Science and Mathematics Education Centre

Evaluation of a Constructivist Learning Environment in Secondary School Mathematics for Arabic Learners Whose Second Language is English

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This thesis is presented for the Degree of

Doctor of Mathematics Education

of

Curtin University

July 2017

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: 

Date: 12. O7. 2017

Abstract

Over the last three decades, constructivism has been a major influence in mathematics education. While the past studies indicate that constructivism has been fairly productive and accepted in Western educational settings such as Australia or Great Britain, there is little research of its efficiency in an Arabic mathematics classroom. Can constructivist ideas be successfully implemented in such a setting?

The feasibility of the implementation of a constructivist learning environment in a Year 7 boys' Arabic mathematics class in an international school in Qatar was the main focus of this research. More specifically, the study aimed to determine the effectiveness of the implementation of a constructivist learning environment, to evaluate the students' reaction to the environment, and to determine the cultural appropriateness of the constructivist strategies being implemented in the boys' Arabic mathematics classroom.

Radical constructivism, social constructivism and critical constructivism informed theoretical background of this study and account for the scales of the constructivist learning environment survey (CLES) used in this study - personal relevance, uncertainty, critical voice, shared control and negotiation. My interpretation of the three facets of constructivism reflects my understanding of what teaching and learning of mathematics should be about, and the classroom activities were planned in the line with that understanding.

The effectiveness of the constructivist-informed teaching and learning was evaluated in terms of how successfully I, as a classroom teacher, converted constructivist ideas into practice and addressed the CLES scales within my classroom. The students' reactions to the constructivist learning environment was examined in terms of how the students responded to the CLES scales and to what degree they appropriated the constructivist ideas. The cultural appropriateness of constructivism in my Year 7 boys' mathematics classroom was analysed in terms of my ability as a teacher to facilitate the elements of a culturally relevant constructivist classroom - the reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice, and classroom practices. Additionally, I explored some conflicts between constructivism and Arabic cultural viewpoints.

This study could be considered multi paradigmatic as post-positivist, interpretivist and critical paradigms had an influence on me and my inquiry. However, it was mainly influenced by an interpretivist standpoint. I communicate with the reader that everything I did was a result of

my personal experiences and circumstances. I employed the participant observation strategy that included one Year 7 boys' class. Three students from the class were selected for a closeup analysis. This study combined qualitative and quantitative data. Qualitative data were obtained through mathematical and non-mathematical tasks, reflective journals, semi-structured interviews and observations, while the quantitative data were collected using the Actual forms of the CLES at the end of year. A narrative inquiry was chosen to present the qualitative data in a coherent way and to depict the classroom events in a meaningful manner. These stories provide information about the way the constructivists learning environment was created, try to capture students' responses to the learning environment, and offer an insight into the classroom dynamics, and relationships between all involved. The legitimacy of my field work was guided by Guba and Lincoln's quality criteria of trustworthiness and the legitimacy of my presentation was guided by verisimilitude and usefulness.

Four propositions emerged from the study:

- the implementation of the constructivist learning environment is viable in an Arabic boys' mathematics classroom, especially with negotiation and uncertainty aspects,
- students in an Arabic mathematics classroom are influenced by their cultural background,
- the CLES could be employed in an Arabic classroom to offer an adequate and meaningful account of the learning environment, and
- the teacher's cultural background and beliefs may affect the implementation of the constructivist learning environment in her classrooms.

The results of this study reinforced my belief that the practices informed by the three facets of constructivism have a positive impact on the learning environment. Additionally, I have become aware of the complexity of culturally relevant practices in mathematics education. Implications of this research include suggestions for teacher education; courses addressing the nature of mathematics, culturally relevant pedagogy and complex political and ethical issues that would be beneficial for beginner teachers. The study revealed the need for further research to be conducted in this area, possibly involving samples that represent a wider range of sociocultural groups and different ages in an Arabic context.

Acknowledgements

I would like to acknowledge the contribution of an Australian Government Research Training Program Scholarship in supporting this research.

A very special gratitude goes to my supervisor David Treagust, for guidance and support in overcoming academic and personal obstacles, particularly in the final stages of writing the thesis. Academically, his work influenced my study. Personally, his consideration and support kept me going when the time was tough and helped me bring this thesis to an end.

I would like to thank Peter Taylor who was my Constructivist lecturer. His feedback and comments made an impression on me and the impact of his work on my study is obvious through the thesis.

I would like to express my appreciation to Bill Atweh who provided me with the opportunity to commence the doctoral studies.

I thank the students who have participated in this research and the Principal and the Head of the Department who allowed me to conduct this study.

I would like to thank my mother-in-law, Josephine, for her views on issues related to this research and stimulating discussions during data collection and thesis writing.

I am thankful to my husband Richard, for his encouragement and tolerance throughout my doctoral program, and his patience to listen to my talks about my students and study. I want to thank my children, Nevena and Nemanja, for their love.

I am grateful to my parents and brothers who were always there for me when I needed them.

I dedicate this study to my mother, Milosija, who made me the person I am today.

I dedicate this study to my late father, Milenko, who made me the teacher I am today. Dad, I owe it to you and your passion for puzzles and enigmas for kindling and nurturing my love for mathematics.

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Chapter 1: Introduction

1.1 Introduction

Over the last three decades constructivism has become one of the most influential forces in mathematics education. Traditionally teaching mathematics included transmitting facts, procedure and rules, while students passively received that knowledge. Constructivism is the exact opposite of this traditional view in that it values students' autonomy and personal construction of concepts. The main role of a constructivist teacher is to scaffold and help students develop their own ideas instead of to present the 'correct' type of knowledge. Critical constructivism is concerned with changing socio-cultural aspects of teaching and learning, and has the goal of creating a classroom where students explain, and negotiate mathematical meanings, and critically reflect on their decisions. As such, constructivism is embedded in emancipatory traits, with personal constructs and critical skills being valued. With such characteristics, constructivism could be described as a modern phenomenon in education coming from the West. In this perspective, the West means cultures that are derived from and influenced by Western European countries, mainly England, Australia and America. However, one needs to understand that the skills of independent decision making and critical reflection are not innate or naturally developed. At present they are promoted in the West, and are not established to the same extent in other cultures. The Western way of life and values, regardless of how natural and logical they appear to be (to western people), generally, are not accepted worldwide. For example, traditionally, in the Arab world, some of these assumptions, like raising your critical voice about classroom events, could be seen as an inappropriate act of disobedience. This raises the question of the appropriateness of constructivist ideas in a non-western socio-cultural context, to be precise in the Middle East. Is it possible to create the constructivist learning environment in other cultures, which have a different value system? What would be the result of the implementation of the constructivist environment in an Arabic classroom?

This study examines the implementation of the constructivist learning environment in an Arabic boys' mathematics classroom. Additionally, it seeks to find out whether constructivist approaches are culturally appropriate in an Arabic socio-cultural context.

This introductory chapter provides an overview of the main components of the study. The purpose of the present chapter is to provide background information about the study, to outline its theoretical framework, research questions and significance, and to outline the other chapters.

1.2 Theoretical framework

This section describes the basic ideas that framed this research: constructivism and its assumptions and forms that influenced the study, the Constructivist Learning Environment Survey (the CLES) which was used as a reference guide for lesson planning, the aspects of Arabic culture and culturally appropriate teaching.

Constructivism has been a major influence in mathematics education over the last three decades. According to Von Glasersfeld (1995), knowledge is actively built up by the cognising subject, as opposed to being passively received. The function of cognition is adaptive and its purpose is to serve the subject‘s organisation of the experiential world. Knowledge is not constructed to reflect reality; it is rather the best fit of it. In radical constructivism the concept of truth is being replaced by the concept of viable construction. Viable constructions are actions where we construct meaning of the world around us based on our past experiences and it has to be consistent with our previously made structures (Hardy & Taylor, 1997). It is important to notice that this definition of constructivism emphasises the individual construction of knowledge.

Many theorists, including Cobb (1994) and Driver, Asoko, Leach, Mortimer and Scott (1994), propose a dialectical model where the two positions, personal and social, complement each other. Social constructivism recognises social context as a major component of learning, and according to Pritchard and Woollard (2010), cognitive development best occurs through discussions and reasoning with peers and adults. Driver et al. (1994, p.9) see making meaning as ‘a dialogic process involving persons-in-conversations, and learning is seen as the process by which individuals are introduced by more skilled members’. The exchange of ideas in any context is likely to lead to a greater understanding for the participants, i.e. the learning is social in its nature.

Recently, constructivism has been enriched with an ethical facet. The need and desire to understand the complexity of learners and their social reality have made many researchers

adopt social and critical outlook in their work, and consider the issues of identity, language and power. The perceived neutrality of mathematics education research in the past stems from the work of predominantly white, male researchers whose studies did not address issues of equity. A current major concern is that studies continue to give priority to mathematics content that offered little for underprivileged students (Martin, Gholson, & Leonard, 2010). Critical constructivism is influenced by the work of Habermas (1974) that recognises that human cognitive interests - technical, practical and emancipatory - are determining the way in which we create knowledge. Hardy and Taylor (1997, p.148) argue that if radical constructivism is combined with 'the socio-cultural context of knowledge construction and moral imperative', it can be a referent for teachers 'deconstructing traditional objectivist conceptions of nature of science, mathematics and knowledge'. Constructivist theory together with the critical theory of Habermas resulted in the critical constructivism which offers ethical guidance for regulating the discursive practice of knowledge construction.

There are a number of benefits of constructivist teaching and learning. Constructivism does not support a one-size-fits-all approach to prescribed curriculum or teaching strategies; students' needs are unique depending on their background and corresponding strategies and resources should be unique. We are not meant to have particular strategies that will work across the board; everyone's requirements are different. Tobin and Tippins (1993) suggest using constructivism as a referent and reflective tool in teaching. Another advantage is that students will feel appreciated and motivated if their experiences are valued and used on the lesson planning. Further, constructivism puts students in the position to be participants in their own education. By applying principles of critical constructivism, one is actively trying to expose hidden values in society (Taylor, 1998).

Implementing a constructivist learning environment is about getting to know students, growing with them and creating a safe environment that is contributing to their knowledge construction and cultural identity. Constructivist environments created in different classrooms will not be the same as they depend on the students' background and needs. However, there are some practices that proved to be successful: being aware of students' outlooks, structuring lessons to include their personal interests and to challenge their views, and incorporating assessments in day-to-day teaching and learning are strategies recommended by Brooks and Brooks (1993). Taylor, Fraser and Fisher (1997) discuss the use of the Constructivist Learning Environment

Survey (CLES) to help teachers assess the extent to which their classrooms are conducive to students' knowledge construction.

The Constructivist Learning Environment Survey (CLES) was designed to enable teachers to monitor the development of constructivist approaches to teaching and learning science and mathematics (Taylor, Fraser, & Fisher, 1997). The viability of the CLES was examined through a number of small-scale and large-scale studies (Taylor et al., 1997). The CLES applied in the classroom consisted of 25 items, organised into five scales: personal relevance, uncertainty, critical voice, shared control and student negotiation. Personal relevance focuses on how much students' everyday experience is related to the mathematics classroom. Uncertainty assesses the extent to which students are given an opportunity to experience mathematics as a result of humans' work and a cultural setting. A critical voice gives the students an opportunity to question teachers' strategies. Shared control means students have the power to decide what strategies and activities will be used in classrooms. Student negotiation focuses on how much students have an opportunity to explain and justify to other students their ideas. Lesson planning in my classroom was guided by the CLES scales.

It is important to understand that constructivism introduces the assumptions as personal creation of knowledge, responsibility for the created constructs, critical thinking and reflection on the decision. While these skills may be desirable in a western setting, they may not be a part of every socio-cultural context.

The aspects of Arabic culture and its possible impacts on teaching and learning need to be taken into account in order to consider the applicability of constructivist strategies in an Arabic classroom. Hofstede (2011) defines a culture as the collective values, beliefs and behaviours that distinguish the members of one group or category of people from others. Generally, it is used to describe ethnic groups or nations. Arabs are people who speak the Arabic language and mostly live in the Middle East. The majority of the Arabs are Muslims (more than 95%), and Islam has a significant impact on social values. Some facets of the culture, like the influence of Islam, are rooted in the Arabic tradition. In contrast, it is important to note that some aspects of Arabs' lives changed in the last century due to Western influence and are present to various degrees across the Middle East. The discovery of oil and gas 60 years ago was a major factor in the economic development of the Gulf countries, and subsequent rapid modernisation. In 2006, the year we arrived to Qatar, there were no traffic lights. By the time we left, 8 years

later, a modern road system which had been constantly maintained and expanded, was in place. During that time, the skyline of the city changed immensely, from a few buildings to over 40 skyscrapers. Not all things coming from the west are accepted with open arms and people could be wary of them. Sometimes it felt weird living in Qatar. For some things time has stopped; you see people covered in the traditional clothes in the malls and parks. Many aspects of the society are very traditional and strict. However, in recent years things have been changing drastically. To indicate fast technological development, Arabic does not have special words for technology terms like telephone, computer and so on. It uses English words. From one side people enjoy modern life and the convenience of the new technology. On the other side, traditional and cultural values are still firmly in place. The first national poll in Qatar in which women were also candidates was in 1999 (Anoushiravan, 1999), and it is only over the last decade that women going out to work became commonplace. Doha, the capital city of Qatar, will host the FIFA World Cup in 2022. Similar changes have been happening in all Gulf countries to a certain extent. The escalation of English in the Arab world is such that in many Middle East countries, the language of instruction in many schools is English, and Arabic has been relegated to the second status. With the exception of Syria, in higher education, science, engineering, medicine and business courses have been taught in English (Zughoul, 2003). As a consequence, many children do not have a mother language in the true sense of the word; they have two second languages, Arabic and English. Aspects like these are likely to have an impact on any implementation of the constructivist environment in an Arabic cultural context. Are these liberal changes coming too fast?

Culturally responsive pedagogy is about respect and an understanding of differences. In an educational setting culture could be regarded as a complete experience for each student. If the classroom strategies employed in my classroom were to be culturally appropriate they needed to be mindful of the students' culture.

Perso (2012) describes various stages of understanding and appropriating others' cultures. A half century ago, an emerging focus in education was cultural awareness that focused on understanding the differences in cultural groups. Later, it grew into cultural sensitivity that refused to make any judgements against differences. Recently, the attention shifted to cultural competency which seeks understanding and effective communication in different cultural settings. The difference in the various stages is based on awareness on one's own values and beliefs, and valuing diversity (Perso, 2012). Teachers have responsibility to understand the

point of view of students with a diverse ethnic background, and be able to teach within a different cultural context.

Culturally responsive teaching takes into account the student's cultural background to create a caring and appropriate learning environment. The teachers' role is to help students construct their knowledge and achieve academic success, and to preserve their cultural identity (Gay, 2002; Ladson-Billings, 1995). Ideas that underpin the culturally relevant pedagogy could be summarised in the following five themes: reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice and classroom practices (Gay, 2002; Ladson-Billings, 1995; Villegas & Lucas, 2002).

The constructivist theory, the aspects of Arabic culture and culturally appropriate teaching will be further explored in Chapter two - Literature Review.

1.3 Background of the problem

Constructivist theory had a significant impact on education and has been applied to a great degree in many countries around the world. Some studies suggest that constructivist strategies are superior in relation to traditional styles (Wooten, 1999). For example, results across 138 analysed studies suggest that inquiry-based strategies that emphasise students' active participation are more effective than more passive practices (Minner, Levy, & Century, 2010). Much of constructivist research and implementation have been conducted in the western world. For example, in England, constructivist notions such as students' existing ideas and the real life examples were integrated into official documents of the *Secondary National Strategy,* organised by the Government Ministry of Education. It must be said that in England, successive governments have brought their own changes in education. In Australia constructivism is prevalent across state and territory education systems and there is some evidence that approaches such as inquiry-based and student-directed learning are privileged by the Australian Curriculum (Australian Government Department of Education, 2014).

On the other hand, according to Kirschner, Sweller and Clark (2006), minimally guided instructions and inquiry-based learning, as suggested by constructivism, failed to create an effective learning environment. Mayer (2004) argues that past research indicates that

constructivism is 'a formula for disaster' (p. 17) and its practices have not produced effective learning. Mathematics, particularly, has been seen as the area where direct instruction is preferable, and rote learning and memorisation are vital (Donnelly, 2007).

There have been some researchers arguing for the implementation of constructivism in mathematics and science education in non-western countries, including those in the Middle East. A study in Iran investigated the effect of constructivist teaching on students' academic achievement in mathematics, among 364 high school girl students. The results indicated that constructivist teaching affected knowledge, understanding, application, analysis, combination, and evaluation in a positive manner (Aydisheh & Gharibi, 2015). A study in Malaysia investigated the effects of the student-centred learning in mathematics on learning skills among pre-university students and teachers. Results showed that the learning skills were demonstrated through students' interaction and better planning of the lesson (Zain, Rasidi, & Abidin, 2012). In Turkey, the mathematics curriculum, primary and secondary, were redeveloped on the basis of constructivist teaching. The results of a study evaluating the mathematics curriculum indicate that the change was positive and the curriculum generally met the expectations of a constructivist curriculum (Sahin, 2010). Another study involving first-year secondary mathematics pre-service teachers showed that the students in the constructivist learning environment had better retention of the mathematical concepts than those taught by traditional lecturing (Narli, 2011). A study examining Turkish and German mathematics teachers' and their students' values, suggests that primary and secondary mathematics teachers in Turkey and Germany incorporated constructivist approaches into their practices (Dede, 2015). A research on the effectiveness of mathematics games on students' attitudes and the learning environment that was conducted in the United Arab Emirates, indicated that classes involved in mathematics games perceived their experience as having a greater personal relevance (Afari, 2012). A study conducted in a chemistry course at a higher education institution in Qatar, provided some evidence of the implementation of western pedagogical practices in a high-context culture. The results indicated the positive effects of the Process Oriented Guided Inquiry Learning (which was informed by social constructivism), and students' easy adaptation to it (Qureshi, Vishnumolakala, Southam, & Treagust, 2016).

In contrast, a study conducted in Botswana found out that primary school teachers were not inclined to use constructivist approaches in the teaching and learning of mathematics, which is likely a result of the examination-driven curriculum and the large student to teacher ratio

(Major & Mangope, 2012). Similarly, a study including mathematics teachers and pre-service teachers in Riyadh, Saudi Arabia, suggests that the teachers have limited understanding of constructivism practices, prefer a silent classroom and do not feel confident in a classroom where students' prior knowledge is taken into account and built on (Alsharif, 2014).

Traditionally, mathematics is seen as the most absolute subject, and somehow, many parents (and teachers) think that traditional ways of transmitting knowledge via lecturing work the best. In my experience, people find it hard to acknowledge mathematics' fallible nature and believe that one of my roles as a teacher is to explicitly tell students what kind of procedures and solutions are correct. Mathematics was always going to be the most difficult subject within which to implement changes. Specifically, in the Arab countries in the past, traditional teaching styles were emphasised, with the lesson's content and delivery considered the most important aspects of the classroom, and rote learning seen as a main learning strategy (Brewer, Goldman, Augustine, Zellman, Ryan, Stasz, & Constant, 2006; Najm, 2015).

As mentioned earlier, constructivism symbolizes the new modern thinking against the old dogmatic ways of representing nature and science, which is a characteristic of emancipation, common in the Western world. Further, constructivism is enriched with a critical side. One can claim that constructivism, with its logical and critical facets, is a western construct. Constructivism, as such, with its western roots, may not be easily accepted in the Arab culture, especially in the context of the mathematics classroom. Possibly, people in the Middle East could be apprehensive of educational ideas coming from the west. I consider myself as a partially western person, and I do not want to adopt all western values. Not all western standards are easily accepted by me; they have to pass my personal and cultural test before they are appropriated in my life. A study in Saudi Arabia reported that the current higher education system is heavily based on rote learning and the transmission of knowledge, and students' overdependence on the teacher, the authority figure, and their inability to question his or her answers (Hamdan, 2014). Many women still have a limited access to university education as their role is still based on conservative and religious cultural practices (Hamdan, 2014). While some studies suggest that constructivist strategies may be suitable in education in non-western countries, with their considerations of students' background, they need to be examined for their cultural appropriateness (Baker & Taylor, 1995).

The research aims and questions were shaped by these issues regarding the appropriateness of constructivism in my teaching context, an Arabic mathematics classroom.

1.4 Purpose of the study and research questions

The main goal of the study was to investigate the implementation of a constructivist learning environment in a Year 7 boys' class in an international school in Qatar where most of the students are of Arabic origin. The specific aims of the study were:

1. To determine the effectiveness of the implementation of the constructivist learning environment.
2. To evaluate the students' reaction to the constructivist learning environment.
3. To determine the cultural appropriateness of the constructivist learning environment in a boys' Arabic mathematics class.

Research questions:

1. How effective was the implementation of the constructivist learning environment?
2. How did the students respond to the constructivist learning environment?
3. How culturally appropriate was the constructivist learning environment in a boys' Arabic classroom?

The effectiveness of the implementation of the constructivist learning environment was examined in terms of the accomplishment of putting the constructivist ideas into practice. It was analysed through my reflections and the students' responses to the CLES and the environment.

1.5 Overview of the methodology

The strategy adopted in this study is the participation observer strategy. I tried to generate a comprehensive description of the classroom environment and the students' reaction to it. I used both qualitative and quantitative data for this study. The qualitative data came from observations, from the students' and my journals, from mathematical and non-mathematical

tasks and interviews, and these were presented using a writing inquiry. Quantitative data came from the CLES.

I addressed the questions by observing my class, and particularly focusing on three students, Adil, Nazir and Max. My interpretations of the students' actions were examined within the smaller context of the classroom and wider context of the Arabic culture.

- The effectiveness of the implementation of the constructivist learning environment was assessed using the CLES. Additionally, the stories were examined for the evidence of the implementation of the constructivist learning environment aspects - personal relevance, uncertainty, critical voice, shared control and negotiation.
- To investigate the students' responses to the constructivist learning environment, the stories were examined for the indication of students' reactions to the CLES scales.
- To investigate the cultural appropriateness of the created environment in my classroom, it was examined for the features of culturally appropriate teaching - reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice and classroom practices. Additionally, the conflicts between the aspects of Arabic culture and my interpretation of the constructivist classroom were explored.

I want to draw the readers' attention to the language I am partially using in writing this introduction, and the rest of the thesis. In this doctoral study I found myself reverting to different means to express myself than I have previously used to do in my academic writing. In my former courses the language required was precise. With mathematics you have to find a right way to communicate, to get to the point. In this thesis, getting to the point became a complicated task. My writing lost its technicality and gained a casual confessional tone. Detailed research designs and my reasons for embracing various writing styles are further explored in Chapter two.

1.6 Significance of the study

This research is important as there is not much research conducted on the cultural effect on the implementation of the constructivist learning environment in mathematics classroom in Arabic countries. The study can benefit teachers wishing to establish the constructivist learning

environment in an Arabic classroom, and help them produce teaching practices that can influence students' learning and view about mathematics.

The study is likely to provide some insight on the use of the CLES when assessing a classroom in an Arabic socio-cultural setting.

1.7 Overview of the thesis

Chapter two provides a review of literature relevant to this study and includes constructivism and its forms, aspects of Arabic culture and culturally relevant teaching. Chapter three describes the methodology employed in this study and introduces the setting and participants. In Chapter four classroom stories are presented. In Chapters five, six and seven the results and analysis were presented while Chapter eight summarises and discusses the findings of the research, implications, limitations and suggestions for further research.

Chapter 2: Literature Review

This study describes the implementation of a constructivist learning environment in mathematics high school classes where the majority of students were English as Second Language Learners of Arabic origin.

This chapter reviews the literature that influenced the study. This review represents my interpretation of some work of the field that contributed to my growth as a teacher, and is supported with my reflections. I think that my explanations are extensive in most cases as I want to communicate with the reader how my understanding of mathematics and its teaching has evolved. This section after all provides the background of what, in my opinion, the nature of teaching and learning should be, and why I created the classroom environment the way I did. It has five main parts: constructivist forms, constructivist teaching and learning, the Constructivist Learning Environment Survey (CLES), cultural characteristics of Arab people and culturally relevant teaching.

2.1 Constructivism and its forms

2.1.1 Introduction

Constructivism is a broad term; there are many facets to it. One builds his or her own interpretation of it. In this section I try to paint facets of constructivism which influenced my way of thinking, teaching and learning.

I briefly explain positivism at the beginning of the chapter as it influenced my development in the past; most of my formal schooling was delivered using an objectivist approach. The next part is on radical constructivism and discusses the ways it accounts for the process of learning. It proposes that a pupil is an active participant of his or her learning process, and that new concepts have to fit with the previous experiences. Shortcomings of radical constructivism as a referent for teaching include the lack of accountability for social process, ethical guidance, and the lack of practical implication. As an answer for the limitations of radical constructivism the following facets are introduced: social constructivism and critical constructivism. The three facets, radical constructivism, social constructivism and critical constructivism account for the

scales of the Constructivist Learning Environment Survey (CLES): personal relevance, uncertainty, negotiation, shared control, critical voice and negotiation, used in this study.

2.1.2 Positivism - traditional approach

For centuries nature (and mathematics) has been seen through the realist eyes. The traditional approach proposes that reality is of an objective nature and exists independently of anyone to observe it. Knowledge and truth about reality are objective and not subject to change. Consequently, mathematical knowledge consists of certain and unchallengeable truths. The goal of science and mathematics is finding out that truth. Such rigid and firm views call for equally rigid and firm methods for finding out the external truth. Accordingly, reality is experienced through senses and with precise and accurate measures the truth can be extracted from the world. Using inductive logic people are able to find patterns and formulas that mirror reality. Mathematical axioms are assumed to be true and logical rules that preserve truth, and they allow nothing but truths to be deducted from truth (Ernest, 1991). If the patterns are not immediately visible to us it could be due to false measurements or an inability to control variables (Anderson, 1998).

My formal schooling has mostly been influenced by traditional approaches. Even history, generally not seen as an 'exact science' was concerned with discovering the external and precise truth, despite acknowledging various discussions and opinions, and describes the truth as ideal (Perovic & Smiljevic, 1989).

It does not necessarily mean that I always applied traditional ways of learning especially in the subjects that mattered to me; however, I cannot deny the traditional methods have been a significant part of my (academic) life. Those methods certainly influenced me and my development as a student and teacher; although, the focus of my study was a non-traditional way of teaching and learning.

2.1.3 Radical constructivism

When I undertook the unit on constructivism during this doctoral program I found it challenging; I found myself reading and rereading, writing and rewriting, scrutinising every

word and trying to represent the theory in a personally accessible way. The more I created pictures about radical constructivism, the more I was drawn into it. This section describes radical constructivism and its main characteristics. Some critiques of radical constructivism are discussed and implications in (my) teaching are explored.

In ancient Greece, Xenophanes, a philosopher and poet, questioned the existence of the real truth as it would call for comparing new knowledge with something already considered to be the real truth. In the 18th century Vico portrayed knowledge as humans' personal constructs, and more recently Piaget based some of his work on the constructivist ideas (von Glasersfeld, 1995). Ernest von Glasersfeld made the greatest contribution to radical constructivism in modern form. Some regard radical constructivism as an epistemological perspective in philosophy. On the other side many see it as a learning theory. Von Glasersfeld (1995) brands radical constructivism as post epistemological or postmodern, as it is not concerned with ontological issues and the existence of reality; its only concern is how learners get to know. Regardless of the stance one takes, radical constructivism is defined by the following propositions:

1) Knowledge is not passively received but it is actively built by the cognising subject.
2) The function of cognition is adaptive and cognition serves the subject's organisation of the experiential world (von Glasersfeld, 1995, p.18).

The first proposition states that knowledge cannot be received through our senses nor communicated to us via language (von Glasersfeld, 1995). The learner actively constructs his or her knowledge, not by passively observing and recording data. Some other paradigms acknowledge this proposition: trivial constructivism, sociocultural cognition, social constructivism and social constructionism (Ernest, 1995).

The second proposition is more controversial. Radical constructivism replaced the notion of truth with the notion of viability. Truth cannot be true in itself but with respect to some given context (Quale, 2008). The world is experienced in a subjective and personal manner and the concepts and explanations one constructs build his or her experiential world. New constructions must fit with the previously built constructions from the experiential world or the experiential world needs to be reorganised in order to accommodate them. More than one viable explanation may be created and what one chooses to be a better solution is based on his or her

personal criteria at the specific time. The individual organises his or her knowledge to better adapt to the world.

Critical considerations of radical constructivism

There have been some critical responses to radical constructivism. In this section I briefly discuss some critics of radical constructivism: philosophical considerations of radical constructivism, its (perceived) lack of social influence on one's construction of the world, the lack of ethical guidance for recognising a suitable knowledge and the lack of practical implications.

Philosophical considerations

Scerri (2003) claims that basic constructivist philosophical positions could be seen as antiscientific. The subjectivity of knowledge implies that people are free to create any construct they want and all knowledge is equally true. Critics argue that it suggests that the students' constructions should be acknowledged for their educational value and given the same status as the scientific ones, which attaches a relativist label to constructivism (Mathews, 2002; Scerri, 2003). Taber (2009) argues that the constructivist literature does not suggest that students' constructs are seen 'as scientifically important, but rather as pedagogically significant' (p. 166). By valuing students' ideas, I acknowledge that there are reasons why they created such constructs and they have their own epistemological and applicational value. I acknowledge that that they went through a process of choosing and evaluating information to arrive at such conclusions.

Radical constructivism has been fairly popular in some fields, but some believe that it has run its course as it has not established itself as a paradigm; although, it has been called a progressive programme (Taber, 2009). According to Riegler (2015), in order for radical constructivism to be a part of the future researches, it needs to step away from the question about philosophical acceptance and instead focus on showing its usefulness in various disciplines. He believes that educational science has already proven to be fertile in that field.

Social considerations

An individual constructs his or her knowledge by organising his or her experiential world, all with the goal to adapt to the world. One's experiential world is the organisation of his or her constructs, experiences, interpretations of others' actions, and reflections (Quale, 2008). As radical constructivism emphasises the individuality and subjectivity of personal constructs, critics claim that radical constructivism undermines the social component of constructing knowledge (Solomon, 1987). Von Glasersfeld (1989) states that social interaction is the most frequent reason of perturbation. Through interaction with others, people attach certain meanings to particular words and have an expectation that the others will do the same (Quale, 2008). Based on their constructs people make predictions about others and the way they would behave in certain situations. If they behave as expected and no unexpected action is taken by others then we conclude that others have the same (compatible) viable constructions as we have and those will have the second order viability (von Glasersfeld, 1995). Some intersubjective level is achieved and we come to believe that the second order constructs are somehow more 'objective' than our other constructs. Sharing knowledge does not mean that two people have created identical meanings; they rather have compatible meanings. On the contrary, to clarify the point, all of us have been in situations when we think that we have perfectly understood others (i.e. we created compatible meanings) only later to realise that we are not exactly 'on the same wave length' (Quale, 2008, p. 244). Hence, radical constructivism identifies the social factor of constructing knowledge.

The social aspect of learning will be further explored in the later part of the thesis while discussing social constructivism.

Ethical considerations

Radical constructivism bases its theory on viability; the construction that survives is one of the best fit. How could one such theory be a referent for teaching? On the other hand, objectivism offers the absolute truth and as such it stands for moral values. Radical constructivism does not offer an ethical basis for identifying an appropriate knowledge. On the contrary, the term 'survival of the strongest' may even have undesired effect, as it carries only subjective and individual benefits (Hardy & Taylor, 1997).

In the classroom, distorted communication attaches greater value to the mathematical knowledge which 'reflects absolute truth' rather than to social interaction between students and teachers. It preserves a dominant place of the teacher over students and the reproduction of social norms. Stears (2009) states that the employment of social and critical constructivist principles in a science classroom allows for the personal needs of learners to be met allowing them to function better in society. Proponents of critical pedagogy claim that teaching and learning should involve not only knowledge required by the curriculum but the wider forms of education in the culture, for example, bodies of knowledge produced by marginalised groups, the process of racism, cultural biases and the forces that shape curriculum. Critical pedagogy aims to help teachers to empower their students (Kincheloe, 2008). Hardy and Taylor (1997) suggest extending radical constructivism with a moral dimension by joining it with Habermas's theory that suggests an ethical approach to the social construction of knowledge.

Habermas's theory is helpful as it works towards the deconstruction of systematic distortion and offers an opportunity for students and teachers to analyse their roles. Cobb (1994) proposes a classroom where students and teachers make sense of the mathematical concepts through discussions and debates where their learning becomes the subject of a critical appraisal and negotiation.

The critics regarding ethical considerations include treatment of the traditional ecological knowledge. Taber (2009) describes traditional ecological knowledge (TEK) as knowledge regarding sustainability of local resources and is developed by local population that has lived in the same part of the world for generations. Bowers (2007) argues that constructivist approaches neglect TEK. While Taber (2009) acknowledges these concerns, he claims the reasons lay in the structure of the formal science schooling and its inability to accommodate TEK, rather than in constructivism.

This aspect of learning will be further explained in the later part of the thesis while discussing critical constructivism.

The lack of practical implication

A major criticism of radical constructivism is that the research is more valuable from theoretical and philosophical perspective, rather than practical, and that it does not offer a specific guide to teaching (Solomon, 1987). Solomon (1994) argues that it still not clear what is meant by constructivist teaching. Mathews (2002) is more specific and aims his criticism at discovery learning; he equates this strategy with unguided discovery. Bowers (2007) claims that constructivist teachers believe that they are not to influence and obstruct the student's learning and construction of knowledge. I am not sure if this approach is even feasible; it would be very difficult not to have any influence on the students' learning.

It is a mistake to interpret the constructivist view as pure discovery learning without any guidance. Learners differ with their starting points and how far they can reach with their understanding. It is the teacher's responsibility to find ways to help students connect to the relevant knowledge using demonstrations, models, analogies, questioning or hints for example, and this is how the teacher provides guidance and support in the construction of knowledge. Taber (2009) points out that being a constructivist teacher does not mean not being able to explain, illustrate or demonstrate, but rather trying to guide teachers in understanding students' learning difficulties and selecting a more productive teaching strategy.

Taber (2009) argues that the impact of constructivism in teaching and learning has been influential despite the claims of the lack of a practical guide. As a specific example where the constructivist approaches have been adopted in an educational context, he talks about the English National Curriculum. Through the *Secondary National Strategy*, the Government Ministry of Education delivered professional programmes aimed at improving standards. Constructivist ideas such as students' existing ideas and everyday life experiences were integrated into official documents. While England has seemingly made a step forward by formally acknowledging constructivist strategies, in my opinion, constructivist guidance cannot be introduced in such an abrupt way. By trying to take full control over teachers' professional development and the way they approach lesson preparation, education fell in the same traditional trap. One does not start thinking in a constructivist way and implementing constructivist strategies after a weekend course. An instruction booklet and a short training course will not change schooling. Many theorists regard constructivism as a referent which may help maximise learning in any circumstances (Tobin & Tippins, 1993). For example,

classrooms where the students are organised in small groups may be regarded as more productive than traditional lecturing; however; constructivism could be used as a referent to optimise learning during lecturing.

Classroom implications of radical constructivism

The following sections discuss some implications of radical constructivism for (my) teaching and learning. The concept of learning, uncertainty of mathematics and personal constructs are discussed.

