the bricks of the building, but the design of the house of mathematizing is processed on another level. As it is with culture, the core of what is learned through participation is *when* to do *what* and *how* to do it. (1993:24)

Bauersfeldôs emphasis is that being part of the mathematics classroom is being in a culture that uses mathematics. Both the classroom and the mathematics culture complement each other in helping learners learn. This should not be mistaken to explain mathematics enculturation. Mathematics enculturation, which I find synonymous to learning, takes place in a learnerôs mind.

However, in my reanalysis of the constructs presented above, I have since concluded that there are three overarching attributes for what an enculturation process entails and those are language, learning, and negotiation of meaning.

Language

As I indicated earlier in this chapter, it is through language that we get to communicate with one another and share ideas. On the other hand it can limit what one can express and as such this can lead to a situation where one is likely to be misunderstood. On this issue von Glasersfeld (in Masha, 2004) indicate that the most often misguided notion with respect to language use is in how writers, speakers, and in particular educators, use it as though words and signs are containers of meaning that they want to convey. Though I agree with what he is saying, I still feel that it is through language that we can construct our own hypothetical models of learnersô thinking and knowledge. That is, the thoughts as expressed might not be conveying

the exact thinking of the learner, but that allows us to formulate our own thoughts that make us to act the way we do.

From a social point of view, we have seen in chapter 4 how difficult it was for Sarah to adapt to the evolving classroom culture. She could not interact or express her thoughts because of the language used as a medium of instruction in the classroom. As such her enculturation into the evolving ways of how things were done in her classroom was not a smooth one. On the other hand, Hellen who has been in this school since she started schooling found the environment friendly. She is part of the culture. She lives it, represent it and it is through her that the culture is expressed. She was able to freely express her thoughts and it was easy for her to interact with her group mates or us. One of the reasons why this was possible was because she is comfortable with language used in her classroom.

In constructing mathematical meaning (understanding mathematical concepts) from a social perspective, language plays an important role on how learners communicate mathematical ideas and how they learn. It was evident from literature in chapter 3 that individual learners develop personal knowledge of language, mathematics, and logic through prolonged participation in socially situated conversations of varying types (Ernest, 1998). Ernest continued to say that in learning mathematics, sustained participation in conversations helps in generating, testing, correcting, and validating subjective representations of mathematical knowledge. As educators we do not have access to learnersô thoughts or knowledge as this can only be identified as the individualôs mental constructions. Consequently, it is through interaction (not limited to) with learners that as educators we can formulate what learners know and understand.

The paragraph above in a way explains how learners get encultured into a mathematical culture in a social classroom. In chapter 4, we have seen how difficult it was for Sarah to be encultured into the mathematical culture as compared to Hellen, who through constant participation was moving along and showing progress in terms of understanding mathematical concepts. The difference between the two learners is that Sarah could not express herself because of the language while Hellen was always

ready to express herself. These are my assumptions on what Sarah could be going through. The question is, what could she be going through?

In summing up this subsection, language irrespective of different interpretations and forms is at the core in terms of how learning takes place. In the next subsection, I will look at how learning becomes an integral part of the enculturation process.

Learning

My understanding or belief of what learning is has been, throughout this report, accounted for from a constructivist perspective. In this perspective learning is conceptualized as the results of individual sense-making process. Each learner constructs his or her own individual mathematical meaning.

However, what I still find to be a challenge is explaining the development of mathematical meaning at individual and classroom (social) level. I, however, take comfort from Cobbôs construction, as indicated in chapter3, that there is a reflexive relation between individual and classroom (social) processes. The classroom (social) processes should reflect individual construction and these, in turn, should reflect classroom interactional processes. It is, though, at individual level that we can formulate constructions of what is going on in the learnerôs mind, whereas at classroom level we can locate the individualôs constructions within the social interactions. My construction on these arguments is that, based on what the learner brings as prior knowledge, social interactions may have a facilitative effect in individualôs sense-making.