Learning

Von Glasersfeld (1995) bases his concept of learning on his interpretation of Piaget's work. His explanation of the learning process accounts for the cognitive conflict strategies and justifies the persistence of pupil's constructs (Hardy & Taylor, 1997). When experiencing new material one tries to recognise something known. The learner compares familiar aspects of new material with some previous experiences and creates the concept of equivalence between them (von Glasersfeld, 1995). Experiences are assimilated based on their familiar characteristics; their other characteristics are not perceived at that time. Assimilation reduces the experience to already existing structures and it does not represent learning (von Glasersfeld, 1995). However, if an unexpected result occurs, a perturbation arises and the accommodation cycle begins. The learner reviews and re-represents the experience and tries to resolve the perturbance. Characteristics, previously neglected by assimilation, are revisited and the learner tries to see what was unique and different about the experience. A reconstruction of the experiential world is made to account for newly revealed characteristics. Once an explanation is constructed, the perturbation is neutralised and the equilibrium is established. According to von Glasersfeld (1995), this is how radical constructivism accounts for the learning process and cognitive conflict based teaching strategies. On a more personal note, the radical constructivism notion of learning appeared to account for my process of organising my thoughts and knowledge when solving mathematical problems. The notes from my journal taken when I was faced with the dilemma should I help my students and how much when solving problems somehow reflect von Glasersfeld's process of learning (p. 108). While

rereading my journal it appeared that I was just going through the learning process as described by radical constructivism. It loosely matched learning or at least I saw it that way. In addition, radical constructivism accounts for the process I was going through while learning about it; I was rereading, rewriting, remembering various stories from life, and trying to explain it through my past teaching and learning experiences. For me, radical constructivism acts as verification for the process I am going through, and this is the justification I need, that it fits my personal requirements; it reflects my way of thinking and learning.

Uncertainty

The main characteristic of radical constructivism is its respect for personal experience (Ernest, 1995), which may help uncovering the traditional myth about absolute certainty in mathematics. Numerous teachers agree that many students will not necessarily learn through traditional lecturing and it is not possible to transfer ideas into students' heads (Treagust, Duit, & Fraser, 1996). There has been a rise in student-centred classrooms. However, traditional views and the understanding that mathematics portrays an absolute truth still constrain mathematics and science classrooms. Consequently, students' opinion may not be taken into account which is the central idea of radical constructivism. Many teachers believe that if they provide a suitable environment and create a classroom with relevant conditions and activities, students should arrive at the scientifically and mathematically accepted knowledge. Never mind that in the past, decades or centuries were needed to create the same concept. It is not always the case that only a formal deductive proof warrants the correctness of a mathematical problem and the certainty of mathematics. Even published work can have mathematical mistakes, as it is checked by humans who can make errors. The four colour theorem (no more than four colours are required to colour the regions of the map so that no two adjacent regions have the same colour) can be proved using a computer which represents humanly uncheckable proof (Ernest, 1991). Taylor and Hardy (1997) suggest that providing teachers with understanding of the historical development of mathematical ideas may help. Ernest (1991) claims that it is necessary for teachers to be aware of ontological and epistemological views of mathematics in order to be able to implement radical constructivism in their classroom.

Personal constructs

One of the main implications of radical constructivism in the classroom is respect for the students' background and his or her previous constructs. Driver et al. raise awareness of unique personal preconceptions in teaching and implementing curriculum (1994). Ernest (1995) acknowledges that learning occurs from personal experiences and reflection on interpretations of others' activities. Consequently, they support the use of manipulatives in the mathematics classroom. Additionally, they acknowledge the existence of folk mathematics and claim that folk mathematics as activity personally meaningful to the learner can be an appropriate classroom task. Von Glasersfeld (2007) argues that mathematical concepts could be described through the real life experiences. For example, instead of defining a point as an element without depth, width and length, it could be represented as 'the centre of the area in the focus of our attention' (von Glasersfeld, 2007, p. 216).

Radical constructivism offers a justification for personal relevance and uncertainty scales of the CLES. Additional implications of radical constructivism in the mathematics classroom will be further explored while discussing the implementation of the CLES.

2.1.4 Social constructivism and its classroom implications

Radical constructivism's influence in education has risen as it successfully explained the cognitive processes. Radical constructivism's explanation of learning has been criticised as it does not fully account for the social aspects. Language, culture and interactions with others are all part of the social domain (Ernest, 1995). This section describes social constructivism, its approaches and implication in teaching.

All forms of social constructivism share the notion that learning is affected by the social domains. The cognising subject constructs his or her meaning as a response to it (Ernest, 1995). Many theorists (Cobb, 1994; Driver et al., 1994) adopt a framework where personal constructs of meaning and social interactions complement each other. Knowledge is personally constructed but socially negotiated and cognitive activities are constrained by social processes. Constructs are personal; however, they depend on what the environment serves it with. Therefore, knowing is both individual and social; they are in a symbiotic relationship. This

complementary view is used as a basis to account for cultural items, such as mathematics (Ernest, 1995).

Enculturation is the introduction of the novices into a particular cultural group. Mathematics (and science) is a part of wider cultural setting and its education should be done in terms of an enculturated perspective (Aikenhead, 1996). Learning occurs when a novice to the community is supported by an experienced member; the teacher's role is to provide the access to appropriate models of mathematics (science) and to help make sense of the mathematics (scientific) tools (Driver et al., 1994).

Driver et al. (1994) emphasise the symbolic nature of science and its socially negotiated nature. Cultural tools of mathematics include concepts, investigations, theorems and symbols. Moreover, they include the use and creation of instruments, logical and creative ways of thinking, preciseness and elegancy of solutions and the scrutiny and the beauty of mathematics. Additionally, it includes personal happiness and satisfaction of an achieved goal and social negotiation. Once the constructs are discussed and validated within the mathematics community they become officially a part of mathematics. The mathematics community has a role to help students make personal sense of constructs. One has to keep in mind that this rigorous process is not 'bullet proof', and the constructs are still human and fallible. It is enough to have a look at the Newtonian theory and the Einstein theory. The first is failing where the second one is succeeding, and yet it does not stop us from using both theories where appropriate.

One gets to know mathematics through its activities. Therefore, teaching mathematics does not involve teaching the structures that represent the world but activities which mathematics enables us to do: developing thinking and reflective skills. Classrooms are to be organised to allow collaborative learning which helps students learn not only concepts but values of the scientific (mathematical) community (Driver et al., 1994).

A teacher should understand that a student may have ideas not compatible with mathematically accepted theories. A constructivist teacher needs to be willing to listen to any ideas and understand that these ideas fit with the students' framework and are internally validated. Confrey (1990) suggests a (gentle) reconstruction of these ideas.

A powerful construct should have an internal consistency and be compatible with the other student's constructs. It should have multiple use and representations. Students should be able to justify and explain their constructs. Confrey (1990) suggests an agreement with an expert as a characteristic of a powerful construct. I partially disagree with this point. How would we define an expert? I was faced many times with a problem when I had different opinions about the nature of a mathematical solution to my colleagues. To which expert were the students supposed to listen? Completing a degree in teaching or mathematics does not give one necessarily the status of an expert, nor is a teacher always in receipt of all mathematically accepted knowledge. Everyone has his or her own interpretation of mathematically accepted knowledge. An informative communication with the teacher (expert?) could be qualified as an agreement with an expert. Let us not forget that a teacher can learn from a conversation with a student. If the student's constructs are not mathematically accepted the teacher should build a path which is to a certain extent compatible with both the mathematically accepted view and the student's view.

The teacher as a representative of mathematical society has an obligation to make useful knowledge accessible to students and the classroom activities should be organised so that students learn currently accepted knowledge in the mathematics field. Tobin and Tippins (1993) suggest a number of ways that may help to optimise learning. The teacher may support the students' learning so it is built in a direction difficult to achieve without him/her. The students should be given an opportunity to express their knowledge in a variety of ways: discussing, writing, drawing and acting.

Social constructivism offers an explanation for the negotiation and uncertainty scales of the CLES. Further discussion of the implementation of the scales is presented in the next chapter while discussing the implementation of the CLES.

2.1.5 Critical constructivism and its classroom implications

So far I have presented radical constructivism and social constructivism and their influence on teaching and learning. Radical constructivism and social constructivism do not offer any ethical and moral guidance for teachers looking to reform their classrooms. On the contrary, radical constructivism's notion of the 'best fit' in terms of personal usefulness may promote a

classroom where all different constructions are 'fighting' each other (Quale, 2008). What teachers do in their classrooms is not supposed to be only about the 'technical' side of mathematics, i.e. students knowing their 'sums'; they are changing the complete image of the mathematics classroom: the 'sums', the way it is perceived and verified, the way it is communicated, its applications and responsibilities.

Formal schooling in the USA frequently defines the concept of what it means to be educated in the terms of upper class white culture, pushing students to sever ties with their backgrounds (Steinberg & Kincheloe, 2010). Critical pedagogy is drawing on practices generated within a local community rather than on the knowledge of those in power. By focusing on critical empowerment and using activities that reflect a multicultural shift around the world and authoritarian positions, teachers are in position to address the issues such as stereotyping and oppressive practices within school (Miskovic & Hoop, 2006). Critical pedagogy has been inspired by various sources such as feminist theory, critical theory and neo-Marxist cultural criticism (Miskovic & Hoop, 2006). Culturally relevant education has a strong critical constructivist incline and enables teachers to better facilitate change in their classrooms. Many researchers identify critical thinking and social justice as one of main components of culturally appropriate classroom (Brown-Jeffy & Cooper, 2011; Ladson-Billings, 1995; Perso, 2012; Villegas & Lucas, 2002). Culturally relevant education will be discussed later in this chapter.

Critical constructivism is concerned with changing socio-cultural aspects of classroom. The goal is to create a classroom where students explain, justify and negotiate mathematical meanings and critically reflect on their decisions. The socio-cultural structure of the classroom is affected by powerful ideologies which disempower teachers and students and may obstruct even reform minded educators (Kincheloe, 2008; Taylor, 1996; Taylor & Campbell-Williams, 1993). For example, Kincheloe (2008) talks about the myth of Eurocentrism, that prioritises European views and beliefs. This section discusses the interests which govern the creation of human knowledge. Some implications of critical constructivism for teaching and learning are discussed at the end of this section.

Habermas (1974) identifies three interests in the human society: technical interests, practical interests and emancipatory interests.

The *technical interests* manifest in curriculum through hard control, by setting predetermined objectives in a strongly controlled environment. The democracy we live in could be deceptive.

Some constructions of reality are legitimated by the governing culture and others are oppressed. Power ways in culture are naturalised and teachers deliver the predetermined knowledge of dominant culture (Kincheloe, 2008). Students are not able to question the teacher's activities and the nature of curriculum and its effect in their lives (Kincheloe, 2008; Taylor & Campbell-Williams, 1993). Students do not have power to determine the path of their teaching learning and are more valued as passive learners who do not question explanations and authority.

Similarly, teachers are caught up in the rigid structure where they are accountable to school, parents and students, and do not have power (or time) to change their classrooms. The myth of hard control prioritises the delivery of curriculum and the end of year examination and grades.

The *practical interests* are reflected in the curriculum in students' communication and interactions, the way they interpret and explain their understanding (Taylor & Campbell-Williams, 1993). All participants have an opportunity to express themselves and disclose their intentions, and in return they may inquire about other people's opinion and intentions (Habermas, 1987). For example, the classroom is affected by the cultural myths that assist with the reproduction of socially accepted norms. In education they are manifested through the myths of cold reason that support already established systems and promote authority and the truthfulness of knowledge. These myths are not visible and easily identified (Brown-Jeffy & Cooper, 2011; Taylor, 1996). Consequently, in the classroom the teacher still acts as an informer; the goal of the arriving at the correct answer is seen as a sufficient motivational goal and mental activities and creativity is frequently disregarded.

The *emancipatory interests* promote critical awareness of the myths that affect our understanding of society and our responsibility towards it. For example, the current mathematical education does not always address the issue of mathematics' role in society and its responsibility, and the emancipatory interest within classroom attempt to change that.

Some aspects of these concepts like intellectual freedom and social justice belong to the non-cognitive domain. The interpretation of these concepts is subjective and personal and one person's view is different from many other people's point of view. In today's world one is witnessing various interpretations of truth, freedom and social justice. I can promote only what I consider to be truth and freedom. I want to believe that I am equipped with enough knowledge, skills, experiences, respect, understanding, compassion to promote honesty and freedom.

Culture could be defined as the norms, values, beliefs, expectations and conventional actions of a group (Aikenhead, 1996). Students operate in many cultures and subcultures such as language, gender, ethnicity and religion, and (western) science is just one of them, and they may experience difficulties by crossing from one subculture to another (Aikenhead, 1996). Science (and mathematics) has the norms such as mathematical idealisation, empiricism, preciseness, rationality, logic and value free which are shared within the scientific (mathematics) community. Aikenhead (2000) argues that science is actually western science - the way it is taught and appropriated comes from the west - and as such is not a common part of all cultures and subcultures. Learning as enculturation is seen as a limited approach which does not take into account other students' subcultures. By treating science as common culture it has been given a privileged position in society.

Aikenhead (2000) argues that only by adopting pluralistic cultural perspectives may all students receive an appropriate education. His pluralistic view treats western science of the same importance as students' common-sense science.

There are three levels of learning:

- Shallow learning where teachers, parents or students' goal is to attain a grade and learning is selective and the focus is on formulas and rules.
- In-depth meaning-making where students are engaged in the construction of scientific knowledge and expected to accept scientific explanations as valid. The issue is the desire for all students to be enculturated into western science. Consequently, enculturation may result in assimilation and turn into shallow learning.
- Learning as cultural phenomenon, acculturation, attempts to avoid enculturation into western science by identifying western science as subculture itself. The focus is on how various cultures interpret the natural world including the western view (western science) (Aikenhead, 2000). Students become more aware of their own interpretation of the world. In the scenario where the student's home culture is compatible with the science classroom, the cultural border crossing is smooth. On the other hand, when the outside the classroom life is incompatible with western science, the border crossing could be impossible.

In my understanding, acculturation describes an ideal mathematics and science classroom. However, there is an expectation that the teacher understands the other cultures and

subcultures, and is able to identify border crossings. It places him or her in a privileged and advanced position. Additionally, students, parents, teachers and school may have different opinions about the compatibility of home cultures with western science, and consequently disagree on the teaching and learning activities. A student, becoming aware of his or her own interpretation of the world, is not a goal which may satisfy all parties.

The teacher needs to create a classroom where everyone's opinion is respected. Taylor (1996) argues that the teacher is in a position to communicate the technical nature of curriculum and assessments.

Many teachers understand mathematics as a privileged way of knowing and are reproducing that opinion in their classrooms. Even today formal schooling and university is unattainable for many students for various reasons. I felt privileged for knowing mathematics and finding it easy; it opened many doors for me. While I understood mathematics as humanly-constructed, for me it was still a beautiful form of a human construct. Things like non-Euclidean geometry or the Gödel Incompleteness theorem which revealed mathematics as unsound and weak, made it even more perfect in my eyes. Mathematics for me was a collection of games and puzzles, and as such did not really have a place in the practical world. I enjoyed proofs, refutations and counterexamples. They promoted logical thinking, and this is what I thought mathematics was about, and this is what I wanted my students to take away from my classroom. I used to insist on students having a similar opinion as me. It took me a while to change my attitude and arrive at the understanding that mathematics needs to be approachable and accessible to everyone in his or her own terms. In order to communicate this, I tried to paint various sides, especially a human, soft side, of mathematics in front of my students. I was careful to use the words create, construct and invent, as opposed to find and discover.

Critical classroom is grounded on social envision of justice and equality, concerned with the needs of those faced with oppression, concerned with well-being of students, and committed to resisting the harmful effects of dominant power and empowering students (Kincheloe, 2008; Steinberg & Kincheloe, 2010). It is not an easy job to promote mathematics as reflective and critical activity; students (and teachers) have their ideas what teaching should be about and what knowledge is. They may feel insecure and the intended teaching activities may have an opposite reaction. Caring and trustful relationships, communication and understanding each other, need to be promoted as equally as intellectual values. All involved should participate in

the construction of the ethical and social reality of the classroom. Students need to be invited to question the norms of the classroom.

The impacts of critical pedagogy in a mathematics classroom should help develop 'students' interest in uses for mathematics in their lives, finding its application that improve lives of oppressed people and produce a passion for students to know more about the subject' (Kincheloe, 2008, p. 11,). Taylor and Cobern (1998) suggest that specific cultural, moral, spiritual and aesthetic values should be incorporated into educational approaches. The mathematics classroom should promote involvement by different cultures, societies and religions. The nature of mathematical thinking should be highlighted in the classroom with emphasis on mathematical concepts over symbols (Taylor & Campbell-Williams, 1993). Many of the conventional mathematical symbols are not in use in every culture.

Critical constructivism offers a partial explanation and background for the critical voice, shared control and uncertainty scales of the CLES. Some implications for my teaching were discussed in this section. Further discussion of the implementation of the scales is presented in the next chapter while discussing the implementation of the CLES.

2.2 Constructivist teaching and learning

2.2.1 Introduction

At the beginning of this degree program I completed the unit Teaching and Learning in Science and Mathematics Education which examined the practical implication of constructivist theory in mathematics and science education. I had a chance to learn and reflect on the importance of students' prior knowledge and a range of classroom strategies. This was my first introduction to constructivism. At that stage, for me, it represented all these strategies which I was already using to some extent in my classroom. Possibly, this unit had an impact on me as I had found a formal validation and conformation for what I was doing. I embraced something that supported my point of view. I was trying to create a constructivist environment in my classroom.

2.2.2 Constructivist teaching strategies

Following from our previous discussion, constructivist teaching and learning involves 'activating relevant ideas already available to learners' (Taber, 2011, p. 55), and construction of knowledge upon their existing knowledge. Common characteristics of 'more-constructivist' methods include taking students' former knowledge into account, interactive discussions and problem-centred work (Malone & Taylor, 1993). This section gives a brief overview of the following constructivist strategies: the learning cycle model, the constructivist teaching sequence, the conceptual change model and the bridging analogies. I believe that constructivist teaching is an ongoing process of evaluating students' needs, strengths and weakness, and making an optimum decision based on that information and my pedagogical and mathematical background. The following strategies and models have helped in creating some of the activities which were used in the classroom.

The *constructivist teaching sequence* attempts to take into account students' preconceptions. It is similar to the learning cycle model; however, emphasis is on the exploring and contrasting students' ideas. First, students investigate and discuss a phenomenon. Then, based on their ideas, they go through the process of theory making by using approaches such as guess-and-check or creating a table or drawing diagrams. The learners are given the chance to explain their theory, and question other students' theories. The teacher (may) introduce a mathematical explanation as an alternate theory. He or she tries to consider the students' theories in order to find activities to restructure students' ideas (Driver & Scott, 1996; Duit & Confrey, 1996). My interpretation of the constructivist teaching sequence could be seen on the example of linear relationships (p.118). Students first investigated and discussed a tile pattern problem in small group, followed by theory making. The groups got the chance to do their presentation on the whiteboard, when we scrutinised their solution. I did not get a chance to explain the problem in my way; the class decided on the best answer. Further, I was able to identify some points for further discussions.

The *learning cycle model* has been designed to improve conceptual change. It includes three phases: exploration, term introduction and concept application. First students investigate new ideas and discuss their findings (exploration). Then, the teacher connects mathematical ideas to the main term (term introduction). Finally, the students apply their understanding in further examples where they have a chance to gain a different perspective on the concept studied (Duit

& Confrey, 1996). A version of the learning cycle model, the 5E model, leads students through five phases: engage, explore, explain, elaborate, and evaluate (Duran, Duran, Hane, & Scheuemann, 2011). In my class, over the period of three lessons, we reintroduced linear relationships using this model. In the first lesson, students were given some real life situations and asked to represent them in a variety of ways (graph, table, and rule). Then, they discussed their observations (they came up with more or less similar concepts: starting point, point on y-axis, how much, amount for up, term patterns and so on). After a short discussion on how we would name these characteristics I told them that someone (un)fortunately created the names that are used in mathematics in many countries across the world: the y-intercept and the gradient. While they did not have a problem with the y-intercept, the term gradient sounded a bit abstract and some students carried on using our informal names (i.e., amount for up or down).

In the third lesson, they created questions where one form of representation was given (i.e., create a situation, table and rule when the graph is given). Additionally, during the year, they used their understanding of the concept to make connection with patterns and sequences.

The *bridging analogy model* is a strategy that starts with the students' understanding of a phenomenon that is (partially) true. Then, a bridge is facilitated between existing ideas and mathematically accepted ideas (Duit & Confrey, 1996). The analogies can be divided into the groups (Richland, Holyoak, & Stigler, 2004):

i) Analogies not related to mathematics. In Year 7 classes we used balancing scales to explain the solving of linear equations.

ii) Analogies related to mathematics. When expanding single brackets in my classes we first recalled the learners' mental strategies for multiplying a single-digit number by a two-digit number. For example, let us consider 7×13. Many students in my class did this as 70+21 (i.e., 7×10 + 7×3), or 77 + 14 (7×11 + 7×2).

Duit and Confrey (1996) note that the benefits of bridging analogies include using prior understanding as a starting point. It gives the students familiarity at the beginning. It does not ask them to give up their ideas, so the new concept seems less abstract. Empirical studies on the use of analogies suggest that the most determining factors contributing to the success of the analogy were: how it was presented, its context and how much students were involved in

mapping the analogical relations, and that the effectiveness of analogy should be measured in terms of generating engagement and meaningful discussion (Guerra Ramos, 2011). Analogies can help students visualise abstract concepts and promote meaningful learning with a careful recognition of relevant features and the points at which it breaks down (Guerra Ramos, 2011; Harrison & Treagust, 1993). However, if used unsystematically, they may not produce the desired result (Orgill & Bodner, 2005). I believe that many students apply analogies to understand a new concept; however, not all analogies are applicable and it could be a two-edged sword. Many students will expand double brackets in the following manner $(x+2)^2 = x^2 + 4$, as they used analogy with the Distributive Law.

Duit and Confrey (1996) claim that constructivist approaches are superior to traditional ones; they take seriously students' existing ideas and encourage discussions and growth of students' concepts. Brooks and Brooks (1993) argue that 'students' points of view are windows into their reasoning' and 'awareness of students' points of view helps teachers challenge students, making school experience contextual and meaningful' (p. 60). Students have a chance to reflect on their own and other students' work, and learn some debating skills and the mathematics related language. One weakness of these models is that students may not recognise the cognitive conflict. The teacher may find it appropriate to start the lesson by asking students to comment on $(x+2)^2 = x^2 + 4$, however, some students may not see anything wrong with the statement. What may be obvious to the teacher may not be so obvious to the students. Further, some students may not participate in the discussion; ultimately, they want to know what a correct answer is. This is what learning represents for them; knowing a correct answer.

Borg, Hewitt and Jones (2016) propose the Mathematics-Negotiation-Learner (M-N-L) framework with regards to constructivist teaching emphasising teachers' sensitivity to learners' constructions. There is no an attempt to prescribe a particular teaching method, but the framework suggests that the teacher assumes the role of a negotiator between mathematically accepted knowledge and the learner, and finds a way to build a path between their understanding of a mathematical concept and those of his students. In this interaction, the teacher goes through the perturbation process in order to understand students' mathematics and ways to cater for that understanding.

One of the common threads of these strategies is that they deal with the concept change to the certain extent. This important facet of the constructivist strategies is discussed in the next section.

2.2.3 Conceptual growth and conceptual change

Duit and Confrey (1996) describe conceptual growth as the change where the learner does not have to reconstruct his or her previous beliefs in order to accommodate a new term or concept. It 'refers to the addition of new terminology, definitions, and isolated facts that do not disturb one's previous beliefs' (p. 80). Let us demonstrate the conceptual change through some examples. Consider a student who understands similar shapes and is able to solve a right-angled triangle given three measures. The introduction of the trigonometric terminology will not disturb his or her previous constructions, and is considered a conceptual growth. Hewson (1996) claims, that conceptual growth could be characterised as 'learning without difficulties'; it happens when students' existing views are consistent with what they learn. I feel that the term 'learning without difficulties' does not do the justice to learning. Having views consistent with mathematics does not provide 'learning without difficulty'; it cannot be simplified like that. Perhaps just introducing new terminology for already understood concept occasionally could be classified as the conceptual growth from Hewson's point of view.

Duit and Confrey (1996) describe the *conceptual change* as the change in the priority of the concepts. The conditions that need to be met in order for the concept change to take place, and the learner's conceptual ecology, are the main components of the concept change model (Hewson, 1996). It proposes that the learner must be dissatisfied with his or her existing ideas and the new ideas must be intelligible (the learner must be able to understand and represent the concept), plausible (the concept must appear to be believable) and fruitful (the learner should be able to use the concept for further constructions) (Hewson, 1996). Many of pedagogies trying to facilitate conceptual change regard cognitive conflict as an essential part in an effective construction of new knowledge. Cognitive conflict is a student's awareness of the contradictory pieces of information preventing him or her to solve a problem (Chow & Treagust, 2013). The teacher is seen as a facilitator who provides opportunities for students to express their opinion and make sure that everyone's opinion is valued, and the learners need to

be willing to change their ideas. Students should take responsibility for their own learning, respect other students' views, and be willing to change their opinions.

Duit and Treagust (2009) debate that the term 'conceptual change' may not be appropriate. It is used as an exchange of the students' prior constructions for the scientifically accepted theories and somehow reflects the objectivist way of thinking. The learning is supposed be a process in which pre-instructional ideas are going through a continuous and gradual change. The term 'conceptual reconstruction' better reflects the actual meaning of what is happening (Duit & Treagust, 2009).

One disadvantage of this approach is that students may not accept mathematically accepted theory in a long run. I have seen many times students understand the concept the first time we do it, and the first few lessons are successful. For example, expanding single brackets say $3(x+4)$. They realised that the previous model does not work (i.e. $3(x + 4) \neq 3x + 4$), the new explanation looked believable and they understood why it worked (using analogy or seeing multiplication as a repetitive addition), and were able to use it in a number of situations. Later in the year some of them started making mistakes. There could be a number of possible reasons why it is happening. One reason it happens is because they might not have been exposed to multiple representations of the concept. A student may have a mathematically accepted view of a concept; however, he or she should be exposed to various representations of the same concept. Another reason is that students may not find the concept fruitful in a long run. The students are able to grasp the concept and use it for a short period of time, for specific kind of questions; however, they do not understand the problem as theirs personal and may not feel committed to it. Brooks and Brooks (1993) claim that in order to 'foster the development of students' abilities to organise and understand their individual worlds, teachers need to encourage students to find their own problems (p. 29). Duit and Treagust (2009) argue that the conceptual change depends on many factors including motivation, interest and emotions.

Next, it may be difficult to persuade a learner that new ideas are better than old ones. The inquiry could be too complex for students to be motivating and exciting; therefore, they will not be able to engage fully. I think a teacher will have to accept that some students are not ready for the complexity of a specific mathematics theory and accept their relevant construction that is within proximity of the target concept. Some students will continue to prioritise their pre-instructional ideas. Conceptual change strategies could be effective in teaching

mathematics and can promote change in students' attitudes; however, if the conflict is excessive it can have a counter effect, and cause withdrawal and frustration (Chow & Treagust, 2013).

Driver et al. (1994) propose the notion of a conceptual profile where the learner is holder of multiple explanations. It has been argued that the conceptual change models assume that teaching will result in the equilibrium and the acceptance of the science view. Some conceptual change models fail to acknowledge that students may continue to favour their pre-instructional concepts. Their common-sense explanations are possibly constantly validated in everyday situations and appear to be acceptable without any constraining of rules. Dawson (2014) supports the notion of the conceptual profile and argues that it is acceptable to have multiple understandings of a concept, and that commons sense views do not need to be changed as long as they are used in appropriate situations. Everyday explanations, unlike scientific concepts, are useful in specific situations. Students are not going to give up these logical ideas easily. They have had them for a long time and they have been helpful in many situations.

The next disadvantage is that the conceptual change is mostly related to changes of science (mathematics) concepts; it does not include conceptual changes of the nature and understanding of science (mathematics) (Duit & Treagust, 2003). Further, emphases of the studies are usually isolated scientific concepts, while the concepts related to environment, technology and society are being neglected (Duit & Treagust, 2003).

I have used these models as a starting point or a reference what is an appropriate teaching strategy. Some examples of my teaching strategies have been described in this review. A teacher cannot always plan to apply one strategy as students' responses may guide him or her in a different direction.

2.3 The constructivist learning environment survey

2.3.1 Introduction

This section considers the CLES, a classroom environment questionnaire, which was designed to help teachers monitor to what extent their classroom is consistent with constructivist ideas.

The constructivist learning environment survey (CLES) is used as a referent for teachers who want to reshape their classroom practice and implement a constructivist learning environment. Additionally, it is used to identify students' opinions and perceptions about the classroom (Taylor, Fraser, & White, 1994).

The CLES consists of five scales:

- *Personal relevance* focuses on the connection between the school work and students' outside of school life.
- *Uncertainty* assesses the extent to which students are given a chance to experience mathematics as a result of humans' work and a cultural setting.
- *Critical voice* gives the students an opportunity to question teachers' strategies. Students have to feel that it is acceptable and appropriate to question the teacher's strategies and express concern about their learning.
- *Shared control* means students have the power to share control of the learning environment.
- *Student negotiation* focuses on how much students have an opportunity to explain and justify their ideas to other students.

Initially, the CLES was concentrating on cognitive and some social aspects of teaching and learning; it was focusing on the students' prior knowledge and conceptual change, and the effect of the interaction and communication between students on their learning (Taylor et al, 1994). In recent times the traditional view of mathematics started changing and mathematics has been described as the product of human construction which is validated within the mathematical community. However, research has shown that the traditional classroom is still embedded with the cultural myth of objectivism that promotes mathematics as absolute truth and therefore puts constraints on students' curiosity and questions. Additionally, the mathematics classroom is affected by technical interests that emphasise the final product - covering curriculum for the purpose of passing the examination (Taylor, Fraser, & Fisher, 1997). Therefore, the CLES was revised to include a cultural and emancipatory aspect.

Radical constructivism, social constructivism and critical constructivism, discussed in the previous section, account and explain the way different aspects of the CLES - personal relevance, uncertainty, critical voice, shared control and student negotiation - were constructed. The first principle of radical constructivism states that the learner is actively constructing his

or her knowledge. The second principle accentuates the involvement of the learner in the construction process. These two principles put emphasis on the role of the past experience and the personal relevance in learning and teaching. The second principle stresses subjectivity of our constructs, including mathematical constructs. This human fallible characteristic of created constructs establishes uncertainty of mathematical concepts. Social constructivism introduces the third component of learning, that the knowledge is socially conveyed. Therefore, mathematical knowledge is socially negotiated. The constructed knowledge is validated within the mathematics community, and becomes available to the public as a recognised piece of information (Drive et al., 1994). This facet acknowledges interaction, communication and negotiation with others in building knowledge. I believe it provides some justification for the personal relevance as well. Students belong to their own cultures and subcultures. In order to introduce them to the mathematical community the teacher must identify borders to be crossed, some touching points to make mathematics relevant to students. Critical facets of constructivism help students (and teachers) uncover the cultural myths of objectivism and the cold reason that affect our teaching and learning (Hardy & Taylor, 1997). It supports students in learning to be responsible for their actions and to freely express their views and inquire about other peoples' opinions. Consequently, critical constructivism informs the shared control, critical voice and negotiation scale.

2.3.2 Past studies involving the CLES

In order to use the CLES to find out if I could successfully implement the constructivist learning environment in my class, it was important to examine its reported validity and usefulness. A number of studies using the CLES supported and validated its application in monitoring constructivist learning environment (Taylor et al., 1997). Previous studies include various educational settings around the world. The CLES was found to be reliable and helpful in creating a picture of the teaching epistemologies in science and mathematics classroom.

Taylor, Fraser and Fisher (1997) reported two case studies conducted in Western Australia, which implemented constructivist learning environment. The studies confirmed that the data obtained from the CLES were generally compatible with the qualitative data. Afterwards, the CLES was used in two larger scale studies in Australia and USA and satisfactory internal consistency and factorial validity were achieved. This combination of small scale and large

scale studies indicated that the CLES is a suitable tool that helps our understanding of the constructivist learning environment in science classes in Western countries.

Kim, Fisher and Fraser (1999) used the CLES to investigate a science curriculum in Korea that supported constructivist ideas. The Korean version of the CLES was reliable and valid. Classes reflecting constructivist views were perceived more positively, with favourable students' attitude, than the classes taught in a traditional way.

Aldridge, Fraser, Taylor and Chen (2000) used the CLES in a study involving Australian and Taiwanese science classes. Quantitative data analysis supported the reliability and validity of the CLES in both countries. Qualitative data appeared to be in disagreement with the CLES to some extent; however, the interviews helped with the interpretation of the difference.

The CLES was used to guide and monitor the development of the constructivist learning environment in South Africa. The study that involved 1864 students across 6 schools supported the CLES's factor structure, internal consistency reliability and discriminant validity of the CLES, and indicated its suitability for mathematics classroom in South Africa (Sebela, Fraser, & Aldridge, 2003).

In a study in Florida, Spinner and Fraser (2005) used the CLES to assess the effectiveness of the Class Banking System, an innovative mathematics programme. Three case studies, involving grade 5 students, were conducted and observations and interviews supported the results obtained by questionnaires. Nix, Fraser and Ledbetter (2005) conducted a study in north Texas where the CLES was administrated to 1079 in 59 classes taught by 12 teachers. The factor structure, internal consistency reliability, discriminant validity, and ability to distinguish between different classes were supported by the study and the overall results indicated validity of the use of the CLES.

Peiro and Fraser (2009) used the CLES to investigate 739 science K-3 students in Miami, USA. The modified English and Spanish versions of the CLES were found to be reliable and valid. Strong and positive correlations were found between students' attitudes and the nature of the classroom environment. It is worth mentioning that a follow-up study in USA where a shorter version of the CLES (Johnson & McClure, 2004) together with qualitative data, was used to evaluate the implementation of an innovative science teacher professional development programme, the Integrated Science Learning Environment, showed that the change in the

teachers' environment at the university level appeared to cause a similar change in their classrooms. Strong factorial validity and reliability was reported (Nix & Fraser, 2011).

These studies established validity and reliability of the CLES in various educational settings around the world, and indicate its suitability as an instrument for assessing students' viewpoints and reshaping classroom practices.

There have been a limited number of studies using the CLES in science or mathematics classes in the Middle East. In his study about the effectiveness of mathematics games on the students' attitudes and learning environment, Afari (2012) used just one component of the CLES - personal relevance - along with the 'What is happening in this class' questionnaire (WIHIC). Overall the survey instrument was found to be reliable and valid.

2.4 Aspects of the Arabic culture

2.4.1 Introduction

There is not one specific Arab culture; the difference exists between different communities and countries. In this section I try to describe same relevant aspects of the culture that I have become aware of while living in the Middle East, and that could have affected my students and their actions and behaviour, and consequently affected our teaching and learning. By no means, should one think that these aspects are homogenous across the Arab world. The characteristics I mentioned serve to provide an insight into the Arab culture. However, their application and correctness depend on the context and vary greatly across different groups. Gay (2002) points out:

> As is the case with any cultural component, characteristics of ethnic communication styles are core traits of group trends, not descriptions of the behaviours of individual members of the group (p. 111).

My students come from Qatar, Syria, Jordan and Egypt and had been exposed to the different aspects of the Arabic culture to various degrees. Furthermore, the students had been in school since their early primary years and were exposed to different teaching and learning techniques.

2.4.2 Islam

Beliefs and pillars of Islam

Majority of the Arabs are Muslims. For many Muslims, Islam represents not only a religion but also guidance for various aspects of life. Some Muslims prefer religion to be their personal matter. On the other hand, the Arabic countries use Islam to guide their governments.

There are six basic Islamic beliefs: Allah, the angels, the prophets, the revealed books, the hereafter and destiny. Islam teaches that there is only one God, Allah, the creator and knower of everything. Through his messengers, the angels, Allah revealed his teachings to the prophets. The Qur'an was revealed to Muhammed, the last prophet, and after Muhammed his revelations stopped. Islam teaches that there is the hereafter life, the Day of Judgement, Paradise and Hell.

Muslims believe in destiny and that Allah has power over everything. They are given free will and will be responsible for their actions when the Day of Judgement comes; however, everything is in Allah's hands and regardless of the human actions, he decides what is the best for them (Hussain & El-Alami, 2005).

The five pillars are the actions that Muslims are obligated to perform: the testimony of faith in Allah, ritual prayers, obligatory charity, fasting during Ramadan and pilgrimage. Every Muslim declares the testimony of faith which states that there is no other God but Allah, and Muhammed is the messenger of God. Muslims pray five times per day, at fixed times, at dawn, mid-day, mid-afternoon, sunset and nightfall. They try to pray at the specific times; however, if it is not possible they may pray before the next prayer, or do all missed prayers later in the day. Financially secure people are obligated to pay 2.5% of their leftover income to those in need. Muslims are obligated to fast during Ramadan for one month; it is meant for them to learn to empathise with others who do not have food (Hussain & El-Alami, 2005). Reasons one may be exempted from fasting include: children, pregnancy and breastfeeding, sickness, weak and old, and travelling. There are ways in which missed days could be compensated. A friend of mine was sick during Ramadan and missed a number of days. Later in the year she was fasting, before the next Ramadan, to compensate missed days. Muslims are obligated to make the pilgrimage to Mecca at least once in their life time, given that their health and finances permit it.

The school calendar and timetable were organised around religious days. As the Islamic holidays shift with the lunar calendar (based on cycles of the lunar phases) which is 10-11 days shorter than one year, holidays shift forward for 10-11 days every year. To determine the beginning of Ramadan, the method of visual sighting of the crescent with naked eye is applied. As a result, the holidays sometimes unexpectedly start 1-2 days earlier. Iftar, the evening meal, is done as a community with friends and family, when people get together to break their fast together. We, as a school community, frequently had Iftar together. People tend to stay up late at night in family gatherings and wake up early for Suhur, the early morning meal, before fasting. Many children, especially in older classes were fasting. Even if not fasting, they were involved in the social gatherings. As a consequence, the school day was shortened and started later during Ramadan. Many of my students were possibly sleep deprived and hungry during Ramadan.

Epistemological and ontological concepts and critical thinking in Islam

In Islam, Allah is regarded as the creator and the knower of everything, humans, nature, social and legal ceremonies. He knows the past and the future. In Islam, knowledge comes from Allah's revelations to his prophets, from reasoning and observations, and from empiricism.

The establishment of Islam coincided with academic growth in the Arab world. In its early days, Islam nourished the tradition of critical thinking. The Qur'an and the sayings of the Prophet Muhammed encouraged education and the search for knowledge and guided Muslims to think about all the creations including nature. After accessing the work of the Greek philosophers, Muslim scholars were influenced, particularly with respect to scientific thought and inquiry. After the expansion of Islamic land many books were translated to Arabic, and consequently used to develop science. The Arab world produced many scientists from that time (Al-Sharaf, 2013). For example, in mathematics, al-Khwarizmi adapted the Hindu Arabic numeral system which is in major use today. At that time in Europe, the Roman number system was still in use. The question they were not allowed to think about was the nature and the existence of God (Al-Sharaf, 2013).

For Muslims, knowledge is truth. The most important source of knowledge is revelation. For example, Allah revealed his teachings by sending angels with his messages. The Qur'an was

revealed to Muhammed and after his death revelations stopped coming from Allah. Revealed knowledge is absolute. There are other revelations; however, the Qur'an is regarded as the only revelation which is preserved in its original form. In the early beginnings, there were very few written materials, and the Qur'an was memorised and orally transmitted for generations. That practice stayed until today and there are many Qur'an reciting competitions. Muslims regard the Qur'an as the only true teaching remaining from God. God and everything else is known through the attributed characteristics. Further, knowledge can be acquired through rational thinking, logic and contemplation (Al-Sharaf, 2013). A theory states that a number of unknown objects are reduced by 'moving from known objects to unknown ones' (Al-Sharaf, 2013, p. 276). However, human intellect is limited and revealed knowledge is needed in order to confirm the reliability of that knowledge. Next, knowledge can be acquired through experience and empiricism (Al-Sharaf, 2013). The senses are used to find out the properties of a phenomenon. The senses have limitations and are fallible; thus, knowledge gained through experience may be unreliable and needs to be confirmed by revealed knowledge. Therefore, the main source of knowledge is the Qur'an which, additionally, needs to support any other acquired knowledge (Azram, 2011). The Qur'an makes the pursuit of knowledge an obligation for Muslims, and through that quest for knowledge, people fulfil their purpose (Ahmed, 2012).

Revelations are superior to other sources of knowledge, and it appears that the principles and teachings from the Qur'an are viewed as an absolute truth. Consequently, in mathematics classrooms, solutions to the problems are regarded are either right or wrong. It is likely that the students possibly understand knowledge as unconditional, and may not consider investigative approaches and discussions as necessary. Lecturing is likely to be preferred teaching style as it, from a simplistic perspective, transmits knowledge. Additionally, memorisation is an important part of the Arab culture because of its connection to learning and transmitting the Qur'an. As a result, it may be seen as a suitable learning strategy in the mathematics classroom as well.

2.4.3 Collectivism

According to Hofstede (2011), collectivist cultures place more importance on the needs of the group over the needs of the individual. In a collectivist culture, the norms of the society are organised around the functioning of the group rather than the well-being of the individual.

People have close relationship with their family and tribes, and are committed to work for the benefit of others belonging to the group. In return for their loyalty they are protected by the group. Generally, people in the collectivist cultures are obedient and protective of their tribe rather than being confrontational and protective of their own comfort and individuality (Hofstede, 2011). As the society is ruled by the norms that focus on the well-being of the group, people are unable to detach themselves from it, and are expected to pledge their loyalty to the group, and follow the wishes of their fathers and tribes. Their own goals are overlooked for those of the community. In comparison, in the individualistic cultures, the focus is on personal freedom, development and goals.

The Arab culture is highly collectivist. The close ties with the family and the family integrity are very important to the Arabs, especially for the males. Loyalty to family, clan or nation are of great importance to Arabs, and people are dedicated to preventing shame coming to them as it will affect not only them, but their families and tribes, and even future generations. The position of an individual in society is shaped by religion, gender and family connections. Personal and family honours are highly prioritised in the Arab world.

According to Jandt (2010), individualism and collectivism are related to the communication style. In the individualist societies, the needs and desires of the speaker are clearly communicated and included in the spoken message. On the other hand, the communication styles of the collectivist societies tend not to show the needs of the speaker in the fear not to make the other person feel bad. The students may be unlikely to raise their concerns about the strategies employed, as traditionally, social harmony is better achieved if they are passive. Cooperative learning strategies, group discussions and peer-tutoring are likely to be preferred by the Arab learners.

2.4.4 Power distance

Power distance is the way the culture deals with inequalities (Jandt, 2010). It is the degree to which the less powerful members of an organization accept that power is distributed unevenly. Organizations could be family institutions as well. In this way, a society's level of disparity is promoted to the same extent by both the followers and the leaders (Hofstede, 2011). In the cultures with large power distance, older people and those of higher status are respected, parents teach children obedience and dependents expect to be told what to do (Jandt, 2010).

The Arab culture is characterised by a large power distance (Najm, 2015); the opinion of the elderly, religious and political leaders is respected and opposing it would mean losing face. Culturally, people are inclined to trust their leaders (Arab Cultural Awareness, 2006). Family commitment and cooperation with others and respect for the authority figures are valued in the Arab world; although, small changes are noticeable in some aspects of society. Subsequently, in the classroom learners may prefer to be told what to do and how to think and act.

2.4.5 Language

Arabic is a diglossic language, which means that multiple distinct varieties of a language are used. It has two varieties: modern Arabic used in writing and formal speech, and colloquial Arabic, used in every day speech. Further, colloquial Arabic has many different forms; for example, Egyptian Arabic is different from Iraqi Arabic (Jabbari, 2012). They could be so different that speakers of different dialects cannot understand each other. In Arabic countries children learn the colloquial version as their first language, while modern Arabic is studied in school, and could be almost regarded as a second language. Some argue that it is impossible to teach Spoken Arabic within the classroom because of the variety of dialects (Jabbari, 2012). It is interesting to note that modern Arabic and colloquial Arabic do not have the same prestige, and a full body of literature exists in the modern variant, while almost none in the colloquial form (Jabbari, 2012).

Qatari students have been in this school since their foundation years. Even in the public schools English is one of the main languages for instructions, as the Ministry of Education is trying to find ways to modernise the country. For migrant children this is just another international (English speaking) school. Some of them have been here for years. Regardless of their background, for the majority of students, all formal education has been conducted in English, so they lack any formal knowledge of modern Arabic. They speak the colloquial version of Arabic at home with their families and have Arabic lessons once per week. To complicate the situation, many families employ foreign nannies whose knowledge of the language is limited. Taking into account that Arabic grammar is more difficult than English, the majority of children do not have the proficiency met by the first language speakers. People see and speak of their world is to a great extent determined by their mother language (von Glassersfeld, 1995). My students almost did not have a mother language. Arabic is like a second language for them.

I tried to describe some aspect of Arabic culture but I do not feel I did justice to it. These and many other characteristics, like hospitality, family, honour and dignity are difficult to simply explain.

2.5 Culturally relevant teaching

2.5.1 Introduction

Culturally responsive teaching takes into account the student's cultural background including values, past experiences, learning styles and ways of communication, to create a caring and appropriate learning environment. It emerged as the educators were 'trying to develop a closer fit between students' home cultures and the culture of the school' (Brown, 2007, p. 67). Culturally appropriate, culturally relevant, culturally responsive and culturally compatible teachings are some of the terms used to suggest the inclusion and utilisation of the students' culture in school practices. The foci of culturally appropriate teaching are achieving academic success and preserving the cultural identity of students (Gay, 2002; Ladson-Billings, 1995); the needs of the whole child are considered (Brown-Jeffy & Cooper, 2011). School administration and leadership are core aspects of culturally responsive teaching. Formal processes within an institution need to be analysed and changed, and culturally responsive pedagogy needs to be implemented across all levels within the school. However, given the scope of my research, I am not focusing on that dimension of the culturally appropriate teaching; my main focus is the classroom dimension. The purpose of this section is to provide theoretical background and offer my personal understanding of culturally relevant pedagogy.

2.5.2 The aspects of culturally responsive pedagogy

Various researchers identified a range of characteristics of culturally responsive classroom. Ladson-Billings (1995) recognizes three criteria for culturally relevant pedagogy: academic success, cultural competence and critical consciousness. Gay (2002) identifies five traits of culturally responsive teaching: developing a cultural diversity knowledge base, designing culturally relevant curricula, demonstrating cultural caring and building learning community, cross-cultural communications and cultural congruity in classroom instructions. Villegas and

Lucas (2002) outline the following characteristics of culturally relevant teaching: socio-cultural consciousness, high expectations, desire to make a difference, constructivist approach, deep knowledge of their students and culturally relevant teaching practices. According to Perso (2012), the stages towards cultural competency teaching and meeting the needs of culturally diverse students are: awareness of a teacher's own attitudes, beliefs and stereotypes, and reflection on her own culture, valuing diversity and integrating knowledge with professional skills. From the characteristics identified by these academics, the following components of the culturally relevant teaching emerge (Gay, 2002; Villegas & Lucas, 2002):

- Reflective nature of the teacher
- Caring and positive environment
- Knowledge about the students
- Critical thinking and social justice
- Classroom practices

With the components as critical thinking and social justice, culturally responsive teaching can be regarded as an implication of critical constructivism.

Reflective nature of the teacher

Actions within society are underpinned by the norms of the dominant groups. Many teachers are comfortable within their own culture and are not aware of the (hidden) society values which may threaten the students' progress. Culturally responsive teachers start the quest for cultural competence by examining their personal attitudes and values, and acquisition of the values, knowledge, skills and attributes that allow them to operate appropriately in cross-cultural settings (Perso, 2012). By questioning her own beliefs and outlooks, a culturally responsive teacher steps out from her comfort zone and comes to understand about her own (possibly discriminatory) behaviour. She becomes more aware of her view of society and her place within it, and of the ways students' and her actions are shaped by society (Villegas & Lucas, 2007). Through self-reflection she needs to learn about her perception of different ethnic groups. In that process she may examine others' perception of her own background and their reactions. Underachievement of ethnically diverse groups needs to be seen as a social and institutional barrier, and a teacher needs to have a desire to face the barrier and commit to change. In order

to respond to the needs of her students, the teacher needs to think about the skills needed to cross cultural bridges within the classroom (Montgomery, 2001). She needs to be willing to learn about other cultures and to communicate effectively with the people from a different cultural background (Perso, 2012). Self-reflection is a stepping stone towards a culturally responsive classroom.

Caring and positive environment

A culturally responsive teacher cares about her students and uses her knowledge to act in the best interest of her students. She needs to use the students' background and experiences to create a supportive classroom climate and allow the academic achievements of her students. Together they build a culturally appropriate classroom. The emphasis is placed on the welfare of the group rather than the individual (Brown, 2007; Gay, 2002). Traditionally, students with a different cultural background were considered as the students at risk, and somehow, teachers' expectations of their academic success were lower (Villegas & Lucas, 2007). Consequently, traditional practices of rote learning and basic skills instructions were more likely to be applied in such classrooms instead of activities requiring problems solving skills (Villegas & Lucas, 2007). The caring environment is reflected in the fact that the teacher expects excellence from her students (Gay, 2002). A culturally responsive teacher firmly believes that her students can succeed academically. Her perceptions of students have a high impact on their performance and show respect for students and their families. The culturally appropriate caring is action oriented and uses creative resources and strategies to safeguard academic success for the students (Gay, 2002).

Knowledge about the students

Knowledge about the students and their needs is an important aspect of the culturally relevant teaching. In order to meet the educational needs of her students, the teacher needs to know not only her subject area but also the cultural background of her students. From the characteristics listed by various researchers (Gay, 2002; Ladson-Billings, 1995; Villegas & Lucas, 2002) it could be noted that the knowledge about ethnically diverse students is not only about cultural sensitivity and respect; their values and norms must be acknowledged and incorporated into

the classroom practices. A culturally responsive teacher builds communication with the students' families as they are ones who know them the best. Families should be encouraged to take an active role in the students' education and encouraged to participate in class and school activities (Montgomery, 2001). This relationship promotes respect between school and home. Furthermore, knowledge about the students enables the teacher to integrate their everyday experiences into curriculum. Cultural characteristics and values have a profound effect on the students' learning. Some of the ethnical characteristics include traditions, learning styles, ways of communication and contributions to the subject area (Gay, 2002). A culturally competent teacher is aware of how communication styles of various cultural groups may affect their learning, and consequently, incorporate it into her planning. For example, the western way of communicating is logical, efficient (from the western point of view), precise and direct. In Arabic an appropriate way of communicating ideas may include all relevant and (to western people) irrelevant details recreating all related experiences and feelings (Zaharna, 1995).The contribution to the subject is an important aspect of the students' cultural background and will make them more connected to it. Many are not familiar that the Arab culture pioneered in the fields of science, medicine, mathematics which paved way for the European cultural scientific renaissance. Knowledge about ethnically diverse groups is a base for the appropriate practice within the classroom; a culturally responsive teacher needs to be able to utilise multicultural approaches and include multicultural content into curriculum (Gay, 2002).

Critical thinking and social justice

The social justice aspect is an important part of the culturally appropriate classroom and can help students identify the issues such as equity and privilege. Socio-cultural consciousness is awareness that a person's worldview is a personal perception and is influenced by his or her life experiences and factors like gender, ethnicity and social class (Villegas & Lucas, 2007). It starts with a teacher reflecting on her own culture and using her knowledge of other cultures to identify factors shaping her behaviour and views. Without considering how her own culture shaped her views, the teacher continues to believe in the rightness of her culture and unknowingly forces students to accept different cultural norms. In order to promote social and cultural awareness among my students, I first needed to demonstrate such a stance myself. Language is quite an important factor in shaping our behaviour. For example, I act differently and use different expressions when speaking in English or my mother language. Within their

subject areas, teachers can help students understand that knowledge has many facets including social, and use the learning situation to confront stereotypes and oppression. Culturally relevant teaching deals with gender issues, poverty problems, social justice and freedom, and helps the learner see them from different standpoints. The relevant topics are found in the current world affairs or within the community. Traditionally, these issues were ignored, possibly from the fear of stereotyping. In a culturally responsive classroom such issues and their impacts in society are confronted and critically evaluated.

Culturally relevant classroom practices

Knowledge about ethnically diverse students serves as a basis for improving classroom practices. From my experience, formal curriculum as a part of classroom practice is not always suited to the needs of culturally diverse students. While there are attempts to make curriculum culturally appropriate, usually, examples are, somehow, artificially constructed. For example, they may have involved a person with an Arabic name but always within the British environment and, for example, involving British currency. However, a culturally responsive teacher should be able to make changes and adapt curriculum to the students' needs. Gay (2002) points out that traditional curriculum avoided issues like racism, historical atrocities and poverty, while emphasis was on the achievements of individuals and factual information. The actions of groups, feelings and values were ignored. In the past educators struggled to enrich classroom practices with culture from the fear that it may 'water down' curriculum. In my first year of teaching, my head of department suggested including more real life examples from students' backgrounds, but I was worried that it would somehow soften the concepts that I needed to cover. The inclusion of multicultural strategies and practices makes my teaching and learning more interesting and stimulating, and provides an opportunity for all students to learn and understand different views. Ideally, curriculum should be dynamic and flexible, and related to students' experiences. Display boards need to reflect the ethnically diverse classroom. A variety of cultures, gender, place and time should be included (Guy, 2002). Examples may include Arabic scientists and their achievements, and cases of current, local and global, issues.

The board reflects teachers' expectations, views, and relationships with the students, and in due course, students take these images as the norm (Guy, 2002). Teaching and learning strategies

recognise students' strengths and cultural background (Villegas & Lucas, 2002). Group work and discussions allow students to practise their speaking, listening and writing skills, give them an opportunity to learn and respect each other's opinion, and cooperatively construct the meaning of a concept. Open-ended and inquiry-based tasks give students the opportunity to actively engage in creating their knowledge, critical thinking and problem solving skills. Villegas and Lucas (2007) point out that employing those constructivist strategies does not exclude direct instruction and memorisation; however, the latter approaches do not allow children to think critically and develop problem solving skills. Students do not actively engage in learning new concepts nor do they have an opportunity to incorporate new experiences into their way of thinking. Ongoing and formative assessment is a part of the culturally relevant classroom. It serves to inform the teacher about the students' understanding and to determine future strategies (Montgomery, 2001). Students are actively engaged in the assessment processes. Some examples of appropriate assessments are observations, portfolios, diagnostics tests, and students' self-evaluations. Traditionally, the end-of-term tests were the most frequent form of assessing students' understanding. In a culturally appropriate classroom, assessments are regarded as an opportunity to learn.

Embracing the culturally diverse background of our students is not about tasting food from different countries or wearing your national costume on a school fair day. The students' culture is a whole life experience for them. A culturally responsive teacher needs to be able to reach out to them, get to know about their background and use that knowledge to create a stimulating and caring environment. Along the way, she needs to examine our own cultural biases and stereotypes. The goal for the students is not only to experience academic success, but to preserve their cultural identity and understand others. By developing their problem solving skills and critical thinking, they may become responsible members of society.

2.6 Summary

This research is about the implementation of a constructivist learning environment in mathematics high school classes where the majority of students were English as Second Language Learners of Arabic origin. In this chapter I discussed the theoretical background of my study. The review is supported with the examples from my practice which contribute to my interpretation of the relevant literature from the field.

This chapter has been organised in five sections:

- Section 2.1 discusses different facets of constructivism - radical, social and critical - and their implication in my classroom. My interpretation of the various forms of constructivism underlines my understanding of what teaching and learning should be about, and accounts for the scales of the constructivist learning environment survey employed in this study.
- Section 2.2 describes some of the strategies that helped design the classroom activities. Further, it discusses the conceptual change as a common characteristic of the constructivist strategies.
- Section 2.3 describes how my understanding of constructivism accounts for the scales of the CLES - personal relevance, uncertainty, critical voice, shared control and student negotiation. Additionally, it describes a number of studies that supported and validated the use of the CLES in monitoring constructivist learning environment.
- Section 2.4 discusses some aspect of the Arabic culture, namely Islam, collectivism and language, which influenced teaching and learning in my classroom.
- Section 2.5 describes characteristics of culturally relevant teaching: reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice and classroom practices. Culturally relevant teaching, in my understanding comes under umbrella of critical constructivism which is one of the major principles influencing this research.

Chapter 3: Methodology

3.1 Introduction

The main focus of this study was the implementation of a constructivist learning environment in a mathematics high school class where the majority of students were English as Second Language Learners of Arabic origin. This chapter describes the methodology of the thesis and specific strategies adopted in the research process.

The chapter describes in a detail the implementation of the constructivist learning environment. It presents my interpretation of the scales of the constructivist learning environment survey (CLES) and ways they were utilised. The research paradigm that guided my research was mainly interpretivist; although, it had characteristics of other paradigms. The strategy employed in this research was the participant observation while the method used was narrative inquiry. Quantitative and qualitative data were collected; although, the greater weight was given to the qualitative data as mathematical and non-mathematical tasks, classroom observations, reflective journals and unstructured interviews. The quality criteria guiding this research justifying the legitimacy of my field-work and the legitimacy of my presentation is at the end of his chapter.

3.2 Paradigms and perspectives

3.2.1 Paradigms in education research

Paradigm could be defined as the researcher's epistemological (nature of the world), ontological (nature of knowing) and methodological (how we get to know) principles. In other words, it is 'a set of beliefs and feelings about the world and how it should be understood' (Denzin & Lincoln, 2000, p. 19). The research paradigm guides the researcher with all aspects of the study, from selecting the main goals to collecting and analysing the data (Treagust, Won, & Duit, 2014). There are various classifications of paradigm, the following three categories of positivist/post-positivist, interpretivist, and critical theory, are common in science education.

Positivist / post-positivist research paradigm

In the past, the paradigm of positivism, or scientific method was heavily promoted in education research because of its evidence-based nature. The purpose of the research is to test an independent and objective theory, and to offer a logical and rational explanation of the phenomena. Post positivist researchers try not to get involved with the participants as it can hinder their objectivity (Treagust et al., 2014).

Traditionally, positivist designs include control and treatment groups, pre and post test results, randomised sampling and large sample sizes, which are analysed using statistical methods (Taylor, 2014). The means of collecting and analysing data ensures an accurate description of reality. Post positivist research uses qualitative data obtained through surveys and observations but the data is usually presented using tables and analysed statistically.

The application of the positivism was less successful in the study of human behaviour because human nature and society are too complex (Cohen, Manion, & Morrison, 2007). The decline in use of positivist research has been attributed to ethical issues. For example, if one proposes that a program will have a positive effect in the classroom he or she cannot introduce control classes as consequently they would be subject to less effective approaches (Taylor, 2014).

Interpretivist research paradigm

The interpretivist paradigm focuses on the human experiences in context; the world is experienced in a personal manner and the picture one builds depends on our experience and context.

Constructivist researchers are trying to reconstruct their understanding of the world. The purpose of a constructivist task is to 'understand people's constructions of meanings in the context being studied, because it is these constructions that constitute social realities and underlie all human actions' (Greene, 2000, p. 986). The process is interpretative as one does not really know other people's experiences, only his or her own interpretations of their actions (Greene, 2000). The research aim is to understand how one interprets his or her own and others' actions and beliefs, and to understand their subjective meaning.

Social constructivist epistemology is a dominant characteristic of an interpretative research, which suggests the following methods: prolonged participation, observations, and non-clinical interviews. Reflective turn, another important feature of the interpretative research, is when the researchers value and employ their own subjectivity in the research (Taylor, 2014). Through the reflection in her own beliefs and the interpretation of the students' actions, the teacher tries to understand how the students make sense of teaching and learning (Treagust et al., 2014). Guba and Lincoln (1989) define progressive subjectivity as monitoring the researcher's own reflections, and making them transparent to the audience.

Critical research paradigm

Positivist/post-positivist and interpretivist research paradigms investigate phenomena from two different perspectives. Positivism/post-positivism strives for objectivity and the phenomenon is in the focus, while interpretivism tries to understand the world as it is seen from the participants' view, and focuses on the meaning and interpretation (Cohen et al, 2007). The critical research paradigm is concerned with making the world a fairer and more equitable place; its intention is not to describe the phenomenon and behaviours but to change them. Critical research is of a transformative nature and tries to make a difference in the lives of the participants. Critical researchers reflect on their own beliefs, culture and norms which shaped their identity, and their role in reproducing hidden social norms and practices. They engage in a dialectical thinking with technical and practical interests being regarded as complementary (Taylor, 2014).

Over the last three decades the field of science education has been trying to make the science classroom gender inclusive; traditionally its door was open only for the privileged and for boys. More recently the focus of research has been education in former colonies which continued to adopt curriculum from the western world undermining their own cultural values and language (Taylor, 2014).

Mixed methods research paradigm

By locating their research within a particular paradigm, researchers are provided with an underlying philosophy, and methods and designs to guide their research. Many studies these days have both, empirical and interpretative data and use multiple paradigms as guidance. Treagust et al. (2014) describe a variety of reasons a researcher chose not to commit to one specific paradigm: stakeholders' demands, doubtful practicality of a paradigm, through triangulation, and establishment in dominant post-positive academic world. Greene (2000) claims that practitioners, particularly in education, have been using various methods because of the practical demands of their working environment. They tried at the same time to identify patterns in their workplace along with insights, reasons and explanations of these regulations. Researchers considering multiple paradigms in their research need to understand the philosophical bases of various paradigms, and how they are going to influence their methodology (Greene, 2000).

3.2.2 My choice of paradigm

In the following section I try to describe the reasons for my choice of research paradigm. The three paradigms - post-positivist, interpretivist and critical - had an effect on me and my research, so it could be considered multi paradigmatic; however, it was mainly influenced by an interpretivist stance.

Treagust, Won and Duit (2014) note that many educational research books do not have any discussion about research paradigms and theoretical explanations; they rather explain qualitative and quantitative procedures. Somehow intuitively, I came to understand that since my research was about constructivism, I possibly needed to choose a corresponding philosophical stance and paradigm. However, given my mathematical background, it did not seem a right way to go on about research, despite what my newly created knowledge was telling me.

Until enrolling in this degree, in my formal education I was mainly exposed to mathematical and logical problem solving. Even when learning English in my twenties I was guided by my highly organised and rational strategies. A post-positivist stance is methodologically rigorous and neat and finding a correlational explanation was what I wanted to achieve in my study.

Post-positivism gave me a reassurance that I would be able to design my research and follow protocols and procedures easily and without any fuss. Statistical analysis was something I was already familiar with, and appeared easy to apply, and ensure a rational explanation of my educational phenomena.

Taylor (2014) points out that some academics are concerned with the technical side of their research, while others prefer a philosophical perspective. I started my research being rather concerned with its technical nature. I was excited with the possibility of designing some innovative teaching and learning and changing students' opinions about mathematics. However, the methods I had in my mind were rather quantitative. While I tried to apply constructivist approaches in my classroom, positivist and post-positivist stance appeared to be most suitable for my research (or possibly in my eyes, for any research).

To capture the change in the students' attitudes, I would distribute the survey, and qualitative data obtained through observations, journals and interviews, which were supposed to be analysed for the constructivist learning environment survey scales, and later reduced to statistical figures. My plan was to collect information in an organised way, using tables and charts, which would be analysed statistically. Looking for a pattern was supposed to reveal tendencies in my class. My thinking was influenced by my logical nature and strong mathematical background. Solving any problem was cracking a code for me and a post-positivist paradigm was a natural fit for me. It is not difficult to understand why empirical methods and 'objective' analysis appeal to researchers with a scientific background. Analysing data mathematically gave some certainty note to my research, identifying evidence, patterns and correlations gave some objectivity to my study, and claiming some kind of truth (Taylor, 2014).

As I started my research I became increasingly dissatisfied with my limited choice of methods and the means by which I was analysing data. My tables and charts did not capture the sparkle in students' eyes when a problem was solved and it did not tell of their disbelief that actually they enjoyed mathematics lessons. They did not talk about the students' persistent advocacy of their friend's actions. I felt that my impressions of the students were not given enough significance. I needed to change my perspective to account for my constructs of the classroom interactions, and to give validity to my interpretations of the students' behaviour.

At the very beginning I did not plan for my research to be critical; I was primarily concerned with the technical and creative nature of the curriculum applied in my classroom. As the chosen referent, the constructivist learning environment survey, included a critical facet, and one of my concerns was the cultural appropriateness of my teaching strategies, gradually I created a more complex picture of my classroom, where one aspect could not be taken out and studied on its own. My teaching was concerned with the distribution of power within my classroom, and I tried to teach children to take responsibility for their own learning. The classroom was a place where I wanted them to feel comfortable and able to raise their concerns. Some of my lessons focused on social issues; although, the transformative effect was possibly slight. Nevertheless, to a small extent the research was guided by critical paradigm.

As I brought my investigation to an end and turned around, I saw the major influence of interpretivism. The interpretivist stance helped me become more aware of others' constructions and acknowledge multiple realities. I was looking through various lenses of culture, social setting and my bias to try to make sense of phenomena and interactions. I tried to comprehend what is happening in the students' heads and to understand their actions 'from the inside' (Schwandt, 2000). I tried to make sense of other people's explanations and actions, and create a deeper understanding of myself and others. Everyone has different cultural, social and ethical backgrounds which influence the way he or she construct and present our understandings. While I used quantitative methods, they are interpreted in collaboration with qualitative data to produce a richer understanding of the phenomena in the classroom. I tried to embrace my critical side; however, its effect appears to be visible to some extent only in specific areas of my teaching. Here, I tried to justify my choice of the chosen paradigm (s), but I am not sure if I chose it, I think the paradigm found me.

3.3 Research aims and objectives

The main goal of the study was to investigate the implementation of a constructivist learning environment in a Year 7 boys' class in an international school in Qatar. The class was observed for one teaching year. Students' involvement in the class and my ability to effectively implement the constructivist learning environment were evaluated. Classroom activities were guided by the scales of the CLES: personal relevance, negotiation, students control, critical voice and uncertainty.

The specific aims of the study:

1. To determine the effectiveness of the implementation of the constructivist learning environment.
2. To evaluate the students' reaction to the constructivist learning environment.
3. To determine the cultural appropriateness of the constructivist learning environment in a boys' Arabic mathematics class.

Research questions:

1. How effective was the implementation of the constructivist learning environment?
2. How did the students respond to the constructivist learning environment?
3. How culturally appropriate was the constructivist learning environment in a boys' mathematics Arabic classroom?

The effectiveness of the implementation of the constructivist learning environment was investigated in terms of the success of putting the constructivist ideas into practice. It was examined through my reflections and the students' responses to the CLES and the environment. The students' response to the environment was examined through my interpretation of their behaviour and actions.

The Year 7 course was following the British National Curriculum and the topics included

Number and Patterns, Representing Data, Fractions, Decimals and Percentages, Measurement, Symmetry, Probability, Formulas and Equations, Coordinates and Line graphs, Angles and Constructions. The curriculum was expected to be delivered in that order because the assessments included specific topics. There were three streamed boys' classes. After Year 9 the high achieving boys' class was following an accelerated programme which would allow students to complete all their examinations one year earlier. Consequently, there was an expectation that the programme should be completed at least in the high achieving class. I have to say that I did not particularly feel constrained by time as we had four lessons per week and teachers were trusted that they would do their best to finish the syllabus, without the obligation that they had to do it.

3.4 Implementation of the constructivist learning environment

The constructivist learning environment implemented in this study was modelled after the constructivist learning environment survey, which was introduced in the previous chapter. Chapter 2 explains the effect in teaching of radical constructivism, social constructivism and critical constructivism. They are tightly connected and their implications are frequently overlapping.

The CLES consists of five scales: personal relevance, shared control, critical voice, negotiation and uncertainty, and the classroom and curriculum organisation was guided by these scales. Some ways in which radical constructivism, social constructivism and critical constructivism have influenced my teaching were discussed in the previous chapter. My interpretation of the scales and the additional ways it shaped my teaching and learning are summarised below.

Personal relevance

The personal relevance scale refers to the opportunities that students have to relate their previous knowledge and real life experiences to the construction of new knowledge (Taylor, Fraser, & White, 1994). The items in the CLES related to the personal relevance scale include:

- I learn about the world outside of school.
- New learning starts with problems about the world outside the school.
- I learn how mathematics can be part of my out-of-school life.
- I got better understanding of the world outside school.
- I learn interesting things about the world outside of school.

In my eyes, the personal relevance scale items have an extensive and wide interpretation and include strategies that account for students' pre-instructional conceptions. A teacher needs to be aware of any ideas that students have about the new topics, regardless of whether they are in line with mathematically accepted knowledge or not, as she or he needs to choose an appropriate starting point. By using familiar ideas, a new topic will look more approachable and less abstract. I tried to include activities, which, from my point of view, were related to the students and their interests. I have to acknowledge that students have a wide range of interests and what to one student may be personally relevant, will not necessarily apply for the

rest of the class (Appendix 1 includes students' responses on the question about their interests). I was using a variety of strategies to bring out their prior understanding about the topic, including, questioning, discussions and diagnostic tests. Power point slides frequently included the students' scanned work, which they found personally relevant not only because it was accessing their previous knowledge, but because they felt they personally contributed to the lesson and discussion (Appendix 2 includes some examples of power point slides of the students' work which were used to initiate discussions).

Further, in order to make mathematics meaningful and stimulating, I tried to include their personal interests while creating classroom activities. For example, many students liked football (soccer). Activities included the investigation on favourite sport in the class and the questions regarding the football coopetition organisation. I wanted students to think how mathematics was linked to the real world beyond 'obvious' connections. We discussed how we would spend £300 million to buy new players for a team. The question did not only explore the creation of the team, but the issues of maximising the profit, and considering various expenses and returns. I used the opportunity to promote mathematics and its applications. A study in the United Arab Emirates which investigated the effect of games in the college-level mathematics classes found that classes involved in mathematics games perceived statistically significantly more teacher support, involvement, personal relevance, enjoyment of mathematics lessons and academic efficacy. Further, the results indicated that student enjoyment of mathematics and their academic efficiency were greater in classrooms with more personal relevance. The study suggests that creative activities such as games could be used in mathematical classroom to improve the classroom enjoyment and students' attitudes towards mathematics (Afari, Aldridge, Fraser, & Khine, 2013). Games and quizzes were used in our classroom.

I considered any reference to their culture or religion as personal relevance, as possibly Arabic and Quran were the only subjects considering these aspects of their lives. The students were proud of their culture and many took personally Arabic involvement in mathematics. They had a chance to investigate and do presentations on various mathematicians. I used every opportunity to emphasise Arabic involvement in creating mathematics. We discussed the Arabic number system and recreated Islamic art. There were many references to the Arabic culture including the posters around the classroom and the dates on the whiteboard which were written using new Arabic numerals (numerals currently used in the world are considered old Arabic numerals).

One corner of the classroom had a newspaper display including mathematical features from sport, finance, advertise, politics, etc. Some of the examples were used in the lessons.