It was evident from the two teaching experiments in chapter 4 that Sarah found it difficult to interact with other learners. As such we could not account for Sarahôs sense making at social level. Though, this is not saying that there was nothing happening in her mind. On the other hand her responses to my questions on a one to one interaction and her written work gave little to suggest that learning was taking place as expected. My construction based on my experiences from literature and the classroom interactions is that the ultimate result of the enculturation process is learning.

Negotiation of meaning

In a social classroom learners come with different mathematical backgrounds and such they attach or construct different meanings to the concepts they learn. Their constructions should, however, be acceptable in the mathematical culture. One way of establishing this is by creating an environment that allows for a process of negotiation of meaning. During this process both the teacher and learners come to a kind of official or collective meaning: meaning taken-as-shared. It should be acknowledged that the collective meaning established remains at social level.

One very important feature of this process (negotiation of meaning) is the shaping of learnersô ideas. During classroom social interactions, learners share and critique ideas. This resulted in each learner critiquing his/her ideas in response to other learnersô ideas or probes from the teacher. However, this may or may not result in a new construction of meaning. The teacher should, as part of the classroom social interactions and representing the mathematical culture, use his influence facilitatively. What I mean by this is that the teacher should create an environment that allows learners to share ideas, make learners aware that when discussing the ideas it does not mean that they are discussing the person who raised the idea, and critique those ideas. It is through this debates and critiquing of ideas that each learner is provided with an opportunity to shape his ideas. The challenge becomes if learners do not bring forward their ideas or understandings. If there are no ideas brought forward then there will not be anything to discuss and such the opportunity for learners to shape their ideas will not be created.

One of the reasons why Sarahôs enculturation process has not been smooth was that she was not an active participant (in terms of sharing ideas) during social interactions. As such we could not tell or account for her shaping of ideas at social level.

In summing up this subsection, it is through negotiation of meaning in social interactions that learnersô ideas are shaped. The shaping should not be interpreted as moulding. As I explained in chapter 3, it is learnersô concepts, meanings and processes that are being shaped. As explained by Bishop (1991) ñideas are developed by the learner, constructed by the learner, owned by the learner, and therefore of

course, shaped by the learnerò (p. 126). This is saying that it is the learner who does the shaping in response to messages received from both the teacher and environment (social and physical).

Conclusion

In this chapter I outlined three attributes for what the enculturation process entails. The enculturation process in this context refers to both the classroom culture and the mathematical culture. Therefore, the attributes discussed above caters for both cultures.

REFERENCES:

Bauersfeld, H. (1993). *"Language games" in the mathematics classroom: Their function and the education of teachers*. Unpublished manuscript, University of Bielefeld, Germany, Institute for Mathematics Didactics.

Bauersfeld, H. (1998). About the notion of culture in mathematics education. In F. Seeger, J. Voigt and U. Waschescio (Eds), *The Culture of the Mathematics Classrom* (pp 375 - 389). Cambridge University Press.

Bauersfeld, H. (1994). Remarks on the education of elementary teachers, pre-service and in-service. *Review of Science Education*, 20(1), 175-198.

Bednarz, N. (1998). Evolution of classroom culture in mathematics, teacher education, and reflection on action. In F. Seeger, J. Voigt, and U. Waschescio (Eds), *The Culture of the Mathematics Classroom* (pp. 50-75). Cambridge University Press.

Bishop, A.J. (1991). *Mathematical Enculturation: A Cultural Perspective on Mathematics Education*. Kluwer Academic Publishers, Netherlands.

Bishop, A.J. and Goffree, F. (1986). Classroom organisation and dynamics. In B. Christiansen, A.G. Howson, and M. Otte (Eds), *Perspectives on Mathematics Education*, Reidel,Dordrecht.

Cobb, P. (1995b). Mathematical learning and small group interaction: Four case studies. In P. Cobb and H. Bauersfeld (Eds.), *Emergence of mathematical meaning: Interaction in classroom cultures.* Hillsdale, NJ: Erlbaum.

Cobb, P. and Yarkel, E. (1998). A constructivist perspective on the culture of the mathematics classroom. In F. Seeger, J. Voigt, and U. Waschescio (Eds), *The Culture of the Mathematics Classroom* (pp 159 - 190). Cambridge University Press.