Uncertainty

The uncertainty scale refers to the extent to which the students have an opportunity to experience mathematics as the variable entity which is the product of different people and cultures. The CLES items which correspond to this scale are:

- I learn that mathematics has changed over time.
- I learn that mathematics is influenced by people's values and opinions.
- I learn about the different kind of mathematics used by people in other cultures.
- I learn that modern mathematics is different from the mathematics of long ago.
- I learn that mathematics involves inventing theories.

Students had an opportunity to learn that mathematics structures were created by people and culture from all around the world. Mathematics is what people do including all imperfections; therefore, it is shaped by different cultures and real people (Ernest, 1991). For example, we learnt about various multiplication methods: Russian, Chinese and Egyptian. The way long multiplication and division are represented in my home country, namely, Serbia, is slightly different than in Britain and Australia. We learnt how mathematics changed over time. One example included the construction of π and how it took centuries to come up with the formulas which are in use today. The students had opportunities to experience mathematics as fallible and not always offering the perfect answer. What was acceptable at one point of time may not be true in the future. I told them legends and stories about mathematicians, portraying them with human characteristics (Galois and the duel he did for love). Pythagoras killing his student because of the difference in opinions and the story about a mathematician, who caused his company's huge financial loss and ended up in jail, were some of the examples showing the fallibility of mathematics and mathematicians. I was careful to use the words create, construct and invent, as opposed to find and discover. We even had a little discussion about parallel lines and non-Euclidean geometries. I tried to communicate that the 'correctness' of mathematics depends on the situation. Some of more 'mathematical' examples included rounding, imperial units and measuring.

In our classroom the contribution of Arab mathematicians was recognised, especially in algebra. Islamic art and its connection to mathematics were explored. After observing similarities between 'regular' numbers (1, 2, 3 …) and Arabic numbers (١,٢,٣,...) students recognised that that our standard numbers are Arabic as well.

I was fortunate to have students in my class from various backgrounds. Many of the conventional mathematical symbols are not in use in every culture. My students used a variety of multiplication and division, or decimal point symbols. Further, in Arabic, billion is a different number than in English and we explored the reasons behind this occurrence. I was able to relate to these examples as in Serbian, my mother language, there is a similar structure. These examples helped expose the uncertain facet of mathematics and identify the importance of the subjectivity impact in the creation of mathematical concepts and symbols.

Shared control

The shared control scale refers to opportunities where students are invited to share control together with the teacher, of their learning, including curriculum, activities and assessments (Taylor et al., 1994). The items in the CLES related to the shared control scale include:

- I help the teacher to plan what I am going to learn.
- I help the teacher decide how well I am learning.
- I help the teacher to decide which activities are the best for me.
- I help the teacher to decide how much time I spend on activities.
- I help the teacher to decide which activities I do.

The shared control scale was implemented partially as the school followed the British National Curriculum and some specific topics were included. I needed to 'cover' the topics in a certain order as the assessments were planned to include specific areas. I was able to introduce different topics only if the completion of the required topics was done. On the positive side, while 'covering' topics we spent as much time as we felt it was necessary without the obligation to finish everything at the same time.

The shared control scale was implemented by giving the students an opportunity to build their own understanding of the concept. I tried to communicate that they had power over their own

learning by encouraging them to come up with their own solution and methods rather than asking for conventional techniques to apply. Other strategies focused on providing the student with choice: select your own problem, choose three options before asking me for help, and create a question, given the answer. If they finished their work early, they had a chance to choose a problem from a range of topics not necessarily related to the current topic. As a revision tool, the students were asked to create a topic test and a marking key, which could be a complex task. Some of their questions were included in the test.

Further, the students helped create the assessment framework. First, they were provided with the anonymous reports completed by other students and tried to analyse them. In groups, they came up with a list of weak and good points about the reports. We summarized their findings in the table which consisted of the success criteria in a specific topic and was used as the assessment framework. The framework was given to students and displayed on the wall for self-evaluation. It was included in the assessment to evaluate their own or each other's work.

Critical voice

The critical voice scale refers to the extent to which the students have an opportunity to question the teacher's approach (Taylor et al., 1994). The items in the CLES that correspond to this scale include:

- It's OK for me to ask the teacher 'why do I have to learn this?'
- It's OK for me to question the way I'm being taught.
- It's OK for me to complain about activities that are confusing.
- It's OK for me to complain about anything that stops me from learning.
- It's OK for me to express my opinion.

I tried to establish a positive climate where students felt it was appropriate to inquire about the strategies used in the classroom. They were invited to express their opinions about my teaching. Additionally, I encouraged them to make meaningful suggestions for the classroom activities (pizzas and parties every week would not be considered as a meaningful suggestion). I tried to understand and accept their opinion and incorporate any recommendations that were appropriate. I tried to reassure the students that I would not interpret their actions as rude, and

would try my best to understand their intentions. Despite the constructs such as of non-Euclidean geometry and the Gödel Incompleteness theorem which contributed to the view of mathematics as fallible and humanly constructed, the myths of cold reason still shape the way we see mathematics and preserve its apparently absolute nature (Ernest, 1991). Consequently, in the classroom the teacher still acts as an informer, the goal of the arriving at the correct answer is seen as a sufficient motivational goal, and mental activities and creativity is frequently disregarded. In my classroom I talked about the inadequacy of the formal assessment and the examination, pointing out that that they tend to assess just a limited number of skills and concepts. The book, teachers and the internet are not without faults. After all, they are created by humans and as such prone to mistakes and different interpretations. Just because we need to use a specific book and do a formal assessment, it does not mean that they are perfect and without flaws; no one could possibly know our needs better than us. We had many formative assessments on which the students were able to reflect. I was regularly expressing my values and beliefs about mathematical education and I talked about my course and how it affected our classroom. Students were invited to share their opinion about classroom activities and to suggest their ideas.

Negotiation

The negotiations scale refers to the opportunities students have to express their ideas to other students and to understand other students' ideas (Taylor et al., 1994). It was one of the main features in the classroom. The items in the CLES related to the negotiation scale include:

- I get the chance to talk to other students.
- I talk to other students about how to solve problems.
- I explain my ideas to other students.
- I ask other students to explain their ideas.
- Other students listen carefully to my ideas.

Students had opportunities to work in pairs and help each other. Sometimes, the students sitting on the right side were asked to explain the problem, followed by the students sitting on the left. Another activity employed was the market place. The students in pairs formed a circle. Each pair consisted of an A and a B student. The sheets with the problems were placed on the wall

around the classroom and students usually used whiteboards for explanations. If the pairs worked well I kept moving them in the same direction, otherwise As were moving to the right, and Bs were moving to the left. I walked around and helped if it was needed. Pair teaching is another way that may promote a deeper understanding. The students who act as tutors go through the process of clarifying their personal views and a chance to represent them in a variety of ways. Tutees have a chance to observe the situation from another perspective. The teacher as a provocateur is an appropriate metaphor that could be used in the classroom. The teacher challenges and provokes the students with the activities and questions by putting on and displaying the skills and concepts that students are capable of gaining. Students frequently worked in small groups creating and negotiating their knowledge. Later their constructs were open to scrutiny and negotiated in the whole class. I was communicating with them individually, within the groups and as whole class discussion. Students were asked to explain and justify their ideas. Sometimes I was presenting my solution as a part of the class discussion. Frequently, I was challenging the students' beliefs with provocative assertions and encouraging them to prove or disprove them. Occasionally, we would organise a formal debate to resolve an issue. The students were divided into teams to investigate and discuss the problem followed by the presentation from the teams. The whole class was involved in questioning and evaluation. Pair teaching was used where students were teaching and explaining concepts to other students. By having to explain their way of thinking their understanding and retention of the concepts were increasing. All these activities emphasise the social aspect and negotiation of mathematical knowledge.

Mathematical knowledge is socially negotiated and is validated within the mathematics community. In the class I encouraged negotiation through discussions and debates. I challenged the classes to prove or disapprove statements, or provoked them with the questions with an 'obvious' answer, for example:

1) *0.999…<1*
   0.999…=1
   0.999…>1

   Which statement is correct? Explain your reasoning.

2) *During the book fair the price of a book first went up by 10%.*

   In the second week; however, it went down by 10%.

"Oh well," said Amir, "at least it is back to the amount it started with."

Every new concept or method were negotiated and validated in a whole class discussion before being accepted for the future use. At times I was an equal participator in the discussions offering my point of view. It was an issue that I personally experienced as problematic because I did not want to explain a concept in a traditional manner. My explanations were not always accepted as the most appropriate. More often, I used these situations to shed a different light on the mathematical strategies and guide students via my thoughts, how would 'old me from my primary school' approach this problem. Additionally, I used these situations to explore what mathematicians consider to be a proof.

3.5 Participant observer strategy

The strategy of a research can be described as the most appropriate way of obtaining the material needed for the study. A strategy connects the researcher to the specific methods of collection of data, in my case observation and interviews (Denzin & Lincoln, 2000). The strategy I employed in my study is best characterised as participant observation which involves participation and observation of a phenomenon. The classification of various observations could be based on the level of the involvement of the researcher in the research site: complete observer, observer as a participant, participant as observer and complete participant (Cohen, Manion, & Morrison, 2007). Atkinson and Hammersley (1994) argue that in order to study a culture, in this case a classroom, one has to be a part of it. On the continuum from complete observation without attachments, and complete participation, my role was nearer the complete participation end.

This study attempted to understand the classroom as seen from the students' perspective. The participation observation method was an appropriate way to conduct it as it gave me an opportunity to experience the classroom as a participant, while still trying to observe and analyse.

The researcher is a part of a natural ambient and life and it helps her construct a meaningful explanation. There is something unique in being a participant observer compared to other research strategies. The researcher, in anticipation and with excitement, can see the effect of her own actions from an inner perspective. I could accrue an understanding of the classroom

that only can be gained from personal experience. Prolonged participation observation allowed me to view events not as separate entities but as a part of the classroom culture. It allowed me to get the feel for the classroom dynamics and create a holistic understanding of the class. I was able to recognise some cultural aspects, and observe who students interact with and grasp the way they relate with each other. Consequently, my interpretations had greater credibility.

The participant observation usually takes place over a prolonged period of time and gives the researcher a chance to establish a close relationship with the participants. From practical point of view, participant observation enabled me to conduct interviews and collect survey data at my and students' convenience. Further, the research is taking place in a natural environment and the participants are more likely to act naturally. In a long run, students were less likely to act in a certain way when they were aware of being observed (Cohen et al., 2007). As a teacher observer I had a smooth access to the fieldwork. I had already been in the school for four years, and was familiar with the staff, students and procedures within the school. I was actively involved in the school life. For the students I was just another teacher for the year. For me, primarily, I was doing my ordinary job, and the observed class were just another class I was teaching that year.

Participant observation helped me gain an understanding of social and cultural context and norms. I tried to create meaningful constructs of students' behaviour and actions based on my observations, and place them in a more complete context of the classroom, school and culture. In that journey, I relied on all my experience within the school and country. At times, I focused on the cultural and social side of life, to help the reader gain a better understanding of the setting and background. Therefore, while my observations predominantly came from my classrooms, they included my observations of everyday life.

I encountered two main difficulties. One is getting close and personally involved with the students, which possibly many teachers may report as negative. From one perspective if a researcher is not close and fully involved within the native everyday life and culture, they may not understand it. On the other hand, becoming too close to the participants may result in the loss of objectivity (Clandinin & Connelly, 2000). One way to re-establish my 'objectivity' was through writing reflective notes. Clandinin and Connelly suggest composing and reading field notes to detach oneself from the field. Reliving the events all over again and trying to create meaningful constructions gave me a chance to (temporarily) distance myself from the

classroom. Another problem was rather of a technical nature. As I was teaching the research class (and other classes), I found taking the field notes and writing up observations a difficult and time-consuming task. I relied on my ability to recollect the account of events. Additionally, I needed to be organised and try to write my notes regularly.

3.6 Data collection and analysis

In order to answer the research questions I collected quantitative and qualitative data; although, the greater weight was given to the qualitative data collected. Quantitative data included responses to the CLES which was carried at the end of the study (Appendix 3 includes the CLES questionnaire). In order to make our research rich and meaningful, Guba and Lincoln (1989) suggest greater inclusion of qualitative data which included mathematical and nonmathematical tasks, classroom observations and reflective journals, lesson plans, informal discussions, audio taped interviews with student participants and personal stories.

Mathematical tasks included everyday classroom activities and MyMaths tasks. MyMaths is an interactive online teaching and homework website which our department used occasionally to set homework. Students could independently access any topic and I as the teacher was able to track their progress regardless of the set homework. Non-mathematical tasks asked questions about the students' interests, mathematics and its purpose, and the purpose of the mathematics classroom. Students' words from the non-mathematical tasks were used in the exact form (Appendix 4 includes examples of students' responses to non-mathematical tasks).

Reflective journals were used to express my thoughts and feelings about the study. Personal stories are my particular memories which follow my change as a person and teacher, and helped me better understand some of my past, my reflections and mental struggles. Classroom observations and informal discussions with students during lessons were recorded in a journal. I could not claim that the events that took place in my classroom and the interpretation of these events are factual or valid, and through reflective writing I tried to expose myself. I wanted to be as transparent as possible with my ideas and intentions. It is not possible theoretically nor practically to identify to what degree my subjectivity and biases are acceptable, and my reflective writing is not an attempt to control my bias, but to make my experiences and values visible to the audience (Ortlipp, 2008). Through the reflections I questioned the way I collected

and analysed the data. For example, I re-examined my idea of not taping the lessons. As a result of my reflections I abandoned a post positivist way to collect data using tables and charts, and statistically investigate them. Reflective journals were used to a great extent while analysing and discussing my research questions, especially those related to the cultural perspective of my teaching and learning. Reflective journal writing enabled me to acknowledge and understand the events and people from my life which shaped my role as a teacher and researcher, and to include those while analysing my findings. My reflections did not only serve the purpose of increasing the credibility of my work; they contributed to change of the research process and helped answering the research questions.

Semi-structured interviews were used to generate additional data about the effectiveness of the implementation of the CLE. In structured interviews, the questions are pre-established and have a limited set of responses. They tend to be less flexible compared to semi-structured or unstructured interviews as interviewer is not in the position to improvise and follow inquires created during the interview. Less structured interviews attempt to understand behaviour of participants without restricting and categorising their responses that may narrow inquiry (Fontana & Frey, 2000). My students were young and there was a danger that they would feel anxious in a formal conversation outside the classroom, and possibly be too aware of how they act and what they say. I wanted to avoid that. My intention was to make them feel relaxed and interpret the situation just as another regular conversation with their teacher. Therefore, I did not want to adopt a formal style of interviewing. While I had pre-planned questions I wanted to explore, I did not mind deviating from my key questions and talking about students' interests that were generated during the interview. When appropriate I used humour and encouraged students to talk freely. Before the interview they were given the option to have another teacher present, which all of them declined. During the last term I interviewed all the students who wanted to participate. If students did not express their opinion about the CLES scales aspects of the classroom on their own, they were guided to talk about these. The interviews given by the three target students were presented fully. The information collected in that way has different validity than those presented in my stories, and I felt I wanted the reader to be aware of it; therefore, the interviews are presented differently, in the monologue form, with my voice being excluded. The interviews given by other students were partially used in the results and analysis part. I listened to the conversations and included only parts which I thought were relevant, 'which made me think'. For example, despite my best efforts, the responses from one

student were mainly 'Yes Miss', 'No Miss, and 'Maybe'. Consequently, not much information from that interview was used. On the other hand, some students really opened up and talked about their issues, and such responses were included to a greater extent. In order to give the students a voice I used their words from the interviews in their exact form in my presentation and analysis. For a better flow, occasionally, couple of words were omitted ('hmhmh' or 'miss'). The information collected through these practices served as a basis for my stories.

(Appendix 5 includes interview with the three foci students).

3.7 Ethical Issues

The principal of school and the head of mathematics department were informed in writing about the study in advance, and all relevant details, including consents and appropriate ways of communication with parents were discussed.

The principal, the head of department, students and parents were informed in writing about the aims, nature and procedures of the study. The students and the parents were informed that they have right to withdraw from the research, or not answer particular questions any time (Cohen et al., 2007) (Appendix 6 includes the letter of consent). An information evening was organised where a translator was available. The written consent of the students and their parents was obtained. The students were not identified in the study. Additionally, the study was approved by the Human Research Ethics Committee, Curtin University (Appendix 6 includes the approval of the Human Research Ethics Committee).

3.9 Participants

The participants for this study consisted of my Year 7 Boys class as allocated by the school. There were three Year 7 boys' classes and this class was considered to be the top academic class. I selected that class for the study as they were new to the secondary school and I perceived them to be the easiest to implement any changes. Initially there were 21 students. The majority of the students were of Arabic origin, one was from Romania and one from Indonesia. Students of Arabic origin came from Qatar, Syria, Egypt and Jordan. One student left during the last term. Usually groups were of three, four or five students: Adil, Alex, Noah, Fadil and Oliver;

Nazir, Archie, Imran, Laith and Leo; Max, Kyle, Harry and James; Ahmad, Tyler, Lucas and Fahim; and Habib, George and Joshua.

I did not allocate the students to their groups; they did this by themselves. The general atmosphere in the class was rather positive. Some boys were happy with what was going on in the class and a few of them did not like the way I was trying to conduct our teaching and learning. However, most of the time they were polite and tried nicely to bring up any issues they had. I often felt that there was that nice flow you have with the class of students with whom you click. The classroom was always noisy. Despite having quite relaxed rules, only a couple of times during the year, I had to talk to someone regarding his behaviour.

The foci students for this study were Adil, Nair and Max. I could not claim that my choice of Adil as one of the focus students was random. Adil was chosen because of his good mathematical learning ability. Sometimes, he reminded me of myself at the same age. I thought that he was responding well to the constructivist environment. Max, however, always complaining, was at the other end of the scale, and Nazir somewhere in the middle. When choosing the foci students, the class was divided into three groups depending on the boys' responses to the environment, and Max and Nazir were chosen randomly.

They were chosen after about four weeks into the study. I realised that I could not follow the entire class in depth, and decided to concentrate on three students for closer investigation. I still included the responses from the rest of the class so that the reader can get the feeling of the entire environment. I wanted to investigate the students who at that moment displayed diverse responses to the constructivist learning environment.

3.8 Setting

It was rumoured that in the past the school had asked the Ministry of Education for a four-day working week. No one knew if it was true. It was an international school and was quite relaxed with its approaches. It had an excellent academic reputation; the majority of the graduates ended up in prestigious universities across Europe, Australia, America and Canada, while a significant number enrolled into universities in the Middle East region.

The best words to describe the mathematics department are high-achieving and hassle-free. The results were the best in the school for a number of years, and the staff was trusted to do their best. While a number of professional development courses were organised each year, the atmosphere was calm; the general feeling was 'why try to fix something that is not broken'. As I never felt pressured by the head of department to follow rules or achieve certain standards, I gladly spent a big portion of my weekends in school, touching up displays, and preparing my lessons. Hm, maybe it was just a part of his strategy to get the best out of his staff.

There were about 1000 students in the school and the school approach was reflected in its students; the majority were cheerful and motivated. A high percentage of students, up to 90%, were of Arabic origin and about third of them were Qataris. The rest, maybe a couple of students per class, were from Indonesia or Europe. The majority of the students were from high socio-economic families. In the secondary school the playground was divided into the boys' area and the girls' area. Despite the heat, many boys played football on the field. A couple of the girls might be watching; they were not allowed to play together with the boys. The rest were usually sitting in the shade and chatting.

'It does not look like a mathematics classroom.'

Students were usually surprised the first time they entered the classroom. They would wander around the room looking at the pictures, models and posters. The first thing that struck you was the wall with brightly coloured pictures of mathematical shapes from nature, and Islamic art. 'Why are you using Islamic art and Arabic numbers Miss, they are not related to Mathematics', was the response from my students. I picked up the pictures from the art department when they were about to be thrown away. I struggle to throw things away. Every now and then I tried to declutter my room and each time I decided to keep everything. Books, postcards, magazines, art work, old resources tossed away by other teachers, random things from garage sales, they all found place in my classroom (and my home). 'You never know when you are going to need them' was my philosophy! Everything was carefully organised apart from my desk. It was a place that suffered at the expense of everything else. My desk was in the front left corner. Every couple of weeks it would be cleaned and organised and then gradually it would get occupied by books, files, folders and papers. I was forever trying to find better and more practical ways to organise the classroom, and the shelves and desks would get moved around.

At the back of the classroom was a display about mathematicians from around the world, and their work. Next to it, a mathematical strategy was featured. The Handshake problem was displayed exemplifying a number of strategies: check simple problems, roleplay, draw a diagram and create a table with values. At the front of the classroom was the newsstand display featuring current global and local news related to mathematics. A number of featured articles and graphs were related to football. Saying that I like football is an understatement; I discussed it eagerly with the boys at every opportunity. Next to the newsstand display was the list with the classroom rules. The classroom was rather small. I always wanted a bigger classroom. I think all teachers want a bigger classroom. The desks were roughly arranged into five groups with not much space between them. At the start of the day the first desk was about a meter and a half from the front wall. During the day students edged closer and closer to me, until I was not able to fit there anymore, and then I would have to start shifting around the room.

Adil

I remember meeting Adil for the first time. There was a mathematics competition, and Adil, a Year 6 student was competing with Year 7 students. He took second place and everyone was pleased with the result. In contrast, Adil unhappily accepted the reward, and later tried to explain: 'But I just made a silly mistake, I knew the method.' His animated, black eyes were filled with the tears.

Adil had a natural inbuilt understanding of mathematics the way it was supposed to be understood (This doesn't sound very constructivist, does it?). He understood how it works and what the connections between various concepts were. I never had any problems communicating my ideas to Adil. He did not get incorrect solutions due to his thinking; occasionally he would make a non-conceptual mistake. He did not always get the solution but he would never offer me a wrong one.

Everyone in the class knew that Adil was good at mathematics and at the beginning of the year, his explanations were rarely questioned. He was sitting with Alex, Noah, Fadil and Oliver. Oliver left towards the end of year. They were good friends, sitting together in other classes, choosing the same afterschool activities and spending their breaks together. Oliver was an able mathematician as well, having a stress-free approach to it and enjoying its challenges. He

accepted and respected Adil's supremacy but at the same time had his own world. I could see him liking and finding something interesting in all his subjects. On the other hand, Adil's efficiency somehow awakened the mathematician in many students in the class, especially Alex, Fadil and Noah, who was the weakest in the group and craved more structure and rules in lessons, though in this environment he really tried to let it go. The three boys tried to adopt Adil's attitude and to their own surprise very often they succeeded in their approaches.

Nazir

Nazir was a bright chatty boy. Tall and athletic, he played a wide variety of sports. He would spend every break showing off his football skills. However, in the classroom he was the exact opposite, taking mathematics very seriously. He was quite confident of his skills, with a good reason. His sister thought that he was an excellent mathematician and hopefully was going to do engineering. Nazir's view of mathematics was rather rigid, and he was taken by surprise with some things happening in the classroom. His best friends were Archie, Imran and Joshua (occasionally they would sit together in the class), but during the class time, most of time he sat with Archie, Laith and Leo. I tried to have relatively flexible rules regarding the seating plan and they were the only students in the class who did not always sit together. Everyone else seems to be working with the students they wanted to work with. They decided to sit together only occasionally (Nazir and Archie decided that). They were all capable learners of mathematics.

Max

Max was a lively boy, trying to do everything perfectly. He was a small boy, with big brown eyes and blonde hair which was always going to his eyes. Because of his height the other students would often make fun of him physically, which in turn he did not mind at all. I had to intervene at one point and talk to his tutor teacher as I was worried that the boys would get carried away and literally carry and drop him. In contrast he would not allow anyone to make fun of him verbally. He would get quite fierce and argumentative. It had to be said that he was never mean. He was supportive, always staying loyal to his friends. His best friend was Kyle who was somehow very similar to Max behaviour-wise. Very often they would have little

disagreements, and be upset with each other, only to be drawn to each other after couple of minutes. Interestingly, they had the same approach to Mathematics. Max sat around a table with Kyle, Harry and James. He was one of the students who were not happy with the changes. While Max enjoyed the discussions and was happy to share his views, he, like a few other boys in the class (Kyle, George, Joshua, and Tyler) did not like mathematics classes without the rules given. Harry and James were the exact opposite of Kyle and Max and in their little group they complemented each other. At times, I thought that Harry had got his hand on some of my university work and assignments and acted accordingly; he would use the same wording to describe a situation as I had used in my assignments. He was helping James who was a bit shy, and had a lot of patience with Max and Kyle.

The teacher

Our view of the world is based on our background and all our experience. I have talked about my understanding of radical constructivism, social constructivism and critical constructivism and how it shaped my teaching and learning. In this part I introduce myself as one of the participants. Before I go into greater details regarding my role as the participant observer, I talk about my childhood and the early beginnings of the development of my mathematical and critical side. I want the reader to get to know me, the way I grew up and how I was shaped as person. My intention is to explore my biases, and possibly offer a partial justification for the choices and actions within my classroom. Even in the case of critical constructivism, there is no one universal good and right side. Everything is subjective, and here I am trying to open myself up in order for the audience (and me) to better understand me and my interpretations, and to allow the reader to form his own understanding of the events. Similarly, as in the other parts of thesis, I use multiple ways to express myself; although, overall the tone is rather personal and subjective. I include my thoughts and reflections, and represent myself as a person by exposing my problems, and occasionally poking fun at myself.

The teacher then

My childhood was like a dream; my uncle visiting from Australia, once described the place as heavenly. I grew up in a small village in Bosnia, before the war in the 90s. Our house was next

to a creek, which would become a wild river in the autumn. Frequently, across the stream, we would see deer grazing. I was the only girl in my family, with two younger brothers. My parents were quite feminist considering the place and the time of my childhood. The opportunity to go to the university was not open easily to everyone for a variety of reasons. Some students did not even go to the secondary school. My parents were different, I do not know why; maybe, because they were teachers. They believed that I needed to develop academically because I was a girl, not despite. Frequently, they said that the boys had other options as they were physically stronger, but as a girl, I did not have a choice; I needed to be a good student. I was blissfully unaware that other girls did not have such treatment at their homes. Even my younger brothers shielded me from any physical work:

'Seko (little sis), this is too hard; you should not be doing this.'

My brothers turned to me for all their problems and concerns, from seeking my shelter if gypsies were passing through the village, to never smoking, as they heard from me that it was not good for one's health.

'Seko, something weird is happening. Do not tell anyone. I have some hair growing under my arm.' I was relied on completely with the advice on every possible issue.

I was able to learn and express myself freely. For a long time I thought it was the norm; that all girls are cherished and trusted as I was.

I was forever arguing with my mum. Our opinions clashed; I was always struggling to see her point of view. I recall arguing with her about a school trip and her plans as a teacher at the school, to take another student instead of me. I was the leader of the school dancing group which meant that I was in charge of its management and organisation: auditions, rehearsals, dancing routines, everything. We were competing and were about to take part in the state competition. There was one extra place on the trip and naturally I thought I would be going; after all, I made it happen. However, my mum - the music teacher - had different plans; she had decided that another girl, Branka, would go. She tried to explain.

'I know darling that you did a lot, but this is not the first trip and definitely not last trip for you. You already attended two competitions this year, and will attend a seminar this summer. I am certain that you will get many other opportunities and Branka may not get another chance. You

cannot compare your situation and hers. She did what she could. Do not forget how far she lives; she needs to walk to school every day. Her parents may not even let her to continue with her school, and you know that your father and me are always going to support you. She tried her best and she will go.'

'I do not get it mum; I did everything and deserve to go.' I was talking slowly, word by word, as if it was the problem.

To my disappointment, she did not change her mind.

Or argument about miniskirts; she did not let me wear one.

'But mum, Vanja is older than me and she wears miniskirts. And what about Ljilja; she wears one.' I tried to make a point about my cousin, and my next door friend.

"I know, but Vanja lives in a different environment; Mostar is a big city and people do not care about such things. When we visit her, you can wear your skirts. You are too old to wear miniskirts here. Son (in my homeland, even girls are sons), people here are more traditional; you do not want to create an awkward situation. We need to be thoughtful about their ways. You noticed other girls do not wear miniskirts. And I am not Ljilja's mother, she is not my responsibility, you are my responsibility.'

'I do not care if they are traditional, I do not tell them what to wear. I want to wear a miniskirt.' I was aware that some of my friends were wearing *dimije*, traditional long skirts, but it was not my problem; it had nothing to do with me. I failed to understand my mum's reasoning.

I am ashamed to admit that it took me a long time to understand my mum's view about Branka, miniskirts or anything else. Her roots were not from that place and she spent her youth travelling. However, she quickly gained an understanding of people's lives, traditions and views and respected them. She was the only teacher who refused the gifts for the 8th of March, the International Women's Day. Instead, she organised students to visit and help old women, living in remote places.

I could not understand her viewpoints when I was young. I think it took me to become a mother myself to recognise her reasons for taking another student on the trip. She saw what the arrogant young me could not see: a young girl with a hard life who probably would not get another

chance to travel. My mother was a teacher in the small village school and she did everything to justify the trust placed on her by locals.

Did she instil in me some of her views? I think one needs to grow into these views. As a self-centred young person, I could not understand them; I needed to mature and lose a little of my haughtiness. I started seeing things differently as I grew up, and became exposed to similar situations, and found myself on the opposite side of the spectrum. I started seeing my childhood events with a different pair of eyes. People cannot be treated equally; they need to be treated according to their views and backgrounds. I do not think my mother could have passed on her views, as they needed to be experienced personally. Frequently, one is not able to see beyond her needs and her interpretation of the world. She possibly showed that a respectful and understanding attitude needs to be a part of our every situation.

My early mathematics memories are related to puzzles. My teacher was a never-ending source of brainteasers.

'Son, tell me quickly: how many fingers on two hands? How many fingers on 10 hands?'

'Which one true: the yolk is white? Or, the yolk is of white colour?'

'What is heavier one kilo of the lead or one kilo the wool?'

'There are a few cats in a room. If every cat sees three cats, how many cats altogether?'

The list is endless.

But it does not look like mathematics. Mathematics is not learnt through puzzles like these. Or is it?

At one point mathematics became for me a riddle. Or, should I say, the riddles become mathematics. I enjoyed it and wanted to get to the bottom of it.

'Son, look at this question, it is very difficult. How would you do this? Two large and one small pump can fill a swimming pool in four hours. One large and three small pumps can fill the same swimming pool in 4 hours. How many hours will it take four large and four small pumps to fill the swimming pool?'

The line between white yolk and mathematics is very fine, almost invisible. And at one point I wanted to outwit the problem.

How was my teacher supporting me? I do not recall now any explanations from his side, although others claim that he was good at it. I only remember these endless games which I was playing, and wanting to solve. Nothing compares to the moment when you do that. This is how I was introduced, enculturated to the world of mathematics. My teacher created a mathematical culture based on puzzles and riddles. There were not significant cultural bridges to be crossed; he explored my weaknesses, and accordingly, introduced mathematics to my world.

My teacher liked mathematics more, and he became a better mathematician because of me. In grade 7 he said that he could not teach me anything else, I knew everything he knew. By then, he had taught me everything he knew. Nonetheless, we both continued to grow mathematically. I did not follow any school prescribed curriculum; he provided me with a couple of different books with quite difficult questions which coupled new concepts with a great deal of thinking. The learning experience was pretty much in my hands. Or was it? My teacher could no longer provide me with academic support. However, he was challenging me and providing me with opportunities to show my knowledge. Together, we chose questions for the next day. Mathematics became a personal thing for me. Mathematics became a personal thing for him as well. I enjoyed it in the same way as one enjoys watching a football game. For every problem I used all my previous knowledge to resolve it. I was never tempted to have a look at the solutions at the end of the book; I knew I had to produce a new way of thinking. Sometimes it would take seven days, but there was always a way to be found. We even talked about the nature of mathematics; he believed in its certainty and I recall him saying 'mathematics exists out there, waiting to be discovered'. The overall experiences became our curriculum.

I suppose it influenced my teaching to a great degree. Mathematics is a big game, a big puzzle for me. I like challenging my students with little problems; I like them discovering that unexpected twist in mathematics. I try to help my students to develop this kind of understanding of mathematics. I want them to see how beautiful it is. Sometimes I am successful; they are amazed at how things work. They are challenged to find out why something works. They get creative while writing their own definitions. It does not always work. Some of them see mathematics as a hard, boring way to gain a university place. 'Why do we do this if we are not

getting it in the test?' 'Miss, it would be easier if you just tell us how to do this.' And there are 20 students in the class who expect you to teach them in such way. Maybe it does not work for everyone. It depends on the students' (and teachers') personality and his or her interest in mathematics. My teacher believed in the hard nature of mathematics, but it did not stop him from being quite a constructivist teacher. It depends on the students' expectations and their parents' expectations. And there are always many boxes to be ticked.

And what about the power distribution in the teacher-student relationship? When I was about 12 years old, my teacher admitted that my understanding of mathematics already surpassed his. The teacher does not have to be a greater expert than the student, as long as appropriate caring conditions for the student' development are meet. I am certain of that. Based on my experience, the equal power distribution between the teacher and the students is possible. However, how many schools and parents would accept the situation like that; the teacher not being as good an expert in mathematics, as the student. Of course the things are easier if he or she is an expert, but it is not a prerequisite. Today, there are too many technical interests to be served for something like that to be allowed: a specific scheme of work needs to be accurately followed and exams need to be passed. It is too easy to bring into the question the teacher's expertise.

Why did it work for my teacher? Was it because it was a long time ago in a quite informal setting; no one would harass him if some students did not follow the curriculum? Was it because he was my father and he was not accountable to anyone; my failure would not affect anyone? Was it possibly that being my father he had a greater incentive to push himself outside his boundaries? While there were a couple of students in grade 7 who were pushed beyond the border of the standard curriculum, none of them was a better mathematician than him. But then again none of them grew up with puzzles and riddles.

The teacher now

I was recently married, was pregnant and with one young child, and was forever reorganising my priorities and running around trying (and succeeding) not to be late. I was never happy with the ways I taught, or in fact I was never happy with anything I did. Once you become a mother, guilt become your second name. You constantly evaluate and think that there must be a better way to do things. You keep thinking that you should be a better mother, a better teacher,

a better wife, a better daughter, a better everything; one day you will get there. The kids should eat healthier food, I should spend more quality time with them, my lessons should be more interesting, and the list never ends. During my high school days, I lost my best mathematics skills; there were other interests in my life. I was still frustrated by that. I used to say that I had used to be a good mathematician (it may seem a little strange that a mathematics teacher does not feel like a mathematician). At times, my best skills were almost regained, but never completely. In more recent times, as a teacher, I have come to terms with the fact that maybe my role was not to create new things in mathematics, but rather to help my students become (good) mathematicians.

My role as the participant observer

I was the participant-observer and teaching the class I was observing; therefore, I could not make extensive notes during the lesson. During the lesson I would just make brief accounts, for example:

Nazir - enjoyed lesson, no real life, no mix, exam only

My timetable was helpful; almost every day I did not teach last period. Usually, that period was used to plan lessons related to the observed classes, or to write down my observations and any reflections, without any particular order. The brief records from the lesson would evoke my memories, and become more detailed notes. Sometimes I would write down as much as I remembered about the lesson, sometimes, I would just note one particular incident. Students' written responses were used in the exact form. These accounts, together with my journal notes were used for writing the stories. For example, the brief record produced the following story:

> 'Miss, I really enjoyed today's lesson.' Nazir said as he was packing up.
>
> 'Thank you, but you made it enjoyable for yourself.'
>
> 'I just want to say that I do not know what you mean by 'real life application'; we cannot do real life stuff in the class.'
>
> Usually, on the whiteboard I would indicate the date, objective and a real life application, or they would have to explore and explain a concept using real life models stuff.

'Why not?' 'This is a classroom, and the real world is outside, it cannot be mixed. I know we do things that look like real stuff, but they are not really real life things. Mathematics is just for the class, not the outside world. '

'So you are saying that nothing we do in the class will help you in the real world.'

'Not really, we just need to do well in the exam.'

Although, I did not recall the exact words, I thought that this story captured reasonably well my conversation and experience with Nazir and what I gained from it. These stories became material which was examined for the CLES scales.

In order to examine the data for the personal relevance I was looking for the incidents that indicated the way the students were building their knowledge and recalling their previous knowledge. I felt that independent thinking could be classified as the personal relevance as the student understood the problem as his own and personal and wanted to experience success by himself. Other ideas included working with real life questions and using manipulatives when solving problems.

In order to examine the data for the negotiations I looked for the episodes that indicated the students' participation in the class activities. I looked for their interaction with the other students and the teacher, the way they expressed their opinion and if they respected other students' ideas.

The shared control was examined for the events which reflected the students' ability to participate in decision making regarding classroom organisation and curriculum. I looked for the evidence as to whether the students were able to choose what questions and activities to do, and the methods to apply. Further, I looked for the evidence that they were able to reflect on their work, self-evaluate their knowledge and set appropriate learning goals.

For the critical voice scale the data were examined for the students' ability to meaningfully question teachers teaching and learning.

For the uncertainty scale, I looked for the episodes which reflected their understanding of how mathematics was created. I looked for their approach to solving problems to see whether they expected to be given a procedure, and whether they thought that the methods and solution should be accepted without the validation.

3.10 Writing

A narrative inquiry was utilised in this study as it was the best way to capture my classroom and life experiences. Narrative inquiry is a method that uses field notes, journals, interviews, autobiography, letters, conversations and life experience as narratives, to understand people, the way they act and create their meanings (Clandinin & Connelly, 2000). Guba and Lincoln (1989) note that writing does not only represent the transcription of the field notes but another way of creation of the knowledge. Writing is also a way of discovering self and analysing, as, in different ways, it helps us create different aspects of the topic and form our relationship to it. However, it never captures the studied phenomenon completely. By recalling various events one creates a new relationship without material and gets to know it in a different way.

'I will write because I want to find something out. I write in order to learn something that I did not know before I wrote it.' (Richardson, 2000, p. 924)

Clandinin and Connelly (2000) argue that it is 'the best way to think about experience' (p. 80). Van Maanen (1988) describes the realist, confessional and impressionist tales that could be used to represent research writing.

3.10.1 The three types of tales

Realist tales are the most dominant way of ethnographic writing. Van Maanen (1988) identifies four characteristics of realist tales that sets them apart from other forms of writing.

The first characteristic, the experiential authority refers to the absence of the author from the final text which is supposed to make the story more believable. As an academic, the writer is someone with a trustworthy background, and by using an official voice he fulfils the expectations of the readers as a proper fieldworker and establishes himself as an adequate researcher. Van Maanen (1988) notes that the removal of the observer's voice somehow magically removes 'audience worries over personal subjectivity' (p. 46); it makes them believe that the writer recorded everything that he saw and heard.

The second characteristic, the typical forms, refers to the presentation style which together with the attention to detail, brings out many (seemingly) regular events and points, such as habits and behaviour of participants. The notes are constructed according to the researcher's interests and for the purpose of making a specific point that he or she wants to make. Van Maanen notes that such regularities are not necessarily present in the life of the participants, but may stream from the academic and writing style of the researcher.

The third characteristic, the native point of view, refers to the writer's attempts to represent the participant's account of the events. For the fieldworker using realist tales, it is not always natural to present what the participants said in a presentable form. Direct quotes may be included in text. Further, the participants could be attributed with the improvised words that include the variation of the stories from their culture and everyday life. Van Maanen (1988) warns that in the realist tales, the acknowledgement of the participant's point of view may serve the writer's agenda.

The fourth characteristic, the interpretative omnipotence, means that it is in the researcher's hands to decide what is included in the text and how it is interpreted. According to Van Maanen (1988), many fieldworkers will not have such an arrogant attitude; however, many will not acknowledge the weaknesses of their approach and alternative interpretations.

Confessional tales with their personalised style are often regarded as a reaction to the realist tales. Confessional tales are not intended to replace realist tales, they rather complement them. According to Van Maanen (1988), there are three main characteristics of confessional tales.

The first characteristic, personal authority, indicates that the tale is about the writer. The goal is to create a picture of the world where the writer is operating. In order to communicate with the reader at the personal level, she, the author, reveals herself and how she came to know the world. Her previous understanding of the fieldwork, the ways she entered, got to know it and collected the data are uncovered. In order to personally connect to the reader, the fieldworker reveals her biases and flaws with which the reader can identify. The writer usually portrays herself as an apprentice learning about the world, or as an interpreter of the native texts. The tales uncover the writer's thoughts and feelings, the things that triggered her actions, the way she got to know the world. Additionally, the writer is portrayed as passionate and adventurous character who wants to change things (Van Maanen, 1988).

The second characteristic, the fieldworker's point of view, indicates that the author is representing his images and understanding of the world. The tales follow the growth of author's character as the view seen from her perspective change during the study. The writer goes to the great length to communicate his converse between her personal perspective and outsider's one. She should disclose the ways participants reacted to her presence and actions. The natural environment is exposed through personal experiences and is presented to the reader through the behaviour and norms that need to be adopted in order to function within it (Van Maanen, 1988).

The third characteristic, naturalness, refers to the field worker's stance that her methods and data are adequate. Despite her confessions to all encountered problems, errors, limitations and misconceptions the author usually comes to the conclusion that everything worked well. Her entrance to the fieldwork, the stay and the exit from it are overall characterised as smooth and natural. In order to gain the trust from the audience the writer reveals their naturalness by showing her sympathies and respect for the participants, and her involvement in their life and activities. Additionally, she describes the fieldwork as any other work by painting its interesting and boring sides (Van Maanen, 1988).

Impressionist tales are less common than realist and confessional tales, and usually appear within them. Van Maanen (1988) identifies four main characteristics of impressionist tales:

The first characteristic, textual identity, is the writer's attempt to engage the reader in his stories as opposed to realistically portraying everyday life, or explaining his point of view. The writer wants the audience to experience the native environment in the way he experienced it, interpretation is left to the audience (Van Maanen, 1988).

The second characteristic, fragmented knowledge, means that the story appears to develop in an unplanned and impulsive manner. My thoughts are not as methodical as I want to think, and sometimes can come to my mind out of the blue and without prior warning. The writer of impressionist tales tries to capture that by presenting the reader with memories which appear from nowhere and without a warning. For some reason unexpected stories make sense to her; although the audience may not be able to understand that way (Van Maanen, 1988). Narratives have 'the compelling, sometime confounding, quality of merging overall life experience with specific research experience' (Clandinin & Connelly, 2000, p.115).

The third characteristic, characterisation, means that the protagonists in the tales, including the author, are personalised and their characteristics are built through as the story develops. The writer, similarly as in the confessional tales, paints himself as likable and with flaws (Van Maanen, 1988).

The fourth characteristic, dramatic control, refers to the use of various literary styles which convey the story and hold the attention of the audience. The writer is moving back in time, uses figures of speech and is careful not to give anything before the time (Van Maanen, 1988). The reader is judging the stories from the literary and artistic point of view. The story needs to be coherent and to give an impression that it is truthful and fruitful.

3.10.2 My choice of the types of tales

I used the three styles of writing in my thesis.

The major part of the thesis is written in a realist, objectivist form as my intention was to persuade the reader of the validity of my theoretical framework, with credible information and using a logical style of writing. When I started writing the tales, not being equipped with enough knowledge and experience, I wanted them to be realistic. In order to make my stories credible, I sought to provide the reader with the account of who said what. In my eyes it would offer the reader the justification for my interpretations. I could not remove my voice, as I was a participant as well. My stories are realistic in a way that no event or a character is imagined. Everything claimed that happened actually took the place. The dialogues are as I evoked them to the best of my ability.

My first try to document my stories was done 'properly', with headings, dates and times; it could be a sign of the traditionalist in me. It somehow reminded me of my first attempts to write a diary, back in my primary school. I thought that I had to write it every day, and record everything that happened to me. Every day was starting with the same sentence: 'I woke up at 6:45.' By adopting a documentary style, my stories were supposed to tell a story of what was happening, and I would spot the regularities (or irregularities). In the later stages of writing the thesis I decided to change the format so that it had a more aesthetical appeal. However, I still kept the dialogues in a very similar form to how they were recorded originally. I could not create conversations with the students which were totally imagined; I could not just put the

words in their mouths. With the classroom stories I felt almost obligated to describe it 'correctly', and to ensure that the students said what I claim they said.

I think that in a way interpretive omnipotence is a characteristic of my story. Further, I would argue that interpretative omnipotence is a characteristic of every other story. Everything in the thesis is personal and selected by me in one or other way. My experiences and bias are part of the created meanings. To start with, I noticed the incidents which somehow were striking for me. They would not necessarily be striking to other people. These incidents and events made sense in my eyes. The final text is what I thought was the most adequate way which I am able to produce, to tell the story. This explanation streams from my understanding of constructivism. The knowledge is personal. I noticed and interpreted what I saw and heard based on my previous experiences. Equally, I did not notice some things because of my previous experiences. I cannot deny being selective with the tales; however, I do not see it as a cold and realistic influence. On the contrary, I think it is what makes them personalised. I saw and heard what I wanted to see and hear, intentionally or non-intentionally.

My stories are confessional to a great extent. The elements of confessional writing are visible throughout the thesis. The first part of thesis I wrote was the Literature review using an academic, formal style; however, some events from my past which contributed to my growth as a person and teacher could be detected even in that chapter. I try to open myself to the reader for a variety of reasons. I tell the stories from my life to give the reader the chance to get to know me. I want the reader to see the deeper reasoning behind my actions and interpretations. My past has influenced who I am now. For the same reason I reveal my professional problems. I was a participant in my study. I reveal my personal and health problems to remind the reader that my students and I have a non-academic side of our lives, that school and mathematics (now, this hard for me to say) are not the most important things in our lives. I wanted my fieldwork to be perfect; however, suddenly, the chain of events caused it to be pushed down my priority list. The students are experiencing other things in their lives. It is not only school stories that count. Along the way I expose my subjectivity and biases. I want the audience to be aware of them and possibly help them create their own interpretations. Clandinin and Connelly (2000) advise that if life experiences are not directly related to the research fields, they need to be connected to the inquiry. The researcher needs to make it clear enough why she felt the need to include her particular experiences in the research.

The students' point of view is visible in my thesis; however, their story and the way they interpret the world is told through my eyes. As mentioned before, everything in the tales is subject to my interpretation. Incidents, people and their reaction and statements are described and explained in the way which makes sense for me. By describing some nice and not so pleasant moments from my study I tried to create a natural flow. Possibly, a good feeling in the class affected my behaviour and actions.

My stories have some characteristics of impressionist tales. For example, once I decided to focus my attention on three particular students it seemed only natural to introduce them and build their personalities and characters. Clandinin and Connelly (2000) warn as one begins to write the final research text she may find that it does not capture the meaning intended so she may want to try other kinds. As mentioned earlier, I wanted my stories to be realistic; however, as time was passing they changed. The realistic picture did not really communicate my feelings, thoughts and impressions about my classroom, and the stories appeared to be not enjoyable and captivating enough. Consequently, I wanted to adopt an impressionist style.

When I did the unit on Constructivism earlier in this degree course I found myself remembering various incidents from my life and assigning them different meanings. It appeared that the difficult concepts I was trying to understand were depicted well through these incidents. The same was happening while writing this doctoral thesis. I hope that the reader will find these stories as relevant as I did - they are designed to bring the thesis to life. This is in contradiction with Clandinin and Connelly's (2000) advice to make it clear why I wanted to include some of my experiences in the research. I left some of my stories unexplained and presented in the way I experienced them; I want the reader to create his or her own impressions of some of the events that surrounded my fieldwork. For some reason, for me, the stories from my past were easier to capture using an impressionist style than the stories from my classroom. The tales are about events that really happened to me; however, by using flashbacks, I invite the reader to 'relive the events emotionally, with me' (Richardson, 2000). I cannot exactly pinpoint the reason for that; maybe, as humans, we tend to romanticise our past. It always looks better and more interesting and exciting than maybe it was. Hence, it is easier to take a brush and paint a colourful picture of it. While I had a desire to capture my classroom using an impressionist style, I found it very difficult, especially the stories involving the students. Maybe, in my personal stories, there is no one to give the consent, and I felt free to describe the image from my mind. On the other hand, it was my first attempt to write a novel piece and, possibly,

unfortunately, I just was not good and experienced enough. Despite my willingness I struggled to embrace fully the impressionist style.

Regardless of the writing difficulties, the stories are not real in the sense of being a movie script and what happened, despite my attention and attempts. Our memory can play funny games with us:

'Memories are personal affairs. They are what comes to mind when you think back, not what might in fact have happened in that earlier time in your life. You can no longer be certain what seemed important then, because you are now looking at the past with today's eyes.' (von Glasersfeld, 2010, Preface)

The stories are meant to provide the reader with the understanding of my students, the classroom climate and how the constructivist learning environment was functioning. My experience of the students built over the time. I was seeing them almost every day in the classroom, after school and in the school yard, or even outside school. Many things that contributed to my picture about them I am not even aware of. My image of the students is the product of accumulated experience, which I did not necessarily put on paper, nor was I able to do so. The conversations in the text are fragile and deceptive, the way I remember them, based on the feelings they caused in me. They represent what I saw in them at the different stages of my research and writing. Their representation and their meaning changed with time.

'We realise that there is no one bringing together of the field notes into research texts. We find ourselves frequently engaged in writing of different kinds of …texts…'. (Clanidin & Connelly, 2000, p. 133)

3.11 Quality standards

In the past a judgement about the quality of research was a judgement on how properly procedures and methods were followed. Today, it has been acknowledged that the researcher's background can have a significant impact on the study. One comes to accept that there is no objective reality and that no particular method has supremacy over other methods. I cannot put aside my experiences to access and assess the world. Hence, different angles could be equally valid, useful and legitimate (Smith & Deemer, 2000). There are many ways in which validity and reliability could be addressed. In this study I was guided by the quality criteria of

trustworthiness (the legitimacy of my field work), and verisimilitude and usefulness (the legitimacy of my presentation).

3.11.1 Trustworthiness and credibility

Guba and Lincoln's trustworthiness criterion includes the following aspects: credibility, applicability, dependability and confirmability. The trustworthiness criterion is parallel to the standard enquiry criteria (internal validity, external validity, reliability and objectivity) and as such may not be an option which is fully mindful of the constructivist nature of the analysis. However, it is a practical and sensible choice for researchers concerned about acceptability, validity and usefulness of their study (Greene, 2000). Guba and Lincoln (1989) suggest the trustworthiness criteria as a way to evaluate the quality of a constructivist research.

The credibility criterion refers to the extent to which the research results reflect information from the collected data. In order to ensure the rigour of the research, I applied the following strategies: prolonged engagement, persistent observation, peer debriefing, member check or progressive subjectivity.

The researcher prolonged engagement in the field helps diminish the researcher presence and gain the trust of the participants. Consequently, a greater insight of the research site is achieved (Guba & Lincoln, 1989). I worked in the school as a teacher for four years before I started my research, and was familiar with the environment and children.

Persistent observation enables the researcher to become familiar with the participants and focus on the most relevant aspects of the studied site (Guba & Lincoln, 1989). I was involved with the observed class for one year. I taught them four times per week and was seeing them in the schoolyard and during after school activities. Persistent observation and prolonged engagement gave me an opportunity to get to know the students very well. One of the reasons I did not tape my lessons, was my observation that the students behaved differently in an attempt to do so.

Peer debriefing refers to the opportunity to scrutinise the research with a disinterested peer. Feedback from such an individual can offer a fresh perspective and improve the quality of the study and report (Guba & Lincoln, 1989). I discussed my work regularly with my mother-in-law who has an extensive experience in education. She is a former head of a primary school that specialised in mathematics and she has had some experience in the field of education

research. Our relationship was informal and friendly, and our meetings did not follow a regular schedule; we lived in different countries and saw each other a couple of times per year. In addition to conducting my research, I was working full time, had a young family with a toddler, and was pregnant pretty much throughout all my study. My mother-in-law, my educational friend, fitted around my schedule. I discussed with her emerging issues and questions during the fieldwork and writing the thesis. She did not agree with me on all the issues; while she was in agreement with the strategies I employed in the classroom, she was concerned with the accuracy of my data collection and data analysis. She used open-ended and thought-provoking questions to challenge me to take into account different perspectives. I was the only one making decisions and facilitating all the steps of the research and sometimes in such situations many things are taken for granted and the need to explain my choices was somehow lost. The long discussions I had with my peer debriefer I found very valuable, as she put me in the position to find ways and words to justify, defend and sometimes reconsider my methods and approaches. Through our talks, the strengths and downsides that I was bringing to my research went out into the open. My peer debriefer proofread my entire thesis and her insightful comments, especially regarding the lack of explanations, were valuable to me. 'We ask others to read our work and to respond in ways that help us see others meanings…' (Clandinin & Connelly, 2000, p.60).

Member checks mean that the participants need to be included in the analysis of data. The participants may not be happy with the data and may suggest changes. It is happening continuously during data collection and analysis. Guba and Lincoln (1989) warn that member checking may not always be helpful as the participants may not respond. Additionally, locating the participants may not be easy and practical by the time the report is completed (Guba & Lincoln, 1989). Member checks were conducted to a certain extent. I was a participant observer teacher and was able to clarify on the spot any issues and misunderstandings I had.
Additionally, whenever students had a slightly 'controversial' opinion about something I would double check the inclusion of such information in the study. The students were asked about the inclusion of the information presented in the interviews. However, the final member check did not take place. By the time I completed my report I had left the school and moved to another country. Duit et al. (2014) claim that writing is not a simple task and constant interpretation cannot be simply brought to an end, which makes member checks a very difficult job.

Progressive subjectivity refers to the process whereby the researcher monitors his own emerging constructions. The technique of progressive subjectivity ensures that the inquirer's constructions are not being privileged (Guba & Lincoln, 1989). My progressive subjectivity is evident throughout the report, especially in this chapter. I changed my views and approaches regarding the collection, analysis and representation of the data. I tried to investigate and explain the reason behind my change of mind. Further, my progressive subjectivity is evident in the stories (Chapter 4); I frequently question my teaching strategies, and the appropriateness of the applicability of my ideas.

Negative case analysis refers to the data that appears to produce contradictory explanations. In this study data related to Max produced some divergent interpretations, and the reasons behind this incidence were discussed at the end of Chapter 6 (p. 195).

Transferability

Transferability refers to the level of applicability of a particular study in a different context. Interpretivist researchers are not particularly concerned with generalizability as participants' behaviours as actions are temporary and observed in a specific context (Duit et al., 2014). Transferability is achieved through thick descriptions - the detailed account of the context and the methods applied in the study. Guba and Lincoln (1989) warn that thick description can never be fully achieved as the inquiry has a dynamical and flexible nature and the conditions needed for transferability change with time. I have provided a thick description of the fieldwork experience including context, description of the procedures, the climate within the classroom, participants, and my relationship with the participants, my feelings and thoughts.

Dependability and Confirmability

Dependability refers to the extent to which the constructions of the study are supported by the data collected. Confirmability refers to the extent to which the data and constructions are products of the researcher's experience rather than his or her imagination (Guba & Lincoln, 1989). Guba and Lincoln (1989) suggest respectively, techniques of dependability and confirmability audits for establishing dependability and confirmability of a study. The audits

are procedures in which the processes and actions of the researcher are reviewed by a researcher not involved in the study. Both dependability and confirmability, and the ways they are assessed have a positivist supposition. The audit process suggests the existence of one truth and one reality which is contradictory to the constructivist ideas employed in this study. Therefore, these two criteria have been established only to a certain extent, and not in a way as suggested by Guba and Lincoln (1989). To address the issues of dependability and confirmability in my study I clarified my perspective by providing a detailed description of the framework, implementation and design of the study. I outlined how the data was collected, represented and analysed. Ongoing member checking and peer debriefing are techniques which helped establish dependability and confirmability. My subjectivity has influenced my communication with the participants and the way I interpreted the environment. To overcome that problem, Guba and Lincoln (1989) suggest making known the biases and feelings.

3.11.2 Crystallization

Guba and Lincoln (1989) suggest *triangulation* as a technique that can improve the trustworthiness of a study. In triangulation one applies a variety of methods to validate and find the truth. Crystallization has some similarities with triangulation. Crystallization recognises that the truth cannot be found and identified with a precision, rather the variety of approaches paint different truths, all equally valid. My perspective depends on the stance I take; my construction depends on the context (Richardson, 2000). Consequently, according to Richardson (2000) 'we know more and doubt what we know' and that 'there is always more to know' (p. 934). The methods applied in this study are supporting and feeding each other. Richardson (2000) suggests not only a variety of the research methods but imaginative and artistic forms of representations. I found multiple ways to analyse data and express myself, helped in approaching the subject from a fresh perspective, which equipped me with a better understanding of the situation.

3.11.3 Verisimilitude and usefulness

Is the narrative representation, a valid way of presenting my research? With the stories I tried to capture the happenings in the classroom, albeit in a slightly simpler way, but some things

have been lost in translation. I am not even sure if the stories represent what was happening in my life, or maybe the stories I created shaped all of my experiences and perception. Did I use the narrative as a mediator to represent what I know, or did the narratives shape my knowledge? Did I write about what I saw in the students, or did I see in the students what I learnt from my writing?

The issue of legitimation of the stories rises from the teachers' reluctance to use field notes in their research:

'They worry that field notes will be insufficient to capture field experience adequately… In any event, it is the fear that somehow experience will be lost that drives researchers to try to record or tape all of experience. What we fail to acknowledge clearly enough is that all field texts are constructed representations of experience' (Clandinin & Connelly, 2000, p. 106).

Every study is, in one way or another, about how one addresses and interprets her experiences. The problem of the legitimacy of narrative inquiries is a consequence of our inability to accept stories as a valid way of expressing ourselves. Until recently the issue of the legitimacy was looked through the lenses of properly applied procedures and truthfulness of the study. Possibly, one should apply a more appropriate way of judging legitimacy of his or her study as the effect the study has on others, and their consequent actions.

Would it be more legitimate if I had chosen a different way to represent the data? Would the picture about the students be more complete if I used statistical means of analysis, and used formal language to explain the charts? Would it be more truthful and ethical if I had chosen a more objective approach? It depends on the reader. If they believe that this is how the data should be represented, then possibly my stories do not sound very truthful and legitimate. In this chapter I offered the reasons that the stories are an appropriate way to represent and analyse the phenomena.

Van Maanen (1989) states that literacy standards are more important than scientific ones. After all, the audience 'cannot be concerned with the story's correctness, since they were not there and cannot know if it is correct' (p.105). Well, I do not have much concrete evidence to back up my stories; I have transcripts of the interviews, and my original observations that served as a base for the stories. I have drafts to demonstrate how my stories have evolved. I have students' responses to the CLES. Theoretically speaking I could have made-up everything. I could have

imagined my story. However, the same could have been said for the positivist means of collecting data. Van Maanen (1989) suggests that appropriate criteria for judging the quality of the stories are interest (usefulness), coherence and fidelity (verisimilitude).

A relevant criterion for judging the adequacy of my stories is that of *verisimilitude* which questions whether the stories appear to be real and believable (Denzin & Lincoln, 1994). Van Maanen notes that the appropriate question to judge the quality of the tales is: 'Does it seem true?' Richardson (2000) uses the criterion of the expression of reality, in the same manner, to judge the standard of papers:

'Does this text embody a fleshed out, embodied sense of lived experience? Does it seem 'true' - a credible account of a cultural, social, individual, or communal sense of the 'real'?' (p. 937).

Verisimilitude helps the reader to better understand my situation and the reasons behind my actions. Further, it can be a tool, which makes them better reflect on their own setting and actions. The readers of my study will be predominantly teachers. Geelan (1998) asks: Are the stories presented in the study plausible for them? Will they have a sense of familiarity while reading my stories? In order to make my stories believable I presented the classroom life in the way I experienced it, based on the emotions the memories triggered in me.

Usefulness is another relevant criterion for judging the adequacy of my stories is the issue of usefulness. The readers of my study will be most likely other teachers and researchers. Is this study useful for them? Does thick description provide enough details about the classroom life so that others can find it applicable? Do other teachers and researchers find my interpretation relevant in their classrooms? More importantly, will my stories make them think and prompt them to re-evaluate their practice?

Loh (2013) claims that the trustworthiness technique of peer debriefing can be useful while establishing verisimilitude and usefulness, as the associates from the educational community can verify if the report is valuable for them. Additionally, the technique of thick description can help in establishing verisimilitude and usefulness as the detailed description of the study can provide the answers regarding truthfulness and applicability.

The phenomena and students are described as I experienced them and the stories I tell create the picture of the classroom as seen through my eyes. When a discrepancy in the statistical analysis was observed it was assigned an interpretation as understood by me. From the pool

of all possible stories I chose ones that best represent me and what I want to communicate. I told the stories which I believed had an educational value. Why did I choose these particular stories? Or why did they choose me? Are my stories useful? Are they providing a learning experience for the audience? The audience is the judge if my stories have verisimilitude and usefulness. For example, many incidents show the students' reaction to the constructivist learning environment and that was a paramount part of my study. From my descriptions, other educators can evaluate the applicability of the stories and episodes in their classroom. On a few occasions I describe the strategies and activities I used in the classroom, in a more explicit manner. I did not want just to give an outline of the activity; it appeared to be a dry and blunt way, so I decided to tell it through a story. Other teachers can gain a picture of how I understood and implemented constructivist learning. Some stories reflect the frame of my mind and I think it is important for the audience to see me as a real person. I have read studies where the teacher or researcher was hidden, and it is presumed that everything went smoothly, and that the activities were perfect, but this is not what was really happening in the classroom. I think it is important to show my vulnerability and describe a teacher and teaching as it is. One always feels inadequate and has the feeling that she should be doing something better, and that things in other people's classrooms, especially in the researchers' classrooms, are somehow better organised and more interesting. A couple of stories are told only to capture the climate in the classroom; most of the time it was a pleasant experience and I felt happy being there. One or two stories tell about my relationship with my colleagues and some of the problems I faced. While it was not the focus of my study it all contributed to the overall experience. To a certain degree and from various perspectives, the stories are educationally important.

The audience will read the story from my perspective and it is something new for them, it was not available to them before. The readers will (hopefully) come to understand teaching, learning and research in a new way. My educational peer said that she found the stories 'interesting and informative' and that they made her consider what her 'classroom practice was like' (p. 169).

3.12 Summary

This chapter presented the methodology employed in this research regarding collection, analysis, representation and interpretation of the data. I present the setting of my fieldwork and

the participants. The school where the research took place and my classroom are described. The three focus students are introduced. In this section I talk about myself as one of the participants, and I recall some events from my past that, as I see it, shaped my ethical and cognitive sides. Detailed description of the implementation of the constructivist learning environment was provided. The participant observation strategy was employed in a Year 7 boys' class in an international school in Qatar and it included a variety of data: observation notes, reflective journals, non-mathematical and mathematical tasks and interviews. The stories were written using the mixture of realist, confessional and impressionist genre. Guba and Lincoln's trustworthiness criterion and the criteria of verisimilitude and usefulness were applied to make the field work and its representation valid and adequate.

Chapter 4: Classroom Stories

In this chapter, the classroom stories are presented. The stories are intended to help the reader create an understanding of what was happening in my classroom, how the constructivist environment was operating, and how the students and I reacted to changes in the classroom.

The described events took place over a period of one school year, and are presented in a more or less chronological order. In some instances I try to make it easier for the audience to track my stance on a particular issue, and corresponding stories were grouped together.

My grandad

My grandad was a good story teller. He was a bit odd and a witty character. He travelled a lot compared to those around him, in a country where people live in the same place as their ancestors have lived for centuries. One hardship brought them to the land and another one will take them elsewhere. He read a lot and with his four years of primary education, was something of an academic in his village. He would read a book, put himself in the role of the main character, and tell people the story as his own. They always believed him. Who else would know all these details but someone who truly experienced them? Well, he did experience the story in his own way; the books, places he visited and his playful mind created stories in his head, and people would listen with wide open eyes.

The first night in Qatar

I will always remember my arrival to Doha. It was just after midnight when we left the comfort of the air-conditioned airport. The wave of the heat hit me as I went through the door. *O my God, something is wrong. What is happening? How is this possible?* I was turning around *expecting* some explanation and was met with equally lost faces of my colleagues. The glasses misted in a moment. The long sleeves worn out of respect for my host country started sticking to my body. I started breathing heavily. *How*? *How is it possible to be so hot without sunshine?*

The mosque

The melodious, vibrating call for prayer echoed through the streets of Doha. The voice of *imam* could be heard over the speakers at the mosques in the city; the noise was coming from every direction creating some sort of disordered orchestra.

I recalled my first day in Doha, explain the taxi driver that I lived near a mosque behind the mall. He laughed; there were 30 mosques behind the mall. There was one just outside my window, and for a long time I could not stand its sound in the early morning hours, especially on Saturdays. It would just hit you. And then a marriage and two children later somehow it

grows on you, and you almost start to like it; the sound of mosque will always remind me of the special place this city had in my heart.

November 2001

'How was your interview at that school? I am having one with them on Thursday.'
Paula, a colleague from university, had an interview with a college for the position of the Special Education Teacher.

'Horrible, she asked exam questions.'

'What?' Most of my exams were essays or open book exams, so I was relying on my good learning ability (as I like to say) to pass them. God knows, I did not do any work that year. I even chose to be the maiden of honour at my best friend's wedding back in Bosnia during the school practice. I could not understand people questioning me about this; it was my best friend from high school.

'She asked about constructivism.'

'What is constructivism?'

'You know that learning theory that promotes discussions and the use of real life stuff in the classroom.' Paula was showing me a short paragraph in the main book. She knows everything.

Duh, of course you need to use real life stuff, easiest way to motivate kids. And now I have to study for the interview (Notice the attitude, I knew *everything,* I did not even need to do my graduate diploma).

A couple of days later…

'So, Danijela tell me what do you think about constructivism?' The deputy head looked at me.
'Well, I believe…'
I stayed at the school for four years before moving oversees.

Can I really tell all the stories?

'Dani, I really do not understand the point of all the stories. I can see how the events from the classroom are relevant, but some of the stories do not appear to have any connection to your research.' It was Josephine's comment about my stories. Josephine is my peer debriefer; I discuss my work with her and she proof reads my writing. She is a former head of a primary school and her specialism was mathematics so my research is not totally abstract to her.

I was thinking about her words. Writing was more difficult than I anticipated. I wanted the stories to be more than just some fieldwork notes. I wanted to describe what was happening in my classroom but not in a blunt or boring way. I was not quite sure how much and what I wanted to tell about myself. I suppose, among other things, I wanted to communicate with the reader what kind of a person I was, I wanted to be completely open and blunt about my experiences and possibly to somehow justify my actions in the classroom. Now I was worried, that if Josephine could not understand the point of the stories then others would not be able to do so as well.

It does not work!

'It does not work, it just does not work!!!' I was throwing the papers across the room. I thought I was ready for the new school year, for my research. I thought I'd figured out everything (as per usual). Except, three weeks into my study, it did not work.

'Do not throw out anything; you do not know if you are going to need it.' My husband was warning me.

I looked at a pile of papers with tables, ticks, dots and half dots representing the students' reactions to the classroom environment I created. I thought I would carefully record the students' responses, analyse them (statistically, the only way I knew) and create lesson plans with that in mind. However, it did not work. Was my mind still working in a positivist mode? What was I thinking? What am I going to do with all these tables and dots? They did not communicate what I wanted to say. They did not reflect my enthusiasm when I came home and excitedly shared with my husband what Adil did or what Alex had said. What was I going to do?

In the end I decided to focus on three students only and record their responses. I just could not keep an eye on all of them. It was as if I had just now realised how difficult was the job of teaching. I divided the class into three groups regarding my experience so far with them, and chose one student from each. One group were the students I thought would respond well to my constructivist ideas, one group were the students that in my opinion would respond negatively, and the last group were the students in between.

Adil was very good at maths and I was really excited that he was in the class I was doing research on. I have always liked teaching gifted and talented students. I know it appears to be an easy job. I am not talking about ordinary A or A* students. I may have had 2-3 gifted students in my ten years of teaching, Adil being one of them. I knew deep down that Adil did not need me for the school work. Exceptional students do not care about the teaching style; they adapt anyway. I really wanted to see if I could make any difference in his mathematical behaviour. Adil did not enjoy group work. I recall myself at that age; I did not like working with others, mathematics was too personal. It did not bother me; he could work in any way he wanted to work. Adil's mathematics talent made me think that he would react positively to the learning environment.

Nazir was taking his work seriously. My opinion of him was to a large extent based on his sister's stories. She was in my class last year and always mentioning her younger brother who was very serious and good at maths. She thought that he was going be an engineer. He appeared to be enjoying mathematics and it made me think that he would generally adapt easily to the changes in the classroom. However, there were some warning signs, like his inflexibility and seriousness about mathematical work, his refusal to believe that mathematics could be a part of our everyday lives.

Max did not like mathematics and appeared not to be happy with all changes happening in our class. He could not to see any personal element in learning mathematics; for him, it was something that simply needed to be done. I saw him as someone who may experience difficulties in the changed classroom environment.

I did not choose Adil randomly. Nazir and Max were chosen randomly, literally, by taking the name out of the hat.

The first homework:

What makes you happy?

If mathematics was food…

Adil

'Interests and what makes me happy

- *Watching TV*
- *Playstation*
- *Internet*
- *McDonlands!!!*
- *That feeling you get when you've finished homework!*
- *PEPSI!!!!!!!!!!*
- *Drawing*
- *Safari Grills!!!!!!*

If Mathematics was food… McDonalds

McRoyale!!!

I love McRoyale like I love maths but too much, I can't take. Solving a quiz is like a bite, working it out is nearing towards my mouth.'

Nazir

'There are a couple of things that make me happy but none as interesting as my time sitting on the laptop. I spend my time opening Facebook and using Skype, downloading new programs, and making new animations. Making and playing games is also what I like to do. My favourite thing to do is solving problems within the computer like a virus, an error or anything else, it is

fun! I like sport including football (soccer) and tennis. I have been playing football as long as I remember and tennis for 6 years. I also like watching football or playing it on the PlayStation. And lastly I love to go-karting. I have been only done it a couple of times but I love it! I love the feeling of the speed especially since I'm doing it and ability to drift.

If maths was food it would be jelly because it is simple, unlike writing because it has so many different ways to make it work but maths is simple with only one answer.

Max
'I like playing basketball, skateboarding and drawing.

They (Mathematics) would be pees because I hate them.'

Credit cards are good

'I am not sure if you know what a credit card is?' I brought some bank statements showing the purchase of an item worth more money than what was available in the account. The negative balance was shown in red.

Before I had a chance to say anything more, all my Year 7 boys were waving with their credit cards. They were coming to me and pushing the cards in my hands.

'We know miss what a credit card is. It is like cash just much better. You do not have to carry all money with you.'

'And you always have enough money for everything.'