Cobb, P. (2000). Conducting teaching experiments in collaboration with teachers. In A.E. Kelly and R.A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 307 - 334). London: Lawrence Erlbaum.

Confrey, J. and Lachance, A. (2000). Transformative teaching experiments through conjecture-driven research design. In A.E. Kelly and R.A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 231 - 265). London: Lawrence Erlbaum.

Guba, E.G., and Lincoln, Y.S. (1989). *Fourth generation evaluation*. Newbury Park, CA: Sage

Denzin, N.K. and Lincoln, Y.S. (1998). Introduction: Entering the field of qualitative research. In N.K. Denzin and Y.S. Lincoln (Eds.), *Strategies for qualitative inquiry* (pp. 1 - 34). London: Sage.

De Vos, A.S., Strydom, H., Fouche, C.B., and Delport, C.S.L. (2002). *Research at grass roots: for the social sciences and human service profession* (2nd ed.). Van Schaik Publishers: Hatfield, Pretoria.

Ernest, P. (1998). The culture of the mathematics classroom and the relations between personal and public knowledge: An epistemological perspective. In F. Seeger, J. Voigt, and U. Waschescio (Eds), *The Culture of the Mathematics Classroom* (pp. 245-268). Cambridge University Press.

Kilpatrick, J. (1992). A history of research in mathematics education. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 3-38). New York: Macmillan.

Lave, J. and Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Leontĉev, A. N. (1981). The problem of activity in psychology. In J. V. Wertsch (Ed.), *The concept of activity in Soviet psychology*. Armonk, NY: Sharpe.

Masha, J.K. (2004). *Creating a constructivist classroom learning environment for meaningful learning of mathematics*. An unpublished doctoral thesis. Curtin University of Technology

Mead, M. (1963). Socialization and Enculturation. *Current Anthropology,* 4(2), 184-188. University of Chicago Press.

Newman, D., Griffin, P., and Cole, M. (1989). *The construction zone: Working for cognitive change in school*. Cambridge: Cambridge University Press.

Nunes, T. (1992). Ethnomathematics and everyday cognition. In D. A. Grouws (Ed.), Handbook *of research on mathematical teaching and learning* (pp. 557-574). New York: Macmillan.

Pirie, S., and Kieren, T. (1992). ñCreating constructivist environments and constructing creative mathematicsò. *Educational Studies in Mathematics* 23: 505-58. Kluwer Academic Publishers: Netherlands.

Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. Oxford: Oxford University Press.

Romberg, T. A., and Carpenter, T. P. (1986). Research on teaching and learning mathematics: Two disciplines of inquiry. In M. C. Wottrock (Ed.), *Handbook of research on teaching* (pp. 850-873). New York: Macmillan.

Seeger, F., Voigt, J., and Waschescio, U. (1998). Introduction. In F. Seeger, J. Voigt, and U. Waschescio (Eds), *The Culture of the Mathematics Classroom* (pp. 1-12). Cambridge University Press.

Stapleton, A.J., and Taylor, P.C. (2003). *Representing research and development*. A paper presented at the annual conference of the Australian Science Education Research Association (ASERA), Melbourne

Steffe, L.P., Thompson, P.W., and von Glasersfeld, E. (2000). Teaching experiment methodology: Underlying principles and essential elements. In A.E. Kelly and R.A. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 267 - 306). London: Lawrence Erlbaum.

Voigt, J. (1994). Negotiation of mathematical meaning of learning mathematics. *Educational Studies in Mathematics*, 26(2-3), 273-298.

Von Glasersfeld, E. (1983). Learning as a constructivist activity. In J. C. Bergeron and N. Herscovics (Eds.), *Proceedings of the 5th annual meeting of the Northern American Group of Psychology in mathematics education*, 41-68. Montreal.

Waschescio, U. (1998). The missing link: Social and cultural aspects in social constructivist theories. In F. Seeger, J. Voigt, and U. Waschescio (Eds), *The Culture of the Mathematics Classroom* (pp. 375 - 389). Cambridge University Press.