I was nodding with my head. *'Yep, this is what a credit card is about.'*

The boys were aware of some applications of negative numbers; they noticed its connection to the temperature and understood the credit card concept. Interestingly, they did something in relation to the sea levels in their science class, and Alex noticed that it could be related to the negative numbers as well.

'If you get one warning and one merit is it fair if they cancel each other?' I thought that my example was a bit artificial but easy to communicate my point.

'I guess so, sometimes teachers do that.'

'If a crab is 2m under the sea level and it goes up by 2m, at which level it is now?'

'At the sea level.' few students called out.

'We can say at the zero level. 'Alex added.

'Let a blue counter has the value 1, and the red one, negative one. Can you create zero with counters?'

A quick look around the classroom showed that all of them had the same number of blue and red counters. The worksheet consisted of a number of questions of various difficulties, starting with counters, and progressing towards addition and subtraction with whole numbers. On the whiteboard they could use a program with temperature and sea levels which allowed them to move up and down.

Max quickly skimmed the worksheet: 'Miss you did not teach us how to add or subtract negative numbers. We do not know any rules.'

'Just try your best Max; someone will help you if there is a need. I hope by the end of lesson you will be able to tell me your rules.' I felt I started repeating myself.

They were completing the worksheet quietly. Most of them seemed to be working by themselves, despite having just one set of counters per group. The boys started talking when a question was asked about how they would explain the addition with whole numbers to their younger brother or sister.

'How I would know, no one explained to me.' Kyle sounded frustrated.

'You completed almost the entire worksheet. Surely, you can explain how you did this.'

'But I do not know if the questions are correct or not. I do not know the rules.'

'They are all correct.' Harry said.

'How do you know that?' Kyle asked impatiently.

'You just know.'

I asked Kyle to explain one of his questions.

'You can say that 5 is like 5 blue counters, and -7 is 7 red counters.' He explained that 5 blue counters would cancel 5 red counters and 2 red counters would be left over which had the value of -2. He moved counters around as he explained.

Harry, Max and James were nodding with their heads.

'So what is the problem?'

Max jumped in to help: 'He is not sure Miss, you did not teach us. You have to tell us if it is correct, what the rule is.'

'What do you think what is the rule?'

James: 'I would explain like Kyle did, like you try to cancel some parts and then see what is left over.'

'I see which number is kind of bigger. I know 5 is bigger than -7, but like 7 is bigger than 5, so negative number is kind of bigger, so I now my answer is negative, and then the difference between the numbers is 2, so it is -2.' Harry offered his explanation.

‘That is an interesting explanation. Did you understand the way he explained?’

’Yes, but which one is correct?’ Kyle was looking for my confirmation.

James: ’They are kind of the same.’

’Can you do the questions like Harry explained?’ Kyle questioned.

‘You can as long as you understand it.’

’Would not be easier Miss, if you just tell us the rule, and we do not have to think if it is correct or not?’ Kyle was still trying to prove his point.

I tried to explain (again) that I preferred him to think, saying that hopefully he would remember better if he created a rule by himself.

Max did not seem to be persuaded: ‘I still think you should not be doing that.’

‘She just wants you to think.’ Harry tried to help me. I glanced thankfully at him.

‘You know there is a special name in mathematics if we want to explain that a number is greater in the way you explained. We say it has greater absolute value.’ I told Harry.

He did not like it: ’It sounds like something very difficult. Can I still keep explaining my way?’

For homework, they needed to select six problems which they found most suitable at the moment; there was not need to do all the questions.

‘So we do not have to do all the questions?’

‘No.’

‘So I decide by myself what questions I want to do?’ Lucas asked.

’What if I choose the easiest questions?’ George wanted to protect himself.

’Why would you to that, I will do the last 5 questions and I still need to do one of the easier ones.’ Adil, as always, was looking for a challenge.

‘Why would you do that?’ Joshua wondered.

Noah looked uncomfortable, ‘Miss, can I please do all the questions?’

‘If you want to.’

A collective sigh of relief from almost all class.

As he was leaving the classroom, Nazir said: ‘I really enjoyed this class. I did nothing, just playing with the counters. I did not realise it was over.’ Nazir offered much needed reassurance that something still went ok in the lesson.

I do not think I can be ever completely ready with lesson preparations; you can always do a little bit better. Today, I felt reasonably ok; for me that is the best indicator if the lesson was successful or not. The boys were discussing and any issues they had were brought up in a well-mannered way. I was careful not to offer a specific procedure of adding and subtracting whole

numbers; they still needed to do all thinking by themselves. Somehow in my eyes it is the main measure of my and their success. I did not tell them how to do things; they came up with all ideas by themselves. Although, now when I think about that, the way I started the main activity possibly offered too much guidance. I know it is more related to my feeling of (in)security that I am doing the proper thing. It is easy to fall back into the traditional way of thinking, as it is some kind of guaranty that things are being done properly. I wanted maybe to offer some reassurance, a safety net, that there was a way of thinking that they could rely on.

Can I really teach them?

Can I really teach them how to learn? How to think? Mathematics was always easy for me. When faced with a problem, I try to connect it to anything I know. Of course, you are trying to be logical and selective. When solving a geometry problem, percentages are not the first thing coming up to my mind. Your mind is quickly going through possibilities that can fit into the problem: Pythagoras, trigonometry, similarity, area … What possibilities need to be satisfied to be able to apply Pythagoras somehow? After hours of thinking, suddenly it comes to me: vectors. I have not considered vectors. A few minutes later the question is solved. You have to shape that viable path among all possible paths (if possible). Can you really tell someone what is going through your mind? Can you teach someone to go through this process? Of course a teacher can throw in a piece of information: "Look, you can create a right angled triangle here!", but one would have to be totally in control of everything else to be able to use that piece of information. In fact, the teacher can show you an entire solution, but you would not understand unless you are in control of your knowledge. It is not about that piece of information that the teacher can give me; my knowledge is represented by my ability to manipulate all my previous experiences and use them. It is not even about getting a right solution; it is about going through the process of rearranging my knowledge. This is how I learn. Does everyone else do mathematics like that?

Josephine's reaction

Josephine was not entirely sure about my idea. She pointed out that when she did her project almost 30 years ago she taped her lessons.

'Dani, I am not sure about the way you write your stories, it does not appear to be very legitimate.' She gently disagreed with me. Josephine is my mother-in-law as well, and is very considerate of my feelings. 'Why can you not tape your lessons, then you will definitely know who said what.' She suggested.

There were a number of reasons why I felt that taping lesson was not the best option. I tried to explain. 'You know how Arabs do not like being photographed. Children in school do not like being photographed as well. I am not sure about taping conversations; it may have a similar effect. I tried it once but they all went quiet. Maybe it was for other reasons but I just felt they were different. Then what is the point.'

She is still not sold on the idea: 'I trust that you know what you are doing; however, you cannot remember everything.'

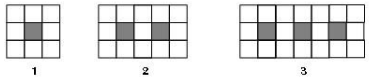
'I know, but you cannot tape everything as well. My opinion about the children is formed on everyday basis; I cannot possibly mention or tape all these incidents. And if I tape my lessons, I will kind of switch off and rely on the tape, but when am I going to transcribe them. That is a huge job. I do not physically have the time. I work full time, I have a baby. I already get up at 4 o'clock to feed her and cook. I do not have time to transcribe the lesson and then spend time making sense out of it. When am I going to do this? I have to do this as I go, on the spot.' I was getting almost upset. I did not want my daughter to eat formula or baby food from jars; I felt guilty enough for working.

'Sorry Josephine.' I calmed down. I really wanted to concentrate on my research and I did not anticipate that suddenly there would be many more important things in my life than my study. 'It is a valid way to collect the data.' I tried to address her concerns. 'There are many options for teachers to conduct their research in the classroom. If you think about that by writing stories I am acknowledging my impressions about the students and their actions. When you teach or write a report, you do not rely on taping, you act on the images you form about the students. I am in the position to pick up the story that tells most about students instead of collecting all information. I can tell the incident that reflects my opinion about them. The incidents that I notice say a lot of about me as a teacher. The choice of the stories does not only describe my students but me as well. Someone else would notice different incidents and that would be correct as well, depending on the teacher's personality.' I tried my best to communicate my ideas.

Josephine was still looking at me with doubt.

Thinking does not count

Today we were exploring linear sequences. The boys really liked the introductory question but it proved to be a greater challenge than they anticipated. No one wanted me to tell them the solution. Eventually, Adil noticed a pattern. I recalled my father asking me the same question when I was their age; I spent ages on it.



The council of Doha wishes to create a path near the Landmark with 100 black square tiles and surround them with white tiles according to the pattern shown above. (In the 3rd pattern, 18 white tiles surround 3 black tiles). How many white tiles will the council need for 100 black tiles?

Find the formula that the council can use to decide the number of white tiles needed for any number of black tiles.

I let them think and talk. The students were to design their own methods while solving the problem. They were free to choose any way to plan and deliver their investigation. There were cubes available, but no students chose to use them. The boys were quiet for about five minutes trying to figure out a solution. After that, they started discussing.

Around the table were Nazir, Archie, Laith and Leo.

'Miss, I listened to all people in my group and they all make sense and we have two different answers. How do we decide which one is correct? Archie and me kept adding 5 and found out that one with 10 black tiles will have 53 white tiles. So 53 times 10 = 530.' Nazir was unsure of his approach.

Leo explained that 5 white squares where added with each new black square, so we would add 5 squares 100 times and with starting three white squares (which he covered with his hand to demonstrate his thinking) the answer would be 503.

'Miss, actually, when I listen to Leo, that makes more sense, but our solution is logical as well.' Nazir added.

I said that in mathematics it is sometimes easier to check if something was not correct rather if it was correct.

'Why did you decide to go to 10 black squares?'

'Because 10 can go into hundred.'

'I see, why not 5 and then multiply by 20?"

Nazir, rather jokingly: 'Or, why not 1 and then multiply by 100?'

'Exactly. Which of these cases is the best?'

'They are all the same. You know what I mean.'

'Why did you choose 10?'

'Just because it is nice and round number.'

I suggested that they check what would happen if they go up to 5 squares instead.

After quickly checking few examples Archie noticed that they were getting different numbers.

I explained that since we decided that the two approaches with 10 and with 5 squares were equally good then the two answers they delivered were equally good. What does it tell us about our approach?

'I can see how my way is not ok, but I cannot figure out why? Nazir was still wondering.

'There are some situations where your way will work. And, it is logical as you said.' The boys continued examining Leo's way.

I am not sure if I dealt in the best way with Nazir's questions. He realised that his method was not correct but I was not sure if I should have taken it further. I like to think that their responses drive my lesson. Do they really? It was an opportunity to possibly explore direct proportion. I felt that he offered me with a chance to take the lesson in a different direction and I failed to do that. I was happy to take it on the board for the future planning, but not this lesson; this lesson was on linear sequences. Maybe I could have suggested to him to investigate what kind of patterns would follow his logic. Sometimes you come up with a right idea too late. I was too concerned with keeping the focus on linear sequences and not ending up with a chaotic lesson.

Ahmad, Badr and Tyler (Lucas was not in school from that group) found one answer and looked bored.

'Each black square is surrounded by 8 white, so 8 times 100 = 800.'

I pointed out that other groups disagreed, but they did not seem to care.

'What about if you have 3 black squares? Should you just multiply by 8 because each black square is surrounded by 8 white squares?' 'You can do this.' Tyler agreed.

'So 3 times 8 is 24. Do you have 24 white squares there?'

Tyler, after a quick check: 'No, but, it does not matter. It does not work for smaller cases, just big. We know that the answer is 800.'

'What about common squares?'

'It does not matter, they will cancel each other.'

'How?' I was puzzled.

Ahmad said that they did not want to do the question any more as they were certain it was correct. They turned the other side of the sheet and started work on a similar question.

I left their group feeling anxious. I did not deal properly with Tyler, Badr and Ahmad. I felt that my attempts to guide them away from incorrect answers were weak. Should I have persevered with questioning validity of their answer? Should I have guided them towards the correct answer? At no point they were excited by the problem, and motivated to succeed.

Alex, Laith and Noah were discussing the problem, while Adil was working by himself. Occasionally, he would help other boys. Oliver, as well was working by himself.

Alex was the first one to explain the question on the whiteboard and he did it in a similar manner as Leo but added 18 instead. When asked to justify that step he changed his mind and added 3.

Kyle, a bit surprised with the explanation: 'Clever, very clever, I did not think like that. I can see how it works. Very good, Alex.' He was nodding with his head. Kyle was being genuine.

Many students started calling out that this was the correct answer and there was not a need for everyone to explain. Tyler, Badr and Ahmad appeared to happily accept the offered explanation as well. I asked them what possible mistakes someone would make while working on this problem.

'We tried to find how many white squares we need for 5 black squares. The answer was 28, and then we multiplied that by 20 so it 560.' Max described his group's tactic.

'Why do you think it does not work now?'

'I do not know, I more prefer Alex's answer. Now it looks better than our way.'

'We did the same thing just we went to 10 black squares, so we got 530.' Habib added.

'Which way is better, Max's or Habib's?'

'They the same. They are different but similar. You know what I mean. It is the same; they just used a different number.' Alex tried to explain.

'Why does not that way work?'

'It looks correct, but I know it is not.' Harry noted.

'It is because of this 3 at the beginning, you should not be multiplying it by anything, and it always stays here. The rule is 5n + 3. You see you just add 3.' Adil explained the problem.

'What rule, what you are talking about?' Kyle said irritably, almost angrily.

Adil came on the whiteboard: 'You see this is a linear relationship. We start with 3 and then keep adding 5. So we can form a sequence: 3, 8, 13, 18, 23, 28, and so on (he connected the numbers with the arrows and +5 signs. So the rule is 3+5n.' He pointed out that the rule could be checked by substituting 2 instead of n for the second diagram; the answer would be the same as the number of the white squares in the diagram. Conveniently, he introduced the term 'linear'.

He was talking quickly, aware that the majority of the class was finding his explanation quite difficult to follow. He wanted to show that he knew the questions and that his explanation was possibly more sophisticated than that from the rest of the class. He was hoping that someone in the class will be able to follow it, but was not really concerned with that. He was looking at the class but not really communicating with them; he was communicating with me. He knew how to solve the problem and wanted to tell me that. Moreover, he knew it in a quite advanced way.

The class spontaneously started clapping their hands rewarding his effort. They did not question if it was correct or not. It was Adil; he must have done it correctly.

'So that is the rule. Now it is easy. Do not take it off, I want to write it down.' Kyle was trying to copy down Adil's writing from the whiteboard.

'I am not sure if I really understand how you came up with that rule. Why it works? I see it works but why?' I tried to stir up a discussion.

'What do you mean why it works? It works; it is the rule.' Joshua was not sure of my question.

George looked at me suspiciously: 'You do not know why it works?'

'I do not understand why we need to explain; it is the rule.' Max did not see the problem.

Only couple of boys understood my question.

'I think the rule works because of what Alex said.' Adil explained that each black square has 5 white squares, so if there are n black square there would be 5 times n white squares, and with the 3 added squares from the front we would have 5n +3 white squares.

Max: 'Now I do not understand again. Can we just use the rule?'

'You cannot have just any rule. You need to know why the rule works.' Adil tried to explain.

Harry: 'I more prefer when we explained it the first time. This way with the rule is confusing.'

I went onto showing them a PowerPoint with visual representation of what Alex had said. Later, we had a look at the tables and diagrams they used while trying to solve the problem, and established that they could be useful strategies. For homework they were to create their own tile pattern and find a corresponding rule.

Nazir, as he was leaving the classroom said: 'I loved this lesson, different than others. I spent all lesson thinking and talking, not doing work, but I did work.' I nodded with my head, appreciatively.

Adil, quietly: 'Miss, I got your acting, like you did not understand why my solution did not work. You were pretending; you just wanted me to explain it properly.'

We have an extra day's holiday

'Yay, we have an extra day off work.' I did not say it loudly but was delighted with news. Yeah, I was a little concerned about losing my year 12 classes, but, hey, we have one extra day's holiday.

Mark, the head principal, had just announced that the Education Department had requested school to close tomorrow for the Eid-al-Fitr Holiday (the end of Ramadan). As the date for the end of Ramadan is based on the visual observation of new moon, we did not know the exact holiday days in advance. It is not the first time that we have had an early holiday. Our regular holiday will have to take place because, well, it was planned. No one seemed to be concerned with the lost time.

Miss, did you put some weight on?

'Miss, did you put some weight on?' A couple of girls approached to me at the break time.

I was seven weeks pregnant and was desperately trying to hide my belly. I was scared and exposed, and was cautious after what happened last summer.

'No.' I was trying to tuck my belly in. 'I hope you do not ask that every teacher. Am I the only teacher with a belly?'

'No, we are just asking.'

As I was leaving I overheard: 'Alla and Jane think she is pregnant.'

In the past, only privileged girls had access to education. Even today, some girls, especially from higher rank, are required to be covered in public. I was always surprised seeing some chatty, mischievous girls outside the school wearing long stylish designer *abayas*, and having their head covered; these two pictures just did not go together. But looks could be deceiving. Girls are little women, they want to know everything and nothing could be hidden from them. They are tense, demand to be involved in every aspect of the classroom and question all my decisions; they want to do it in a 'right way', maybe realising the opportunities education can give them.

Boys are different. They are relaxed, pleasant and charismatic. Once the boundaries are established and relationship is formed, they will eat out from the palm of your hand.

You can write anything Miss

I explained the boys that actually they could have a look at what I was writing about them for my research. In fact I would like if they could come back in the break time and read one of my essays.

'Do we have to?'

'No, you do not have to, but I would really appreciate; it would help me a great deal.'

Only Adil and Nazir turned up, Max was playing football. I was not surprised; Adil struck me as a student who wanted to be somehow 'involved' in the research.

I showed them one story, only parts where they were mentioned, and explained that it was approximately what I was going to include in my thesis. I wanted them to see what actually I was doing and if they thought I wrote about them in an adequate manner. After skimming my work the boys looked surprised and a bit disappointed.

'That's it?' Adil sounded unsure. I think he was expecting my work to be more 'scientific'; after all, it was a thesis for a Doctor of Mathematics Education.

'It just says what happened in the class.' Nazir added.

'I am not sure if it describes actual events, but this is how I remember it to the best of my ability. For example, I am not sure if you said it exactly like that, maybe something similar.'

'Yeah, I remember coming on the whiteboard. And I said something like that. 'Adil confirmed.

'So how can we help you?'

I did not know how to explain. 'Do you look ok in this story? I know it is not exactly what happened, but is it ok to write like you said it? Did I describe you well?' I did not want to use some fancy and abstract words.

'You can write whatever you want Miss.'

'I still have to see what I am going to make out of this, but it is going to look approximately like this. When I finish everything I will change your names, so no one will what you said.'

'You do not have to change my name; I want you to keep my name.'

'You can write anything, Miss, no need to check with us.' The boys were very cooperative.

Insha'Allah

'Insha'Allah Miss, we will see you after school.'

I was trying to organise some extra classes with the boys. Literally translated, 'Insha'Allah' means 'God willing'. Muslims always say 'Insha'Allah' when talking about things they will do in the future. However, reading between lines, it can have a different meaning. None of the children would ever say: 'No, I am not coming after school' or 'Miss, there is a football game. Do I really need to come?' Being up front and openly refusing to attend after school lessons would be bad-mannered. Their responsibility somehow disappeared with the words 'Insha'Allah'. It leaves them with the option of being polite and not communicating the answer directly. Saving face is very important for Arab people.

'Insha'Allah.' I sighed with a smile.

Football is the best

The boys started entering the classroom. They had red faces and hair sticking almost vertically on top of their heads; they were playing football in the break.

'And the reward for the best hairstyle goes to …..' I was laughing while turned around.

They looked each other and one by one joined me in the laughter. In the end all eyes were on Lucas.

At the beginning of the lesson we talked about some jobs mathematicians do. I told them a story about a mathematician who ended up in the jail as his estimations caused the company a loss of 2 billion dollars. I mentioned that ASPIRE (a local sports institution) spent a lot of money on various sports technology and it was important for them to know what was the most popular sport among young people. They may employ a mathematician (who will get a lot of money for the job) to find out the answer for such a question. I asked them would it be ok if the mathematician called them in few days and said: 'O well, football is the most popular sport, can I have my money please?'

‘He would need to provide some kind of evidence.’

‘Maybe he can write a report’, Badr said.

‘Well we are not going to do investigation for ASPIRE but for the PE department.’

> The PE department wants to organise after school activities. They want to know what is the most popular sports among students are. You are asked to investigate what the most popular sports among Year 7 are and to write a short report for the PE department.
>
> Your report should include a brief description of what you did and your findings.

Just weeks earlier the boys did report writing in English and quickly came up with the suggestions of what to include in the report: paragraphs, headings, graphs, bar chart, frequency table, conclusion. (As they were talking, I was drawing a concept map on the whiteboard.)

I helped them organise headings into the following categories: Introduction, Methodology (Adil came up with that one. I told them that I was looking for a more formal name for “How are we going to do investigation”; Adil loves coming up with sophisticated solutions and terminology) and Findings.

In groups they tried to decide how we should conduct our investigation. They just did not seem to agree on anything. Around each table was a lively discussion.

Habib started with the views from his group that football should not be included as everyone was going to vote for football so they were not going to get a real picture what is needed. He said that they would offer five different sports to other classes.

‘How are you going to decide what sports to offer?’ Adil asked.

’But you have to investigate what is the most popular sport. This is what you are asked to do, look at the problem. You cannot just take away the most popular sport.’ Harry did not agree with them.

’Why don’t you first ask what their favourite sports are, so you can include these sports in the survey?’ Oliver suggested.

‘Our way is the simplest way. We do not want to include things like skiing which maybe just one person like, and we do not want to have many sports which just one person like.’ Habib tried to defend his way.

’I think it is not fair.’ Ahmed expressed his opinion.

’Maybe we can do like ‘Other sport’ option. They always do that when you when they ask you questions about school. Sometimes you put many options, but you may forget something.’ Kyle proposed.

’We can do internet research like Facebook to see what sports to include.’ Max suggested.

At the end we decided to check in our class what favourite sports were and include them in the list together with the ‘Other sport’ option.

Oliver proposed that each group investigate a different class which was accepted. He said that we were expected to behave properly and that they needed to introduce themselves and say briefly what the investigation was about. Two students from each group were chosen to go to other classes and

collect information. The boys were randomly picked and first had a practice in the front of class. Leo said that if someone refused to hands up it was ok we will just exclude them from the tally. I pointed out this was how the things were done in the real world; you cannot force anyone to participate. A couple of the boys went to complete the investigation in the computer room.

The boys enjoyed going to other classes and a majority of them completed the report by the end of lesson. Some of them got really excited and passionate, and insisted that the school and PE department would have to listen to their recommendations (Nazir, Joshua and Archie). I promised to take our findings to the PE department. I had to remind them that in real life job if ASPIRE hired a mathematician to write a report, they would not necessary listen to his / her recommendation. It is after all an ASPIRE's decision, or in our case it a PE department's decision. Max and Kyle brought up the issues like the school budget and climate, and said that the PE department had many things to think about; it was not just the case of finding the most popular sport. Maybe they needed to train some teachers or hire coaches. Alex suggested that maybe we can recommend PE Department to do something to promote other sports. We agreed to include these insights and limitations in the report as well. The boys were really excited with the possibility of actually advising the PE department on the choice of the sports activities. Suddenly the investigation came to life; it was a real tangible thing.

Alex mentioned that he read an article about whether people could taste the difference between Cola and Pepsi and thought it would be nice to do this in our class (which we did a couple of weeks later). Oliver thought it would be good to have a pictogram describing students' participation where they would get a merit for good work (which was accepted). In one of the previous lessons I asked them if there was anything they would like to do an investigation on, and I thought the suggestions were a response to my question.

'The lesson was too short. I wished we had another one.' Nazir commented.

At the end of lesson Oliver said: 'Another thing, Miss, I think your desk is a bit messy, I think these files are not helping much, It could be distracting. I cannot see you properly. I will come back in the break time to help you tidy up.'

This kind of investigation is not my strength. I prefer more 'mathematical' activities. Somehow, statistics does not count as very mathematical in my eyes (I believe I speak for many mathematics teachers). While teaching statistics could be much easier than other mathematical subjects because of the availability of the real life examples and students' enjoyment, I have never liked it. I just prefer activities with more logical background which can give them more mathematical experience (as I see it).

I have to say I found it difficult to stop them discussing things. I have to work on that issue. Everyone just wanted to be heard. On one hand this is what I wanted them to do and I am happy to step back and watch the argument develop. I could see that they were gaining from the discussion time; however, on the other hand, my worry was that we cannot spend all our time just talking. They needed a variety of activities during the lesson. Did they? No wonder Nazir thought he was not doing anything. I was not even worried about covering everything. I just thought that an entire lesson should not be allocated to the discussion time. Is it in contradiction

with what I am trying to do in the class? If I try to stop them, I am worried that the boys will think that they are not heard enough. After trying to create classes where they can freely express themselves I wanted to have enough time to hear everyone, especially as everything they were saying was relevant to the lesson. They did not waste time.

Why Mr Mac married a woman older than him?

'Mrs Mac, how old are you?'

'In western countries like England or Australia, even where I come from, in Serbia and Bosnia, you do not ask a woman how old she is.' I tried to pretend like I was avoiding the answer. 'Is it similar in Arab countries?'

'I have never heard of that.' Adil shrugged with his shoulders.

'You cannot be too old; you had a baby recently. How old is your daughter now? One year?' George joined the discussion.

'You know, we were always wondering why Mr Mac married a woman older than him.'

My jaw dropped in disbelief. *Why Mr Mac married the woman older than him?! Let me make something clear, Mr Mac did not marry a woman older than him!!!*

Chat with Nazir

'Miss, I really enjoyed today's lesson. 'Nazir said as he was packing up.

'Thank you, you made it enjoyable for yourself.'

'I just want to say that I do not know what you mean by 'real life application'; we cannot do real life stuff in the class.'

(Most of the time, on the whiteboard I would indicate the date, objective and a real life application.)

'Why not?'

'This is a classroom, and the real world is outside, it cannot be mixed. I know we do things that look like real stuff, but they are not really real life things. Mathematics is just for the class, not the outside world.'

'So you are saying that nothing we do in the class will help you in the real world.'

'Not really, we just need to do well in the exam.'

This is not how we do things in mathematics

'I need to ask you a question.' A colleague from the science department came to the maths meeting,

He continued: 'This student drew an upside down coordinate system, so the negative numbers are up and the positive numbers are down.' He was showing us the diagram. 'It is an important exam, and I want to make sure I mark it correctly.'

Before I had chance to say anything a couple of teachers waved with their heads. 'No, this is not how we do things in mathematics.'

'Is she consistent with this coordinate system throughout the questions? For example, she is not changing her mind half way through and assuming the standard coordinate system.'

'No, no, she is consistent with this diagram; her answer relies only on this system.'

'I think it is ok.' Alma did not see any problem with an upside down coordinate system.

I nodded with my head as well.

'No, you cannot do this!' some people disagreed.

Our science colleague left; however, we continued the debate.

How (not) to design a test

'No matter what you do, I want to see a concrete question with specific marks. I know you like your wishy washy stuff, but please keep it real.'

'What is this? Cartoons in the test? Please can we just have some actual questions, a couple of each kind? And why is this easy stuff in the same paper as the level 7 stuff?'

'It looks good, I like your way of doing things.'

'Dear, I am happy whatever you do.'

I decide to be in charge of the formal assessment for all year 7s as I thought it would work for the study (read my) benefit; however, that task was not as easy as I anticipated. I thought I would create an assessment which would be in the line with the teaching and learning going on in my classroom, and (again, in the line with my research) I tried to communicate with my colleagues and take their opinion on board, but it was still a difficult job to make everyone happy.

No cheating allowed

Last week the class had a test and today we were supposed to go through the test. I find the test analysis always confusing. Each time I try to change the format and to find a more efficient way to do it. First, I planned to discuss the question they found difficult. Then, I hoped they would assess their work and come up with the level and the points for improvements for each other.

Before discussing the questions I asked them the following question:

A farmer is 32 years old. He has 25 sheep. How old is the dog?

‘How are we going to answer that question? Is it a trick question?’ Nazir asked.

‘Why do you think it is a trick question?’

‘Are you going to tell us when was he born?’

‘Can you just subtract 32 and 25? So the dog is 7 years old.’ I asked.

Some student started nodding with their heads.

’But why would you do that? It does not make sense.’ Alex was confused.

‘So does it mean that sometimes you just cannot calculate something? I mean it does not make sense to subtract 32 and 25 just because they are the numbers given in the question. Keep that in mind while solving problems.’

A number of students were not sure about the following question:

The students in a year 7 class were asked what their favourite sport was.
Here are the results: ‘Football / basketball / football / swimming / basketball / football / surfing / badminton / football / swimming / tennis / football / swimming / badminton / football / tennis’

Is it possible to work out the **mean** of these results? Explain how you do this.

‘How would you find the mean for these results? How do you find mean for any data?’

Habib: ‘You add numbers and divide by how many numbers you have.’ ‘Can

we do that here?

‘We can, you have 8 football, 2 basketball, and so on, add them together and divide by 6.’ Max offered his explanation.

‘You get 3.3.’ Noah quickly calculated.

‘Why did you divide by 6?’

‘Because you have 6 different types of sport.’

‘But *is* it the way we find mean? We said that you need to divide by how many numbers you have.’

Oliver: ’No, it is not, you would need to divide by 20, because you have 20 students in the class.’ ‘I

know but you can still calculate something.’ Max was defending his approach.

‘I agree with you. Yes, you can still calculate something, but is it the mean?’

‘No, but we are asked to find the mean and we have to find it somehow.’

Harry: ’We need numbers to find the mean; we cannot add them, football plus basketball plus swimming and so on.’

‘We can only add numbers.’ I tried to explain.

’I understand, we cannot find the mean, but what about the test asking us to find the mean? We just leave it empty.’ Kyle partially agreed with us.

’No, you need to explain why you cannot find the mean.’ Alex pointed out.

Max: ’Just like that, does not matter it is a test question.’

‘Actually Miss, we found by how many students is each sport liked in average.’ Adil explained the meaning of Max’s answer.

’What? What are you talking about? Do not confuse me with things we do not need to find.’ Kyle was almost upset.

I explained how the marks were allocated; it was usually the same as the number of steps required to solve the problem. If the answer was explanatory then it depended on the complexity of the question, the number of different steps and /or the number of various reasons.

The front page of the test was a summary page including objectives and corresponding levels. They were asked to swap papers with the person next to them and try to decide which level their partners deserved. I showed them one test from the other class and told them that the “girl” was obviously ok with the level 4 question, with a couple of mistakes in level 5, and just starting level 6. I thought that she was at about 5a to 6c level at that particular topic. I tried to stress that I was not able to decide the level exactly. I pointed out what she needed to improve in level 5 and 6, and wanted them to do the same for their partners.

‘I think I am not really good or really bad. I think I am in the middle. Because my marks are between 5 and 6 (referring to levels). And also I am answering the questions, doing classwork, and everything.’ Lucas gave his self-assessment. I was glad that he did not only emphasize the test.

Interestingly all the class tried to come up with a formula (which is not what I had in mind; I wanted them to focus on what they could improve). There were 12 sublevels. They divided total number of marks by 12 and came up with the range for each sublevel, differing by one mark or so. (The practice followed by our department as well.).

‘Why did you do that? I thought that you can analyse the paper quicker without any calculations.’ I asked Kyle.

Kyle: ‘I know Miss, but this is clearer, more precise.’

Nazir: ‘I prefer this way as well. I want to know exactly what level I am.’

I marked the test but did not indicate any marks or levels; I left it to them to find out. A couple of students did not want to share their test with anyone (Leo, Laith, George) as they thought that their work was not good enough. They marked their own test. They approached the activity quite seriously. I am not sure whether it is because they had a teacher’s role to mark the test and give a feedback. They were really keen to explain their way of thinking if they did not get full marks (particularly Nazir, Alex and Kyle). It was like they had a chance to do the test again. When I asked them if it would be ok to accept their explanations as a part of the assessment mark the majority disagreed; only few students (Ahmad, Badr, George, Joshua) thought that it would be a good way to boost their marks.

Max: 'It is cheating. The test was on Monday.'

'Í know, but you learnt something today did you not, and you talked it through with James, so it would still be you work.'

'It does not work like that. It was not under the test conditions. I should not be allowed to talk to anyone.' Max was sticking to his view.

'You silly, this is why it should be allowed. Next time only Tyler can study for the test.' Ahmad thought it was good idea.

'Can we actually do this? Can you change our marks today?' Joshua inquired.

All class except Ahmad, George and Badr:'Noooooo.'

It is the same name they just write it differently

I was chatting with the girls from my class in the break.

'Miss you teach my cousin in year 11.' Jana said.

'Really, what is her name?'

'Fatima.'

'Hmm, I know Fatima. I am positive that she has got a different surname. Is her surname not Naumi, and yours is Naomi?' I said. My mother language is phonetical and I remember the spelling of the words as they were pronounced in my language, regardless how they sound in English.

'O no Miss, this is the same name, I know, our fathers are brothers. When you go to the office people just write it differently.' she explained.

And no one cares that officially you have different surnames!?

Rain

I was walking through the hallways of the recently built mall. It was bright and glittery. There were many designer shops: Dolce and Gabbana, Chanel, Louis Vuitton …The golden brick path was shiny; some claimed it was made from real gold. The inside of the mall reflected the culture: lively, rich, sparkling and dazzling with colours. Shopping is a favourite past time of many people living in Doha, for many reasons. I felt one or two drops of rain on my face, which I dismissed in disbelief. Soon I could not hear my daughter's voice; the rain was so heavy that it seemed that the roof was going to collapse. She was screaming and laughing with other children who could not believe with their eyes; *it was raining*. It was raining *inside* the mall. It never rains in Qatar. Soon the drops became leaks. Shop assistants from the luxury, opulent shops were pulling the buckets under the drips of water. A stream was running through the mall. *I do not think I will have my Starbucks today.*

Debating session

'Miss what are you doing here; this is not mathematics?' the kids were still surprised to see me in the Debating activity. All the other teachers were either from the English or Social Studies department.

This year I was trying to do something different rather than usual the Mathematics or Football activity, so decided to try the Debating and Model United Nations Activity (MUN). It looked interesting; many students were involved and they were always excited, talking about tournaments.

As I was studying the judging sheet in front of me, I was thinking how was I going to award marks out of 82, based on a 3 minute speech?

Adil, Alex and Noah were in one team. I had seen them here before but had not judged them.

Adil was the leader, as always. He was telling Alex and Noah how to organise their speeches. Alex was attempting to question his argument and succeeded to an extent. Noah was happy to follow any instructions.

The argument started. The boys took turns in arguing if junk food advertising should be banned. Alex was a bit tense. He had made a lot of progress since the beginning of the year; he used to almost startle when talking. I hoped that our classroom debating helped as well. He used a correct format but somehow failed to rebut effectively. His speech was reasonably smooth but too short. I was fighting my urge to tell him to stop and take a breath. 1:48. too short. Noah's speech was even shorter. He used one argument only. Couple of sentences and he was looking in Adil's and Alex's direction. I felt that he had improved as well, but the speech way too short. Barely 1 minute. Adil was very good. His arguments were clear requiring a sophisticated reply and he easily minimised the importance of opponents' arguments. He spoke in an engaging manner having good eye contact and pace. 3:02. Great timing.

I apologised to the students saying that I had just started my debating course, and was still not a proper judge, but hoped that I would be able to give them an appropriate feedback. The boys lost by a couple of marks (they were all beginners). Adil came to see me, slightly disappointed:

'Miss, but who got the best individual score? Did I get more than 80?'

Journal notes

Adil

We do learn things about real life, for example:

- *time,*
- *temperature,*
- *length,*
- *weight.*

I think the method the teacher uses to teach us is interesting; the way she always makes you wonder more. For example, in the frequency table intervals:121cm– 130cm, 131cm – 140cm, …, she says what if someone is 130.5cm, where will that go? She can also leave us in cliffhanger when she asks if 0.999…(recurring) is larger, smaller or equal to 1. -Left me in shock.-

It is appropriate that anyone ask something about the topic, so long as the teacher hasn't explain it, or the students not understand the method the teacher used, who thinks that she can explain it in a different way. I also consider suggestions appropriate as every student is almost the same age, everyone can basically relate to each other.

My participation class I consider fair. I put my hand up to try to answer the question, even if I have already answered the previous. It shows my eager ambition to show the teacher I understand.

Nazir

I think that we do not discus real life in Maths. Maths is an important subject, I don't love it but I don't hate it nor do I mind it. I like the fact that we always discus work and the sums rather than plain text-book work which I think is boring. I can always ask you things when I need to, there is no problem with that. I can always suggest things when needed. I think I am heard however I get disappointed when we get carried away with exam marks. I mean like that students misjudge others by their marks and never focus on the people class work effort. I would like if we book computer room more often and more time talking about random topics and more activities. I would also like if we redesign the room.

Max

I would like to go their often. I would rather if you teach us, not tell us to discus and try by ourselves. Teach us how to do first then we try. I am very sorry but I don't think you teach us right.

I think we rarely do FUN activates (PARTIES LIKE MR MERRIC'S CLASS). We can also get a pizza and each one has to say how much he wants using fractions.
I like going to the ICT room I'd like to go their often. I like your room how you designed it. Yes life is all about maths.

Just do not tell my father

'Max, can I include what you said about me in my research.'
'What?'

'That I am not a good teacher. It would be very helpful if I can write that.' I tried to reassure him.

'I did not mean that, Miss, you are a very good teacher.' Max was obviously uncomfortable.
'I am serious; it is going to help me.'

'Are you going to tell my father?'
'No, no, it will be only me and my professors, and I will change your name, so no one will know.'

'Then you can write anything, just do not tell my dad.'

Are you still doing your research Miss?

'Miss, how is your studying going? Have you completed it?' Adil asked the other day. It was almost the end of the first term.

I smiled discreetly. The children quickly forgot the researcher part of my role. They did not appear to be concerned with my change in the status from a teacher to a teacher observer. After the initial fuss and excitement that I was doing something 'special' with their class, they quickly, with disappointment, realised that I was just a teacher, an ordinary, regular teacher. I may have been doing something different, but surely, every teacher is doing something different. The only time they were briefly reminded about my other role was when I was seeking their approval and clarification about the inclusion of some particular act or behaviour.

'No, we really do not need mathematics outside the classroom. Maybe if you go to the shop, otherwise, it is just for school.'

'Miss, you can write whatever you want to write!'

'Are you going to tell my father that I said that? Then you can write about that.'

'You want to include that I am not happy with what you do? I *want* you to include it.'

Is it really ok not to record the lessons?

The idea of taping the lessons crossed my mind again. I was mainly concerned about the validity of my notes. I recorded a few lessons and have not transcribed them yet. I was not sure if I wanted to use them now. Surely, now I can know what each student exactly said but somehow it was not anymore the most important thing. They appeared to be *too* aware of the taping. Some students were unusually quiet. I felt taping lesson took something away from me. I could not exactly pin point what was that. Somehow, it made my impressions about the lessons less valid. I could not tape every lesson, nor did I have my recorder prepared when something interesting happened. I needed to rely on my impressions about the students. This was what all other teachers did. My opinion about the students was based on little incidents inside or outside the classroom, not only on the taped lesson. Very often I did not even realise when and how the picture about a student was formed.

The students should not speak in Arabic

'I can hear students speaking Arabic in breaks. We have an increased number of behaviour problems, which is made worse if we do not know what they are talking about.' School has a strict non-Arabic speaking policy. A number of teachers complained that some students speak Arabic during the lessons or break time, which meant that the policy was not reinforced by everyone.

On the contrary, many Arabic staff brought up the issue that students did not have the chance these days to speak in Arabic and as a consequence had started to forget it.

'But, this is their mother language; we certainly do not want them to forget it.' I tried to explain, but was abruptly stopped by a senior member of staff.

'This is a British school, and students are supposed to communicate only in English. I think it is clear.' Mrs Smith stated what the majority of teachers were thinking.

Well not really. It will not happen in my class. I could not care less about the policy. I allow students to talk in Arabic when there is a need for something to be explained or translated. I do not mind at all if they speak Arabic in breaks. After all Arabic is the official language in Qatar, and the mother tongue for the majority of students. I do not understand the fear that students may speak adversely about staff. We will just have to trust them. Why would speaking Arabic cause behaviour problems? Are they going to behave better when they speak in English? *What nonsense!* Many students have brothers, sisters and cousins within the school. It is not natural to speak in a foreign language with friends and family. You cannot speak to your brothers in English. I feel strongly about the issue. People who do not speak other languages do not understand it. I feel how my frustration makes me resentful, and I easily classify some of my colleagues as simple minded and indulged, even racist. *Well, they just speak one language.* The issue has a personal relevance to me. My husband does not speak Serbian and it is very difficult raising children to speak Serbian. I am defined by my mother language and am apprehensive that my children are getting to know the world through different lenses, a different language than mine. What message do we send to these students? By placing importance on English only, we are undermining their culture and sending them a message that Arabic is not as important as English. What about students being distanced from their own culture by speaking English only? Let us even not go into the discussion about linguistic and ethical problems; they may end up fluent in English but what about Arabic, and their connection to their own culture. Where does it leave them?

How did you think of that?

I like showing off in front of my students by quickly finding the result of some calculation. My favourite would be finding the third root of a whole number (works only for whole cubes). Today, I wanted my students to explore and embrace mental calculations.

To start with, we checked that everyone was able to calculate 1%, 10% and 50% of 800QR. I mentioned that in a non-calculator exam there may be a need to do a question quickly, so I would like them to try do the questions in what they thought was the most efficient way.

'Obviously, we may end up with a number of efficient ways; what is an efficient way for one student does not have to be for the other.'

I really did not have to check if they knew how to do some simple questions. I felt better knowing that they were ok and at least that those who were stuck would be able to build on something. I was aware that at times I offered a lot (too much?) of guidance. I was careful not to tell them how to do questions and tried not to confirm whether the question was correct or not. However, I felt better if they were exposed to some correct procedures.

Fadil said that he would first divide 800 by 100 and then multiply by 49 in order to find 49%.

'I suspect that your way may take some time without calculator. I can tell you that the answer is…392.' I said after a short pause. Do you think I used your way?'

'I do not know how to do this. You did not teach us how to find a percentage.' Max protested.

'The best way I learn is first to try by myself, and then I like to discuss it with the person next to me, and see their views and my views and try, and then the teachers' point of solving it.' Harry was almost defending me.
'You explain and tell us how to do this, you tell us the answer, and then we do it. If someone does not do this, we try again. If you do not tell us how to really do this, we may waste our time. We may not know how to do it, but if you explain.' Kyle tried to explain his point of view.

'I was hoping that you may figure out by yourself.' I persevered.

'But I do not know any method how to find a percentage of a number.' Max persisted.

'That is not true. You just told me how to find 10% of a number.'

'But that is easy.'

At that point James interrupted him: 'Look, you can find 15% if you first find 10% and half it.' James was showing him his calculations. 'Now you add these two numbers.'

Max looked at James's exercise book for a few moments. 'How did you think of that? That's clever.' 'But I still do not understand how to do this with all these numbers. Can we work together?' he asked James.

Interestingly, most of them really liked mental strategies (which unfortunately they did not use much previously). Some of them appeared to be amazed with the methods used. They got really excited and started competing with each other around the tables who could come up with a more elegant (*Yay, I succeeded in 'normalising' this word in our classroom practice!!!*) or faster way of finding a percentage of a number. They explained on the whiteboard various approaches. I appreciated to be in the classroom where mental strategies were 'cool'. However, I noticed that Kyle, George, Badr and Tyler continued using the long multiplication procedure instead of mental strategies. Tyler doubted that the new strategies would always deliver the

correct answer. They appeared, in his words, to be unreliable. A couple of students came to check with me a few questions. I felt it probably had to do more with their desire to be organised and do things 'properly' rather than not being able to decide what to do.

They had a choice of practising similar kinds of questions, investigations/extended work on percentages (percentage increase and decrease, reversed percentage) and selected the worksheets for themselves. Many of them attempted the extended work. The boys were particularly happy that the extended work came from a year 11 book. They did the work by themselves, in pairs or groups.

Nazir, Imran, Archie and Joshua started sitting together this term and did not start doing their work until they were given a warning. After that they worked well. I was pleased to see that Ahmad enjoyed the lesson. I noticed that he improved this semester: he participated more in the lesson and was willing to join a discussion or explain on the whiteboard.

At the end of the lesson we had a game and many students showed some impressive arithmetic skills. *Mission accomplished; I will have some serious competition in this class.*

If it is not coming up in the exam…

At the beginning of the lesson Oliver told us more about the InventNow website, where people could register their patents. He said that it was something he enjoyed outside the classroom and urged other students to explore it. Oliver was an interesting and independent boy who enjoyed mathematics classroom. He was one of very few students who were not affected by Adil's reign; Oliver was fighting his own battles and did mathematics for his own personal satisfaction. He spoke about his inventions which sounded, well, quite innovative. *The mobile phone with the credit card slot. That is something.* He told me later that sometimes mathematics lesson made him feel like he was trying to come up with a patent.

For homework they needed to do research on multiplication and division of fractions. It was their choice to do this topic at home. Many insisted that they knew how to do this and thought that there was no need to spend a lesson on that topic. Half of the class had the multiplication and half of the class division of fractions. They needed to provide explanations how and why they worked, and to come up with real life examples. In the class they needed to explain the work to each other, in pairs.

'Where is your homework?'

'My nanny forgot to pack it up.' Lucas immediately regretted his response. 'I forgot to pack it up. I am sorry Miss, I will bring it tomorrow.'

Every day an army of nannies carried bags to school. Occasionally, they would come to your lesson in the middle of the day with a forgotten homework or a lunch box. It was always their fault.

'It must have been the easiest thing we have done in mathematics.' Joshua commented.

However, when asked why it worked no one could explain. Did they think that the algorithm looked logical and easy to accept?

Only Nazir and Adil responded.

'Miss I actually copied it from the Internet. You can easily see what is happening, but first I did not believe it when I saw it. They must be joking. I really do not see how it works. The only way I can understand it is to convert it to decimals and then multiply or divide. It makes sense. I really do not get why it works like this'. Nazir was honest with his 'homework' strategy.

Adil:' Miss I can see how the answer make sense. I mean what is

You have 4 ninths and you need half of them (it was supported by a diagram); however, I just do not get why they multiply across. And division is even weirder.'

At that stage I told them how I saw things when I was their age. I wanted to know why it worked like that; I mean the algorithm was obviously much simpler than addition.

'The fraction line means division so ...' I explained my interpretation on the whiteboard.

$1 \div 2 \times 4 \div 9$ = (rearrange)

$1 \times 4 \div 2 \div 9$ = (At this moment I asked them what we were actually dividing by in total and they recognised it was 18. I recalled that back when I was their age, I compared it to putting a negative sign in front of a bracket, two negatives give a positive.)

$(1 \times 4) \div (2 \times 9)$ (finally replace ÷ by a fraction line)

$$\frac{1 \times 4}{2 \times 9}$$

Couple of them nodded with their heads.

'Miss your explanation is a bit messy.' Not all of them looked happy with my reasoning.

'It is not the most elegant explanation but this is how I made sense of the rule.'

I asked them if they felt they would like to spend another lesson on the same topic to try to understand why things worked.

Leo: 'Miss I think it is going to confuse us. I can kind of see why your way works, but I am happy just to know the way of doing this.'

'Miss it is not coming up in exam and I think most of us are only interested if it is in the exam.' Nazir was practical.

Alex disagreed with him. 'I would like to know because it may help me with other things in mathematics.'

'I am really curious to know why it works. I mean it really looks weird, flip and multiply.' Adil of course wanted to know how things worked. Most of them were shaking their heads.

Joshua stopped at the door as he was leaving: 'I did not like when we have a question, and then you ask us to explain it to each other. I would like if you can first explain question, so we could know. You can maybe make a mistake, but if I ask Nazir or Imran, they will make a mistake more than you, they are my age. Miss, because when I do in exam I might do it wrong. Also, I do not like when we spend half an hour on the board discussing the same question; it is just one question. And then when we have an exam maybe that question will not come up. I feel we waste a lot of time talking about the same problem. We should do more questions. Miss, I

think if someone asks you should explain it. You should explain it on the whiteboard so other people won't ask.'

I tried to explain that all I wanted him to think and create his own understanding of the concept. I promised that I was not going to leave him unsure about any explanation.

I was not really happy with the lesson. I should have done an investigation which would lead them to the rule. I was still going to do this, despite what the majority of the class thought. I was hoping while doing their homework maybe some of them will come up with an explanation. Unfortunately no one did. It was a little bit too much for them. I think division could be more naturally introduced by making denominators the same and then in older years introduce the rule. Unfortunately, many kids knew the rule already so it made things harder (many classes do division and multiplication before addition and subtraction as the rules are easy to remember). By the time they are year 7 or 8, the students are already familiar with the rule and it is hard to persuade them that they should know the reasoning behind it.

Sometimes, the students fail to make a relevant response; they kind of circle around and around but are not quite there. In that case I tell them how I used to approach the problem when I was their age, or what someone else from the other class suggested. Interestingly, because it is mathematics, I remember the ways I made sense of the concepts. I do not remember how I made sense of photosynthesis, but I recall how I understood mathematical concepts. One of the first problems, I was breaking my head over, was how putting a negative sign in front of the brackets changed the sign inside the brackets. It happened in my early primary years. The teacher presented it as the rule and I spent a lot of time trying to figure out why it was happening. If I think about that carefully my constructions have not changed; now, I may have multiple constructions for some concepts. Not all my constructions were simple and elegant but a few times they prompted the discussions. Am I ruining the shared control? I think not. I am a part of my class and I have right to present my opinion as equally as the other participants. I have students presenting their opinion in front of the class, so I am doing the same thing. I am careful not to say 'this is the right way to do the problem', but to present it as my opinion and it is up to them to consider it or not. Another reason I do this is that some students fail to explore the problem at their own pace and quickly become satisfied with a trivial solution. They do not want to challenge themselves with more problematic work. For example, Badr and George did not like investigations and challenges. They opposed the inclusion of higher level questions in any assessments or activities. I was thinking about Joshua's words. There are a couple of boys in the class who really would like me to explain the concept before asking them any questions. This was how possibly mathematics lesson looked like for them in the past. This was what their expectation from the teacher was. I was neglecting the way they learnt mathematics in the past. Was I really taking their past experiences into account? Did I really cover personal relevance from all angles?

We do too much real life stuff

I asked the students to think about the use of real life applications in our classroom.

'I think we do too much real life stuff. They are actually easy examples, and we should do questions from the book. It is not really necessary to do real life examples in the class.' Joshua raised his voice. 'I think you need mathematics for everything. I want to be a doctor or a chemical engineer like my dad.' Harry said.

'I want to be an engineer. My dad is an engineer, and he uses maths. My father told me that I need maths. You need maths for everything. Maths is everywhere, even in entertainment, in football. You showed us and we did examples. We did a lot, there is no need for more. Maths has more real life examples; in other classes they tell you, but it is better what we do.' Leo interrupted Harry. 'I want to be an engineer as well, I need maths for that. We need mathematics in life. For shopping, measurement, everything. We sometimes did real life maths. Maybe bit less than other classes. Maybe we should do more.' On the other hand Noah thought that we did not spend enough time on the real life examples.

Kyle: 'We do not really need real life stuff. For example, if you learn algebra, you first need to do other important things, and then relate it to real life examples.' Kyle disagreed.

And here I was thinking that I addressed the issue of applicability of mathematics in real life to an appropriate level. I really thought that in every lesson our approaches modelled real life examples, or we mentioned some concrete realistic examples. Obviously, the boys had different opinion about that. What qualified as an everyday example for me obviously had a different impact on them. Further, some of them thought that they were really 'watering' our concepts and did not want them. I was surprised by Leo's statement that mathematics was an easy subject to accommodate practical and authentic examples from outside the classroom world. Many people (and teachers) would disagree with him. Surely it means that our 'coverage' of outside the classroom world was adequate.

Never heard of a teacher who first asks students to think

During the book fair, the price of a book first went up by 10%.
In the second week; however, it went down by 10%.

'Oh well,' said Amir, 'at least it is back to the amount it started with.'

'I know it is not easy as it says; you are going to prove us wrong again. You would not ask a question which is obvious.' Nazir commented.

I smiled discreetly; I was pleased that they did not immediately just assume an uncomplicated solution to the problem. To my surprise after a short discussion, quite a few students explained the question as interest on interest.

The students had a choice of questions, percentage increase and decrease or simple compound interest questions. Some still preferred checking answers with me (Harry, Kyle, Max, James, Fadil) although to a much lesser extent than before.

'Miss, I do not understand percentages, you have to explain me.' Max was not happy.

‘I would not say you do not understand everything, let us have a look.’

‘Miss, my father never heard of a teacher who first asks students to think and do explanations before she explains things. Can you explain me the second question?’

‘Let us try doing things together.’

He was trying to do a question where the price of a ticket of 800QR flight for Dubai, was increased by 30%.

Harry tried to explain a percentage increase question using the following steps:

800÷100=8

8×30=240

800+240 = 1040QR

‘Why do you think Harry divided 800 by 100?

No response.

‘Do you understand the question?’

‘We have to find 30% and add it to 800. So why the answer is not 830?’ He inquired.

‘So what are you saying that 30% is equal to 30?’ Again,

no response.

‘You understand the part when we have to add it to 800.’ It seemed from his response that Max was Ok with the adding on part.

I showed him one of the square diagrams divided into 100 parts from the first percentage lesson, and asked him to show me 1% of the square which he did.

‘It is a hundredth part.’ He explained.

‘What if all square was 800QR what would be the value of one of the little squares?’ ‘Eight.’

‘How do you know that?’

‘Because you have 100 of them, so 8 times 100 = 800. You divide by 100.’

‘So if this was our plane ticket what is the value of one percentage?’

‘8.’

‘Do you think you know why Harry divided 800 by 100.’

‘I know, to figure out 1%.’

‘But how many of 1%s we need?’

’30.’

‘Any idea how would you do this?’

'Multiply 8 by 30, this is 30%. And then add it to 800, so 1040. But can we use the way without calculator? I think it is easier.'

'Whatever you feel more comfortable with. You should still try to understand other ways.'

I felt I was guiding Max too much. He was one of the three students struggling (him, Tyler and Ahmad) and at times he felt uncomfortable with that. In addition, he did not feel comfortable with the fact that I did not explain things (and may I say I did not feel comfortable with his father not being comfortable with that). On the other hand, I appreciated him coming forward and asking for help. He wanted to know how to do the problem. I am not sure if I am working against the students' control. I do have responsibility to introduce them to the (currently acceptable) mathematical knowledge and in my opinion this is what I am doing. In the situations like this one I ask questions which I hope will take them in the right direction and I wait for a right response from a student.

Miss, you went to University; you are not going to make any mistake

Alex brought to school his building puzzle; its goal was to build the most stable structure with sticks and nodes. He said that was what he liked doing in his spare time. In his opinion, it was related to mathematics and made him realise that the triangles were the most stable constructions. The puzzle was one of the reasons why he would like to be an architect. I was not sure if it was prompted by Oliver's talk about his patents a couple of weeks ago. Maybe it was Adil's influence during the year. For Adil, mathematics was a personal thing and he approached each problem with passion. It was something everyone was able to notice. At no point did the boys think that Adil was showing off; doing Mathematics with passion was his thing. I felt sometimes that he challenged his group in a positive way. They have tried to adopt his way of thinking when solving problems and become more competitive. Boys started showing their little mathematical things, puzzles and inventions; they made mathematics a personal thing. Alex was happy in his group, he enjoyed arguments with other boy, proving his points to Adil, and interestingly succeeding on many occasions. He loved sharing his puzzle problems with me.

Most of them knew from primary school how to multiply and divide fractions, but no one could explain why it worked. For this lesson I prepared a little investigation which used shading parts of rectangles to demonstrate the result of multiplication and division. It appeared that the class did not enjoy the drawing part of the activity (contradictory to my expectations). Many students commented that division looked more natural; however, they did not think that the multiplication activity helped them better understand it. Only Max and James thought that activity was good and that it helped them understand the multiplication and division. Max was the only one who did not know the rules before the start of the lesson. I noticed this semester Nazir, Imran, Archie and Joshua were not working as hard as they used to. The boys started spending more time together and took time to finish the investigation.

I queried why some students liked to check their answers with me. Harry explained that they wanted to make sure that they were correct.

‘Is there any other way to check if you are on the right track? Can you check with Kyle? Or maybe recheck your method? I can make a mistake, and by the way you are much younger than me, I suspect that you probably work faster than me.’

‘No Miss, your mathematics is good, and you went to University; you are not going to make any mistake.’

As I was walking around classroom I spotted Max’s exercise book on the floor. I quickly leafed through it and put it on the table. Something surprised me; there were not any notes in Arabic. I took other few books from surrounding tables. It was weird. Not one word in Arabic. Surely, they sometimes felt the need to explain something in their mother language.

‘When you write a mathematics explanation, you never write anything in Arabic?’ I asked the students.

‘No Miss, this is mathematics that is not related.’ Habib answered.

‘But do you ever feel that you can better explain things in Arabic than in English? I know when I take notes; I frequently mix English and my mother language. Like, my brain somehow quickly choses the best word to explain something and notes are in both languages.’

‘No Miss, Arabic grammar and spelling are too difficult. English is much easier to use.’ They would rather explain in English than in their mother language.

I was aware that my students spoke different forms of the language. Some of them explained to me the existence of different dialects across the Arab world, and difficulties faced when speaking to someone using a different dialect. However, after this little incident, I have become more aware of the complexity of the situation. It means that their knowledge of Arabic is not very advanced if they find it easier to use English to take notes. What about the construction of mathematical concepts? Do they have to think particularly in English and not rely on Arabic? I was confused. One should not be finding the second language easier to use than your mother language.

We did not do any rules

The boys were trying to find the total surface area of a cuboid. I thought that they would be familiar with the volume and total surface area of a cuboid but a brief discussion with the class last week told me otherwise; before we started the topic on the shape and space they were just familiar with the area of a rectangle. We spent two lessons on 2D shapes and they were doing fine; however, I still found it strange that many boys understood quite advanced percentage concepts (compound interest and reversed percentages), yet there was a need to do some basic area and volume topics.

Each group had a tissue box with the measurements of 24cm, 12cm and 9cm.

Nazir suggested multiplying 24, 12 and 9: 'I have 24×12 from this side, but I have many of these layers inside the box, in fact I have 9cm of them, so 24×12×9.'

'But you do not use these layers to make the box, I mean your box is empty, you do not use paper to make nothing.' Lucas made a point.

'Ooo you are right.' Nazir admitted.

'Well Nazir you found something which is called volume and we will do that next week.'

'Will it be how many cubes are inside?'

'Yes.'

'So, we need to find the area of the paper needed.'

Adil: 'How are we going to do this? We did not do any rules.'

'I like when you explain on the board, and show us examples how to do it. In the book they do not show us examples.' Habib preferred to hear my explanations first.
I was a bit surprised that Adil asked about the rules. Usually he was not bothered with me not presenting them with the rules. Was he prompted with the fact that in the last two lessons we came up with some rules at the end? We do not always do that. After all, Adil liked creating the rules within mathematics, in his eyes, this is what made mathematics.

'It seems that many students cope without being given any rules; they create the rules. If I give you the rule you do not have to think much. But now you will have to try to figure out things and this is important for you and me that you are really involved, rather than waiting for me. I think you can try to figure it out by yourself`. I felt I needed to explain my approach in order to make (some) students feel safer about the activity.

'I chose to do it by myself first. So I can understand it. Then if I do not get the problem you can also show us on the board.' Imran said.
Nazir, Archie, Imran and Joshua were struggling. After some time they still did not move in any direction so I cut and opened one box for them. Joshua looked a bit disinterested and relying on the other boys in his group. The rest of the group suddenly was brought to life. Nazir started drawing lines on the net.

Kyle suggested finding each rectangle separately and adding the areas together.

'Miss what about this hole and these little glued pieces of paper?' he asked.

'Can we not worry about that part?'

'I think they are the same so does not matter.'

'For our goal at the moment we will just assume that there is no hole.'

'Are we allowed to do something like that?' Max was not sure about my assumption.

'We can do this to make the question easier for us at the moment. Later we will create another question concerning holes. If you think about that, these little pieces are not even a part of the outside area.'

'I can see that.'

Later the boys explained the question on the board. Habib explained it as the area made up of 6 rectangles, while Archie found the area of the internet, breaking it into 3 rectangles. Adil explained the formula $2\times(lw + lh + wh)$. Despite the formula was not very difficult, I thought that it was quite impressive that he used variables to deliver his formula. Some students looked confused so he explained it using our example. His working out looked similar to Archie's presentation and that helped students understand his explanation. His effort was rewarded with some clapping.

Adil looked happy and proud of his formula; he felt, the formula looked really 'mathematical' and professional, and that was the way mathematics should be done. He had this view of mathematics that it should look clean and exact, and one of the ways to achieve that was to create formulas.

I pointed out that whatever way they chose it was a good practice to neatly show their working and make sure they communicate their ideas.

'Can we just use the formula?' Kyle asked.

'Do you understand how it works?'

'I do. Adil explained it nicely.'

'It is much better with the formula.' Max agreed with him.

'Just be careful; you still have to decide what measurements you are given.'

Most of the class chose to do questions from the book, while Adil, Alex and Fadil did the questions from the wall in which the area of various prisms was given and they needed to figure out the sides. Alex and Fadil found the questions a little bit challenging but they kept communicating to Adil. The questions resulted in a linear equation with which they were not familiar. Adil first explained the question using collecting like terms, but they found it a little bit too difficult to follow so they decided to guess and check, which worked for many of the questions. After a couple of simpler questions, Nazir, Harry Laith, Leo and Imran attempted to find the area of the composite prisms. They coped with the questions quite well. I felt that Lucas improved this semester. At the beginning of the year he looked disinterested, but now he appeared to enjoy the activities and finding his way of solving problems. Tyler improved as well. He started explaining concepts in front of whiteboard, and seemed to be less stressed about making mistakes.

Miss, you really like your Starbucks

Thursday afternoon is my favourite part of the week (In Qatar, Sunday to Thursday are working days). Every Thursday I do the same thing: while my husband is staying in school and playing football, I go with my daughter to do some shopping and have a hazelnut decaffeinated cappuccino at Starbucks - my favourite pastime. It sounds pathetic; no mother considers grocery shopping to be a favourite pastime, but I love it. I love everything it brings with itself; I spend some time with my daughter and the coffee is something I wait all week for. I do not

even like coffee and never finish it but there is something about what it represents. I am sitting in the coffee shop trying to make myself comfortable (no chair is good enough when you are 6 months pregnant) and my daughter is all covered in chocolate muffin.

A smiley curly haired boy waves at me: 'Hi Miss, you again. You really like your Starbucks.'

'Hi Adil, how are you doing?'

'You know, as usual, I love coming here on Thursday after school and enjoying McDonalds and Pepsi.'

'I know Adil.'

'Have a nice weekend, Miss'

'You too Adil, I will see you then on Sunday.'

I know now what π is. It is more than 3.14.

> What is 'π'?
>
> Mathematician: π is the number expressing the relationship between the circumference of a circle and its diameter.
>
> Physicist: π is 3.1415927plus or minus 0.000000005.
>
> Engineer: π is about 3.

I always thought that this joke communicates well the meaning of constructivism; the same thing is interpreted according to the one's needs and depends on the situation it is going to be used for. It appeared that π had a variety of meanings for my students as well.

A couple of weeks ago the boys were given homework to measure the length across (diameter) and the length around (circumference) for as many circles they could find at home. They were supposed to bring in their homework that day. The objective was to construct a relationship between the diameter and the circumference.

Students presented their work in groups. Max, James, Kyle and Harry thought that when you divide circumference and diameter you get approximately 3. Harry had a beautifully prepared homework where he glued some circular shapes and string to the worksheet. Kyle explained that they could not be really accurate with the strings so this is why the answer was approximate. They were happy with their answer.

'Miss, for me when I am standing in the front of the audience and when I explain it helps me learn more than the audience, I think.' Harry added at the end of their presentation.
Alex, Noah, Fadil and Adil thought that the answer was changing so decided to find the averages of the circumference and the diameter and divide them. They thought that their solution was systematic and detailed. Adil had some doubts about the accuracy of the answer

but was happy with his method; he thought it was really 'mathematical'. By finding the average his answer appeared to be more precise and the method was convincing from mathematical point of view. Later, after hearing Kyle's explanation that they could not be accurate with the strings he thought that it was an interesting idea, but still considered his answer to be precise. I found it interesting that he thought that the problem could be resolved in a mathematical way, by finding an average. I could see that he did not like the idea of mathematics not being precise.

These two groups were lively discussing the problem. They were trying to apply their rule on some questions.

In other groups (unfortunately) a couple of students found the formula $C=\pi \times d$ and tried to persuade their groups that it was a right answer.

'I am not sure Laith why do you think it is the answer.'

'This is the rule, it must be correct.'

'How did you come up with rule and what is this?' I pointed to **π.**

'This is π, look this is here in the calculator.'

'Miss it works.' Leo was doing a question, 'This is how you find circumference.'

'What is this exactly?'

'3.1415.'

'But how did you come up with the rule?'

'Miss this is a well-known rule, we did not have to come up with that.'

Leo and Badr were supporting him, although, it was the first time they heard of the rule. *Oh, the power of rules.*

Nazir, Archie and Imran had a similar problem.

Nazir knew the formula: 'Miss my sister showed me the formula, but if you are going to ask me what is π I do not know. I know it is 3.14, but why I do not know. I think it may have to do something with 360º because it is a full circle.'

I told him that in older years it can be shown that $360^{\circ} = 2\pi$ radians, but it was too complicated for us.

'What does it mean: π?' Archie asked.

'It is just π, I did it before.'

'I still do not understand it.'

Habib knew the formula already and did not try to participate in the discussion

'It is $\pi \times d$. I now that. This is the rule. It is 3.14.'

'How did you come up with that?'

'My mum showed me.'

George rested his case: 'That is it then. We found it'

I told them the story about how π was developed. Even in the Bible at one point it says that the length around a circular lake is three times the length across the lake. Couple of thousand years ago in Greece mathematicians went through a similar procedure as we did today in the class, albeit a more precise one, and they thought that Circumference = 3 1/7 × d. Depending on the methods used and their accuracy, people got different results. I reminded them of the story about Pythagoras and how he thought that all numbers could be presented in the fraction form. It took people centuries to realise that the number you multiply diameter by cannot be written as a fraction. They decided to call the number π.

A couple of years ago all the pupils from school created a chain with differently coloured papers where the digits in π were represented by different colours. The boys admitted that they had never understood what that was about. They were stunned when I explained the meaning of the chain (the first 1000 digits of π).

'And it is never ending?

'There is no to pattern to it?' They asked in disbelief.

While doing some questions many students used 3 1/7. Harry admitted that it looked more natural than using π. 'Miss I would like to see what other people's opinion is in our class on this matter. What would they rather use?' He asked.

The majority of the students thought that using 3 1/7 looks easier and many of them used it. A couple of them used 3. Adil successfully attempted the questions from the wall involving the length of the arc and the perimeter of the composite shapes including parts of a circle.

'Miss, I do not understand why we did all this; you could have given us the rule at the beginning of the lesson. Instead we needed to measure circumferences using string, and all this story about π.' Leo asked at the end of the lesson.

He was interrupted by few students.

Nazir: 'No I really liked it. I know now what π is. It is more than 3.14. It is this entire story.'

I explained that I wanted him to be aware how mathematics was built. Mathematics is not about getting the rules from a book or the internet, it is about creating them. People around the world have been participating in the building of mathematics for centuries.

I was surprised by Nazir's response; usually he is one concentrating on exams and not wanting to waste his time on 'unnecessary' work and explanations. At moments (only at moments) he embraced all vagueness and uncertainty of mathematics.

Nazir's method

A couple of lessons earlier, while trying to find the area of a cuboid, Nazir suggested the following method: 'I have 24×12 from this side, but I have many of these layers inside the box, I have 9cm of them, so the answer is 24×12×9.'

However, we realised that the method would not give the total surface area but the number of cubes inside the shape, the volume.

Today, I thought that the idea could be helpful while trying to figure out the volume of a prism. The students were supposed to find out the volume of a cylinder in groups or pairs. Each pair had a prism (chocolate and chips boxes, and spray bottles).

Some students (Ahmad, Tyler, Kyle, Max, Joshua, Badr) did not know where to start.

I pointed out to the Nazir's idea and asked them if they could see how the cylinder problem was similar to the cuboid problem.

Imran suggested finding the area of one circle and then multiplying the answer by the length (the distance) between the two circles.

'I would add the area of the other circle at the end.' James added.

Max: 'I really do not understand any of these.'

'Remember how we said that if you want to find the volume of a tissue box you find the area of the front layer and then multiply by the width.' Harry tried to help.

'Yeah?'

'Now we are trying to find the volume of the cylinder in a similar way.'

'It is difficult.'

Nazir: 'But you cannot add other circle.' he took one of the cylinders, when you multiply by the length you include that other circle.' He demonstrated with his hands the cross section of the cycle moving through the cylinder. We did an activity on cylinders couple of weeks ago and they remembered cylinders as shapes where cross sections can move from one side to the other side and they used that explanation when we discussed cylinders.

'I see.'

'Are we happy with this way?'

Kyle and Max still had some difficulties, so I sat with them while the others were trying other problems.

They understood the method but were confused by the area of circle part. I reminded them about the activity when we were trying to find out the area of a circle (by counting squares and trying to find the relationship between the radius and area). They recalled the activity but admitted it was a tricky formula to remember. Kyle remembered 3 and thought that he could use it. I pointed out that a long time ago people used it but it was more inaccurate. They could

use 3 until they get comfortable with π. I recalled that a few students thought π was an abstract term to use and used 3 1/7 instead.

Maybe that was my problem; I do not spend enough time on a topic. Max was fine that day with the area of a circle; however, it seemed it disappeared from his head. I was momentarily satisfied that the problem was successfully attacked and we figured it out. However, I did not make enough efforts to make sure it was regularly revisited and it stayed in their heads. It always happens. I am flying through the topic and the students are fine. I make sure that the activities to build the concept are constructive and valuable (*God knows how much time I spend planning!),* but it does not stop there; I need to find a way to make them remember it. I am happy to tell them: 'Describe the procedure in your words', 'Explain it in your way'. I have to make the point of that 'their own way' is to make it more memorable and fun.

I do not think I communicated with them enough the importance of making and displaying 'their own way'. Most of the books are neat but somehow plain. The majority of the students prefer to copy the solution from the whiteboard, and it seems that they are not able to express their own thoughts in an organized and comprehensible way. Despite creating their solutions and answers, they are still struggling to put in on the paper using some systematic approach. They need to be able to refer to their notes when studying.

> The next question was about a triangular prism. After a couple of minutes Archie asked to explain the question on the whiteboard. He first found the volume of the cuboid and then divided the answer by 2 as 'if you add the same one prism from this side you will get a cuboid' (his explanation). The class thought it was a cool way to explain the question; he was rewarded with the clapping.
>
> Habib: 'I first found the area of this triangle and multiplied by the length.'
>
> 'Which way is correct?'
>
> 'You get the same answer.'
>
> 'How come?'
>
> 'You see miss, if you divide by 2 here, that is Habib's way, if you divide by 2 here that is Archie's way. They are the same way; you just divide by two in different spots.' Alex clarified.
>
> 'Aaaaa.'
>
> Many boys attempted the volume of the composite shapes. Adil did the volume of a sphere as well. A couple of students expressed the desire to do the current topic more in depth rather then moving onto the next topic.

I prefer to do a whole class discussion. Somehow, I think that they are more willing to discuss with the whole class rather than in pairs or groups.

The discussions within the groups are lively, but very often they follow the opinion of the person they think is the best mathematician in the group. Groups with Nazir, Archie and Imran, and Adil, Alex and Fadil will challenge each other's opinion and require full explanations.

While the boys acknowledged Adil as the best mathematician in their group they do not just accept his words, and he never presents his answer without an explanation. On the other hand, as Habib's mother is a mathematics teacher. he is the most trusted in his group. For example, Harry and James like helping Kyle and Max, but want to hear someone else's opinion ('Miss, can someone explain in a different way.'). Tyler, Ahmad, Joshua and Badr are very often indifferent. With whole group discussion somehow there is a greater exchange of ideas and they are exposed to more ways of thinking. I have the feeling they all get involved in the discussion even if it is only for the listening part (or maybe I should make sure). I am not sure if it maybe makes me feel more in control of what is happening in the class.

Comics

I was thinking how I always ask students to explain the concept in their own way, and many of them always copy solution from the whiteboard. They claim that was the best way, as they make sure that nothing was omitted. It defies the point; I want them to explain the approach they used to create the meaning of the concept, not the approach someone else used. I brought some examples from other classes (including some of my explanations) so we could see what other students did, and identify what could work for us. I tried not to show them explicitly some taking notes strategies; why would teaching maths be different to teaching study skills? Yesterday I asked them to use comics to explain the volume of a prism; it was ok; although, it took a lot of time. I wanted the boys to be more personally related to their explanation, to physically see that they created it. To tell the truth, it was better than ok as I could see from their presentations if they understood things or not. However, they spent half a lesson discussing, then another half a lesson drawing and that was it, we did not manage to do anything else. They spent way too much time making their pictures look good. You cannot win.

I did it Miss

Relative frequency activity involved some M&Ms; everyone was pleased with that. While the rest of the class was doing some questions on relative frequency, Adil and Alex were trying to solve a problem that required swapping digits.

> When a two-digit number is added to its reverse, the answer is 110 times the tens digit of the original number. Find the original number.

They participated in the discussion, but now after the M&M activity they decided that the questions were too easy for them and wanted to do something different. It appeared that the problem was slightly challenging for the boys. Alex suggested listing all the numbers and checking which ones satisfied the given condition.

Adil did not like it: 'You do not want to do this like that. It just does not look nice. There must be some more sophisticated explanation.'

I liked how he did not accept listing all possibilities as an adequate solution. It is a useful way to spark your thinking, but somehow it lacks 'mathematicsness', if I can say. Adil liked throwing big words in his explanations; no other boy would use the word sophisticated. I could try to communicate the idea that the numbers lesser than zero are negative, i.e. negative three, not minus three. For this class it only took Adil saying it once, and everyone was following him. He just said that it was a more mathematical and elegant term to use and everyone was on the board.

'We can continue tomorrow.' I said when the bell went.

Adil came to see me in the break after the next lesson all excited: 'I did it Miss.'

'If our two-digit number is say AB…' His explanation was very good. I was impressed with his decision to represent the number as AB, and then further in the question to use 10A + B. You do not do these questions in school; you do not have time to do these questions in school, you cannot possibly touch every single approach. I was impressed with Adil's presentation as well. Not many students are able to explain a mathematical question in a precise, nonambiguous and logical way. I have not seen any books aimed at their level using such kind of language. I can maybe take the credit for pointing out that elegant and good solutions are a part of Mathematics. However, that was it. I did not teach him how to explain mathematically. He felt he needed to express himself. He got the message and created a solution accordingly.

I recall solving a very difficult question involving a 6-digit number, using a similar technique just a couple of years ago, yet I do not recall ever using this approach in the classroom, neither as a teacher nor a student since my primary school. It was retrieved from my memory when it was needed.

A part of being a good mathematician is about one's ability to analyse the problem and chose the optimal way. However, it is about having a great memory as well; you need to be able to recall all relevant facts, all relevant problems, patterns, methods and representations, and pull one that works. You cannot go every time through a learning process when presented with a similar problem. In simple words, it would be learning multiplication whenever it is needed in a higher order question and with this approach you would not go far with your mathematics and problem solving skills.

Football is the most important (in)essential thing in the world

'Miss did you watch game last night?' A head appeared on the door.

'Do not ask me anything Aziz. I am still quietly suffering; I need a couple of days to recover.'

'I could not believe it. We were coming back from Spain and I was listening to the commentary.' The boy started explaining. 'You know I watched Real - Barcelona.'

I almost felt envy towards him. *Real vs Barcelona. It cannot get much better than that*. Last month he went to watch City vs Arsenal. It is just not fair.

'My heart is broken. They were 4:2 up. What happened?' I was feeling depressed. Manchester United had a draw against Everton and their title hopes started crumbling.

'When my uncle told me, I could not believe it. I try to watch it, but you know how bad connection on private jet is; I could not see anything. Anyway, I just came to see how you are.'

*A private je*t! This is how one watches all these games. *I just need to get a jet*.

'Do not pretend Aziz. You came to enjoy my misery.'

Will Beckham visit our school?

The lesson started with the following question:

What is the probability that Beckham will visit our school?

'Impossible.'

'Impossible.'

'Unlikely. Very unlikely. Impossible.'

'Unless school agree a weird deal.'

'Miss, nothing is impossible.'

Kyle: 'Miss it is never impossible. There are planes and we are here and there is a possibility that he will come.'

I asked a similar question a class a couple years ago, and the students thought it was impossible. However, the following year Beckham came to Qatar to play a game and while here he visited one of the schools. In addition, a few famous tennis players visited our school last year.

'My opinion is that as long as our school exists and Beckham is alive there is a possibility he would come, although, very unlikely.'

They came up with sentences containing some probability words: certain, possible, likely, even chances…

'It is impossible that my mum will give birth today.'

'It is impossible that Superman will come to save the world.'

'It is possible that someone in our class will get a detention this week.'

'There is an even chance that I will come tomorrow to school.'

'You think there is a 50 : 50 chance that you will come tomorrow to school?' Someone asked.

'Yeah, there are two choices: coming to school or not, so the chance is 50:50.' George explained.

'I agree with him.'

'No, it is not true. What is the chance that you will be sick tomorrow? You even may be sick a little bit but your mum would not let you stay at home.' Lucas said knowledgeably.

'But there are two choices. Why not?'

Nazir: 'Miss just because there are two choices it does not mean that they are equally likely. We should see how many days George missed from beginning of the year and then try to figure out what is the probability that he would miss school tomorrow.'

'I missed only one day.'

'So the probability that you will miss school is very small.'

'Many people would find your explanation logical and useful.' I was pleasantly surprised with his explanation.

The class first did a worksheet and then played the game where a spinner was spun and they needed to place a digit in a right spot so the number is as large as possible at the end of the game. The boys absolutely loved it; they did not want to go for the break.

Adil and Fadil realised that the exercises were very easy for them and decided to take a worksheet from the wall:

Two fair dice are rolled. What is the probability that a total score of 4 is obtained?

Adil: 'Miss I think it requires an investigation.'

'I have an idea.' He shouted after few minutes.

He was drawing tables and organising his data, and got the answer in a few minutes.

I was fascinated. I asked him the same questions just with three dice.

'Miss I cannot use a table anymore.'

'Why not?'

'Where am I going to put line for the third dice?'

'I have an idea.' he yelled again after few minutes.

He was not able to finish it during the lesson and came to see me at break with his answer. He used a pencil as a third line just to visually represent what was happening which helped him realise that there were $6 \times 6 \times 6 = 216$ possibilities and was able to list those with the total score of 4.

We talked about what extended topics he wanted to do while the class was doing probability. He admitted that he did not find it particularly entertaining. He felt (and demonstrated) that he knew the topic. I suggested starting with Pascal's triangle and then possibly permutations and combinations. He expressed the desire to do logical puzzles. There were always a couple on the wall and he did them whenever he had time. He said he would see how he felt in the class and possibly try my suggestion as well. I thought that it was a good idea to stay within the same topic. Did I think it was better to stick with the curriculum? Did I want to make him better

prepared for any kind of exam? At the same time he would do a topic of interest and progress to the next level within a strand.

Miss, sometimes I understand things and we still talk about them

I tried to communicate with the boys that one of the things I wanted to implement in the classroom is that I wanted them to be able to express their own ideas and be able to discuss other students' ideas as well. I asked them if they felt that they could do that in our class. 'I do feel actually that I have a chance to express myself. Every time I say something, someone listens to me, and answer my question or ask something. We have discussions in other classes, but not really as much as here. For example, in other classes we may read some pages and then answer questions.' Joshua said.

'I like how we share our thinking. How we share it, and decide which one is right, and how we learn from that. When we do a question, for example I say how I did it, and everybody listens to me. Although I do not like when sometimes we have questions but it is time to go to another class. We do not have time.' Kyle supported Joshua.

'Miss like for example in year 6 they would not let us to come on the white board and show how we think, but in this class, you let always to come on the whiteboard and show what we think. We never go on the whiteboard (in other classes) and show...' Harry explained.

'I prefer to talk to others. I think sometimes they offer a really good explanation. I felt I had a chance to explain things, but I thought it was a bit less in mathematics than other classes.' Noah disagreed with him. Noah always thought that there was a room for improvement. 'Although, sometimes we spend too much time on discussion. I think you can be faster Miss, sometimes I understand things and we still talk about them.' Noah added.

'If you showed us the way, we will then just do the way and then we did it. If you tell us to think, and then maybe the correct way. There are many ways to do the question. I am able to express my opinion. It was enough. More chance in mathematics than other classes. In other classes you do not need to discuss with others and check things. In mathematics it is only one answer; you know what to check. You have to talk when you do mathematics. We do an equation in one way, and then you see other way, and then it is maybe easier.' Leo thought that the debates were a consequence of the nature of mathematics. I remembered that Leo thought that because of the nature of mathematics it was easy to do real life examples as well. I smiled; this is what I wanted them to feel about mathematics.

'It is quite enough, if there is something I want to say then I had a chance to talk.' Imran added at the end.

The only dissatisfaction regarding communication with others came from Noah who felt that his voice was not heard enough. Noah was in the same group with Fadil, Adil, Oliver and Alex who were all very able learners of mathematics. Additionally, Adil and Oliver were confident

speakers and debaters, and I could see that it was difficult for him to win argument among this group of students. While he was questioning their ideas, because of their mathematical ability, it was more likely that their solution would be commonly accepted than his. I was slightly worried that maybe sitting with Adil, Oliver and increasingly more confident Alex, he did not feel that his ways were always appreciated. However, I knew that Noah would not want to move.

To tell the truth I thought it was a main feature of the classroom; students debating and explaining concepts. In fact, I was worried that we discussed a little bit too much. However, I am aware that things may look differently from their perspective. It is not easy to give everyone a chance to talk. I was worried that some students will end up not being heard enough so I used the random name picker; I wanted them to see that I was trying to be fair.

How did I miss it?

I felt upset and flooded with guilt. How did I miss it?

The email was about a student from my class who had ADHD and was asking for my evaluation. He was in my class for almost a year and I had missed something so important. I have never experienced any problems with him; he was responsive and contributing to the classroom in a positive manner. What was I expecting? A stereotypical view of ADHD students and usual behaviour problems? *Now when I think about that*….I put my head in my hands. I could always find the reasons and incidents to support my failure. Why I was not informed about this? How come I did not notice anything? What would I do differently? He really appeared fine. Although, the questionnaire and review I filled in, was quite positive, I could not shake off the guilt.

Display

I brought a plastic bag full of used boxes and bottles and asked them to come up with a mathematical question and answer related to the shapes. *I knew that used junk will come to use*. There were cuboids, cylinders, triangular and hexagonal prisms. The lesson went absolutely great. They divided themselves into groups and pairs and cooperated really well. The boys shared responsibilities without me telling anything.

For example, while Kyle was making his own cube, Harry set the display explaining how to find a probability and the volume of the cube. Habib and George first found the volume of a triangular prism and then divided responsibilities related to setting the display.

I was a little bit surprised when Tyler and Ahmad took a cylindrical tin. 'What is your mathematical problem related to this can?'

'We are going to find the volume, you just need to find the area of the circle and multiply by the height, see.'

I thought that it was a bit difficult for them, however, they did great job with scaled drawings and explanations.

Adil and Alex chose what they thought was the most difficult problem, a hexagonal prism. Many students stayed in during the break time to complete their work.

I am always surprised with their (positive) attitude when they are collaborating. Max absolutely flourishes in these circumstances. I recalled that he and Kyle behaved the same in other team work activities. They carefully decided each person job: writing, drawing, measuring, and took a great care of their presentation. It could be because they are in complete charge of the choice of the activity and the procedure employed. Additionally, the students are not under the pressure to deliver a certain answer.

They keep on talking and talking

Lucas came to see me in the break time. He thought that the students in our class spent too much time talking.

'I think that the class, they do not like doing a lot of working, they keep on talking and talking, but when we do fun activities, they are all behaving and they want to do work. Sometimes it is really noisy; maybe you can do one thing. That is something that class would like, listening to music.' He suggested.

'Miss, something that helps me learn… just explaining further, or methods, you have to give us methods, to make us understand how to do, like method for algebra, method for long division. It is learning the method how to do it, and the formula how to do it. That is mathematics. First you can ask a couple of students. It is better method for learning, if you try, if students try by themselves. If still they do not know, maybe you can explain, or someone maybe knew the answer, but confusing, maybe you can explain it better.' It appeared that Lucas did not feel comfortable with being explained to only by his peers.

Algebra Menu

We started with the question which used the speed of a car to estimate its stoppage distance. They were quite shocked when they realised that the stoppage distance was much greater than what they had anticipated even for reasonably small speeds. Driving in Qatar is quite a challenge for many. Heavy traffic and fast driving are just some of the problems people experience. A friend of mine was told by a driving instructor that if she was to take a right turn she should not take a right lane but the shortest one, with the smallest queue. The interpretation of the optimal decision is quite different than one would expect. No wonder there are no right turns, only at the traffic lights. The stories were circulating that many young men do not even sit for driving test. Many young people had been involved in accidents with tragic consequences; however, little has been done to prevent such occurrences.

We used the menu maths in our explanation and I thought that previous lesson went really well. Students understood that in mathematics we used variables to represent numbers. They enjoyed the last lesson and found it very easy, which is not always the case with introductory algebra. I hoped that by continuing with the same idea combined with them experiencing success, the concept would be more approachable and enjoyable.

It seemed 'obvious' that the price of 3 fries and then another 4 fries is the same as the price of 7 fries, i.e. 3f + 4f = 7f.

'So this is Algebra, so easy.'

The students could not wait to start with Algebra. For some reason they thought that it was the most important part of mathematics and that all their problems would be solved once we did algebra. Possibly they heard from older classes that it was needed in upper school. Everything was smooth until we reached the question involving different terms.

Harry was discussing with James the following question: 2f + 3s.

'What exactly are we supposed to do here?' he asked.

'See how 3f + 4f = 7f. 7f is more elegant and simple. Kind of more 'squashed', although it is not necessarily the sign of simplicity. Can you do something like this with 2f + 3s?' He started substituting the prices and evaluating.

'What about 6fs?' Badr suggested. A few students started shaking their heads, expressing their disagreement.

'Is it correct, Miss?'

'Remember that the letters are representing the numbers, so any answer you come up with will have to be valid for numbers as well. How can we check if 6fs is a correct answer?'

Adil:' If you write real prices instead of letters you can see that 6fs is not a correct answer.' 'This is not how the waitress would calculate how much we need to pay', Harry commented, 'She is not going to multiply the fries' price by the soda price. Why would she do that? If she had the prices she would do exactly as it says, 2 times the price of the fries plus 3 times the price of the soda.
You do that or nothing else.'

'Yes, yes, yes, I am wrong.' Badr seemed to change his mind.

Frequently, he reacted like that when he realised that the answer he offered is not commonly accepted in the class. Just occasionally he tried to defend his point of view. I mean, I am happy; at last he started sharing his view.

Harry: 'Miss, does it have an answer?'

'What do you mean?'

'I think you cannot do anything else with 2f + 3s. If you are paying for 2 fries and 3 sodas, this is what you are paying for?'

Kyle: 'No, there must be an answer. You always have an answer.'

'But, that is the answer, it is just the same.'

'Well, I suppose that is the answer, you really cannot do anything else.'

'So, I am right.' he smiled satisfactorily.

He turned to James to clarify his explanation.

Harry was a responsible young man. While he was good at Mathematics it did not mean he found it very easy and natural. However, he always tried his best and he tried to help his friends to achieve their best.

'Miss, James and me decided to swap seats. I think Max will do better if we sit together.'

He did things as if he could read my mind and knew how I would like them to be done. He never asked for an explanation of the concept. He would say something like: 'Miss, can someone else explain in a different way so I can think about that.'

When he did his homework he recorded every single step of his thoughts. He was always willing to offer his reasoning: 'You said that you are interested in the way we think rather than the final answer.' He thought that it did not have to have an answer, which was contrary to what many students think. The majority were of the opinion that when solving a Mathematical problem, one was supposed to obtain a solution, and that you had to apply some method. Harry realised that he could not confirm that and he was able to think "outside the box".

Meanwhile, Kyle was trying to come up with an answer that fitted with his belief that this is what Mathematics is about; coming up with a correct answer. I have to say Kyle is very methodical with his approach, but he has the expectation that things will have to work in a certain way.

How to communicate social issues?

We had an assembly today. My colleague next door, a mathematics teacher, Alma, used one interesting example, which made me think. She asked students that for the following week come up with a person who inspired them and to explain their reasons. In a witty way, she identified herself with a young female Arab scientist who was torn between the choice of a rich husband who would bring an easy-going life of luxury, and a fight for her place in the academic world. Alma always finds a right way to communicate her ideas, and makes the issues like the empowerment of minorities, look easy. I was struggling to communicate some social and ethical issues, perhaps of the fear that I would be misunderstood or misinterpreted. She acted without fears, maybe because she was an Arab woman, and her presentation left you without doubts what she wanted to achieve. In a funny way she exposed some of the behaviours of today's culture, and yet it did not look insolent or discriminatory. It was such a simple example, and yet very powerful, if used appropriately.

Susan, the leader of the MUN, Model United Nations Activity and Debating activity, was another teacher who appeared to be fairly efficient at attacking social justice issues. This year I was able to observe some of her teaching strategies. Many times they had discussions related to the emancipation of minorities, including women, which is an issue in the Middle East. I was surprised with the openness of discussions in her groups. I was not sure if the parents would agree with the ideas and questions raised in the class. Certainly they have a greater right

to make their children aware of some issues; I do not have a right to oppose them. It is a difficult question. How would I react if my child was exposed to the ideas I am not entirely happy with?

How do you find a balance of what is an appropriate exposure and coverage of a certain issue? How do you act properly as a teacher, or as a parent? Ideally teachers and parents are supposed to communicate and act accordingly. However, what if their views are in a major disagreement? The more I was thinking, the more I was getting confused and unsure of what was the right answer.

I tried to touch upon some social issues in my lessons but it has been proven to be a more difficult task than anticipated. I have always used the example with the stoppage distance to make my students more aware of the dangers of driving. However, the reaction I was receiving was not always one I hoped for; I recalled a student in other class making fun of the example just after his cousin had an accident and was in coma. I did not know how to react. When teaching in Australia and England I used an example of questioning why a football was cheap to buy (credit for the activity goes to the colleague from my first school, Reno Sinagra). After mathematically analysing the surface area of the ball, how much material was needed and time to make it, it came down to the cheap labour, and the lesson with a little bit of guidance would go into the social justice direction. I could not use such an example in Qatar. Naively, I tried in my first year, only to be faced with ignorance and laughter from some of my students; nothing wrong with the pay of $1 per day. I felt that I need to try to communicate with the children the social justice issues, especially because of the poor conditions labour and household helpers have in this country; however, I could not find a right way. How do you bring these issues up?

I liked M&M as well

As he was packing up for his next class Leo said how much he enjoyed the lesson on Pythagoras theorem.

'It looks complicated, and Miss you made it simple and you made it sound interesting. What we did with water it looks so simple, you can see two squares. That was really interesting to me although it looked complicated. Also you showed us video that x squared + y squared. You make it interesting, it is not boring. I think most are really working for me. You make us do more fun activities, like we did toothpicks. You give us fun, but overall it is still maths. Sometime with other teachers you do fun lesson but you do not learn. You actually encourage us miss, because you make things interesting. Most activities were good. You have to learn something. 'Leo said. 'You let us do things; you just do not tell us what the answer is.' Alex added.

'Miss I understand a lot. In the previous years I did not really understand maths, but I improved a lot in year 7. I liked the way when we were learning something and you made it fun, instead of just working. For example the coordinates, you made us play battleship that helped us in a fun way. This is what I like. It is a fun class.' Harry said.
'Thank you very much boys. I enjoyed the lesson as well. Remember you made the lesson as well.' I enjoyed their class and I knew that I could not take the credit for that. They were a nice group of lads and it was a pleasure teaching them. It was nice being in the classroom where students were eager to learn and where learning was not seen as an 'uncool' thing; just to mention all clapping when someone

comes up with a good idea. Even if they did not always agree with the methods employed, they dealt with it in a calm way.

'Is there any other activity that you enjoyed?'

'Something I liked was cryptograms. It is interesting.' I knew Alex liked cryptograms. Whenever he finished his work he would grab the next worksheet.

'Miss I liked cryptograms. Can we do this more, Miss? I really like it. Can we do this tomorrow?' Noah said. 'We will see, maybe.'
'I really like activity that involves experiment, like Miss about M&M bars when we did. That was really good.' Imran commented.
'I liked M&M activity and Pepsi as well. I liked to do charts, and it was fun.' Harry added.
'I liked M&M as well.' Habib said.
What a surprise; they liked chocolates. You can never go wrong with chocolates. As they say in Serbia, love enters through the stomach.

Can we do exam questions?
Nazir: 'I would really like Miss to do some exam questions in the class.'

'Why? I already completed all past papers. It would be a waste of time.' Adil disagreed with him.

I do not practise doing the past papers in my lessons. It does not mean that we do nothing related to the exams. At the beginning of each topic we try to connect it with the exam expectations. In addition I recommended a website with past papers so the students could practise by themselves. Occasionally, I start or finish my lessons with an exam question, address any problems students experience while working on the past papers or generally spend some time on the exam techniques. However, I do not spend time going through papers during the lesson. Somehow I think that they can do this by themselves and there is always something more interesting to do in the class. *Adil is right; it is a waste of time.*

'We really need to do some exam papers. I think it is time to do some practice.' Nazir was persistent.

A couple of students joined him: 'Yes Miss, we should really do the papers.' 'Why do you not do the papers at home and prepare any problems you experience for the class discussion?' I thought my offer was reasonable and would meet their needs.

A couple of days later…
'The boy from you class, Nazir, asked for an extra tutorial', Jonsey informed me in the staff room. He was the students' favourite teacher (and the teachers' favourite colleague). He was

famous for his no nonsense approach, strict rules, high expectations and scrutinising past exam papers.

I felt a bit disappointed trying to hide it from Jonsey: 'He is quite good. You should not be having any problems with him.'

'Well he just wanted to practise the past papers. He did one and found it quite easy.'

I felt really bad afterwards; I lost Nazir somewhere along the way, and could not pin point the exact moment when and why it happened. I was falsely reassured with his flattering and exciting comments about the class, that I forgot what was really important. Many times he said how he really enjoyed the lesson as he was only thinking and discussing, and I took for granted his participation and embracement of the constructivist environment. Now, he was taking the matter into his own hands, and embracing his shared control, but not in the way I wanted it to happen. He understood the classroom as an interesting place where they can discuss the things, but not necessarily learn, as he saw it from his perspective.

Mathematics was realized

The class was really excited and everyone tried to explain his point of view. In the first part of the lesson we watched the video about Andrew Wiles and the Fermat's last theorem. We were discussing what mathematics meant for him, what mathematics meant for us and how it was created. I was surprised with some of the answers. It seemed that the boys took the questions seriously and thought hard about them.

'Adil said that mathematics was out there. I think maths was discovered and created. For example centimetres, they did not have centimetres, they had to create it.', James said.

'They did not have to use centimetres, but something else like hands and feet.' said Alex.

'Technically if you created symbols, it is not the creation of maths; that is the creation of how to use maths.'

'An interesting point Adil. So, you think that the symbols are not a part of mathematics?'

'Not really. They are there just to make things easier.'

'I saw that program 'Using maths'. You do not have to use symbols; you can use your hands and get the (multiplication) answer really quickly.' Noah said.

'How can maths be discovered? It is not a country. You just came and found 1, 2, 3 on the floor and then you say it was discovered? People actually created maths so they use it. It is not something found on the floor and on the wall. They created the numbers, and they created plus and minus and that is maths.' Haytem was arguing his point.

'Haytem is not really thinking about the word discover as we are thinking. When he says it like that it does sound dumb. Instead of the word discovered you can say realized.' Nazir tried to clarify. 'But sometimes they say, they discovered humans. They are just there how can you have discovered them? And Miss, they did not discover, they invented numbers. Or units of measure. Or other stuff.'

'Miss, we say that it was revealed. And it was realized.' *Revealed?*

Realized? What strange words to use.

'In Islam we think that God told Adam and Eve everything, how to learn, how to eat, how to talk, everything. And they taught their children. It was a long time ago. But obviously it is not everything

Adam and Eve knew, because back then, you did not have countries, presidents, mathematicians.' Habib added.

Last comments

Adil

Mathematics class was wonderful this year. The algebra was fun, because it's kind of like a mystery. One step is actually working it out, but the other step is actually finding out what the number is. I particularly liked simultaneous equations. Some of the things we did were not exactly educational, math-wise, like today's discussion about the nature of mathematics. But, it's generally good 'cause you're just giving us something extra. I have to say today was interesting. I think you were trying to interpret different student's opinions. I think mathematics is out there we just have to be aware of it.

We basically use mathematics every single day, it's just some things are so minor we don't even realize it's mathematical. Usually we use mathematics every day. So, anybody could have used mathematics without actually realizing it was there. For example in cooking. You're supposed to measure the things or how many there are and all. And, Miss, very indirectly our respiratory system kind of depends on that. You're supposed to hold it for a few seconds like inhale exhale, inhale exhale... We just do basic things. Mathematics has word problems, but in algebra it's not really common. It's like I have a number, if I multiply it by six and add nine, it is the same result as if I multiply it by seven and subtract two, therefore, x=11. You can't do real life for everything. For me using real life examples is not really a problem, but maybe for the other students... This is the reason they find math hard. In History we do not do real life stuff, not really, 'cause we go back in time, basically. We don't really do anything about now. In Science, kind of like the reaction of hydrochloric acid with sodium hydroxide makes a salt... Water and sodium chloride which is a salt. I want to be an engineer.

I can tell you what I think. Actually, I recall you giving us a sheet in fact to write down how we feel about math. And then I remember in our math book you said to write down what you want to do more of, or something. So, I put algebra. I tell you what I feel.

I didn't really mind if people didn't listen to me, Miss, as long as you did. 'Cause that was really...I don't know, really, if other people listen to me. If they do not listen to me, it's their loss, it goes on their report. I kind of like explaining to people my way... This is when I kind of like them to listen. I have chance to express myself, I think a little bit more here because, well, math is basically all about different solutions and other people... Miss, you said something about other mathematicians listening to each other and all... When one is speaking all the rest should listen...For example, in science there's not really much to talk about. Well, there's nothing to debate, really.

I prefer to work independently. It kind of depends. The countdown things that you give us, a bunch of numbers and then we're supposed to make this number... That's when I'm kind of on my own. The other day when Alex joined me, I started it then he started and then he just thought

we should team up, basically. I didn't mind. Miss, I think I'm quite independent. I mean, I quite understand it. Well, I'm rumoured to have a little bit higher knowledge of mathematics than most of them because, well, I'm a little more energetic to learn more about math than the others.

The reason I find math easy is because there is an exact answer... There's only one answer. One plus one is only two, nothing else. But in English, that's where it's a little confusing. I'm not that good, but I'm alright. It's like, "You could have either put this" or "You could have either put that." In Mathematics, I am going to put the army into it. Miss, Math is basically about Battle Tactics, but the others require that you actually have a knowledge of things, like the weapons and all. But here, you only need to know the actual way to get the answer. You don't really know the actual questions they're going to ask you or like what exactly they're going to get.

There are some things I kind of paid attention to, like graphs and how to draw the curve. Miss, it's just because I kind of have previous knowledge over these and I was kind of expecting something more challenging. Miss today in our lesson I noticed you had year nine book, like Miss, can I just get the book? I did simultaneous equations. Page 42. Miss, they're really simple, like, this is kind of the stuff we did in class, but once, when I was Yahoo answers I actually showed you how I worked out that question. For example, the Scandinavian movie ticket. Miss, that's the type of things I kind of like. When they're switching around and there are different values 'cause here it's quite easy 'cause they have the same thing. It's like Diophantine equations. Those you have to experiment. Well, in my opinion, you have to experiment these. I actually have an algebra book at home.

Sometime, you give us extension work like for a challenge or something. But in the actual thing, Miss, not exactly. Well, actually Miss, sometimes you actually do because those questions would be fractions. I didn't really know how to solve. But then, I discovered you're supposed to make them the same and then just disregard the actual fraction.

Everybody makes mistakes.

I think the way you teach is excellent. I put you as Miss Smart in the teacher appreciation...'cause you're both a teacher of Mathematics and then you kind of understand everybody's approach of doing everything. There's nothing that really confused you about different student's approach.

Nazir

Usually in primary and this stuff, it was really obvious, we did not do too much thinking, we just had to understand what we were supposed to do. And it was a race, who was going to finish first. It was really easy. And questions themselves, like each question would take 5 seconds.
When we first came into secondary, we actually had a class discussion about the question, we had a debate and stuff. That never happened in primary it was new for me. I had it with my sister, because she likes maths and stuff, but I did not do this as a class, with a teacher or

something. In or class we mostly spent time at the whiteboard and rarely at the book. And with the book, I feel, we only did to ensure that whole class knows exactly how to do it. Even though, that is not sure that maybe everyone that is not their own work. But still, even though, I know some people do that, but at the end they figured it out, because you can see it in exam, you cannot cheat in exam.

We did group discussions, as once you got to the text book the questions took you longer. And when it is longer, and when it is more questions, it is not boring, you like it, and when you understand, but when you do not understand, by the time you finish one question, and it is hard, it is even harder to keep doing more questions. Today, after you told me to leave, I did not leave until I finish two more questions, because I wanted to finish. On the board it was fun that you can express your opinions, by yourself, and also when you answer back to someone, you would say back, do you understand that, it was, even though that the class would get out of control, but you so learn by the end of the lesson.

I prefer we think about a problem, because some time, I prefer if I know what you are going to say, even though I know you do not learn from that. But if you would say something that I did not know, like, why you are doing something, even in maths, you cannot really ask why. To find out why, all the people like the guy who called Pythagora stupid, all the work he does and stuff. There is a reason why, but it would be something that it would take me too long to understand, and I am already fine with not asking why. If you tell me 1+1 =2, I know why because double of 1 is 2 but actually, this is simply example, but when it is very complicated, not this example, but when you have another example, I do not want really to ask. It will make things just more complicated. In other subjects, for example science, the teacher explains on the board, and then we ask questions, but we do not show opinions, because usually, … in science you can show opinions, but is important fact not opinion. No, there is not something you should not understand after you have read it properly, like in maths, for example what we did today, x squared + y squared = z squared, like I get it, x times by itself, plus y times by itself equal z times by itself, like I get it, why? There is a why part. In science, for example, if you say, the roots get nutritions and water from the soil, there is nothing to question in that. There is nothing to share your opinion in that. In maths, for example, when you ask, the whole class, put their hand, Alex, me, …

I had chance to express myself, until the lesson finishes…I am not saying that lesson should be two hours, but I am saying usually people say the same thing but in different words. And they even do not know it. I have a chance to express myself, but, there would not be anything else I want to say, unless I had more time to think. If I had more time to think, that would mean more explaining, that would mean more explaining for everyone, and that would just go forever. Yesterday, or couple of days ago, the lesson finished and we still had a lot to say, if we had two hours, we would not finish. Comparing to other classes not more, it is the most. In other subject I don't think I even share my opinion about anything, like in English, you do not share your opinion, because your opinion will not be wrong and your teacher do not care, like in maths you have to find out if your opinion is write or wrong, in science, like I said, in history, yes you

can, of course you can give your opinion, but we are still year 7, we can' t still disagree with something that is in your textbook or something.

Yes miss we are still in year 7, and most, nearly, a lot of things in mathematics have already been figured out. If it were, if this happened 2000 year ago maybe we could have still, there would not be a right answer, because nobody still proved it. But we know that there is an answer, but we are not sure what is this is yet. People 2000 years ago still had to prove it if something was correct or not. We know what we are taking in year 7. Because, maybe if there is something in year 12, maybe there is something that is too complicated, that people are not exactly sure about but mostly, like 80% they are sure. In my head it is very complicated, but if you get a year 10 and look at year 7 stuff, yeah it is easy, but there is something complicated. Obviously, it can be that hard thing to figure out everything to do with maths, and how many years it has been around.

The debate about the nature of mathematics was good. It is usually… it is good thing for a change, we usually just discuss sums and equations, this is a big question.
How I think it was created? For example like God taught Adam and Eve whatever everything about life including maths, but not in the term of maths in like other stuff that was later on called maths, and later on developed into what we now take in school. And started kind of writing simple and everything Obviously they did not teach their children 1 + 1=2, and saying over and over again, but they had the same principle in what they been teaching their children.

I have no idea, no idea what I want to be when I grow up. I do not think I am gona be a doctor, or engineer or a pilot which most people want to be. A lot of people say that. Most people say they want to be a doctor and they do become a doctor. How many doctors are there in the world? This is a boring job. I want something different. If I hear someone different job I am eager to know more that. But for example doctors, a lot of people in my family are doctors. My sister wants to be a doctor.

You need maths in everyday life, for example banking, you need every day in life.
Where we could use maths? We have not used real life examples, not so much, but it would not be that awesome if we had, it is ok, I do not really care if we have or not. Because, I do not really mind if we have not or not. I like it if we do, but I am not gona be sad if we do not. In English like last lesson, and the stuff before, we were discussing how then we write stuff what makes us angry, we spent all lesson discussing about what makes us angry, and other things and stuff, and also the teacher, I had nine things to say. She told wait for today, but today I did not say it.

I am not sure if I should say it, but you know how the class is crazy and stuff. In maths it has to be like that, because we have to talk, like if you tell us do in your own, ¾ of the class would not understand, only the people who already know, so we have to talk. If you have to talk then obviously something is gona happen behaviour wise.

There were a couple of topics that we did, that I already understood, and I really did not learn anything, but it is not fair for me to tell you, but I understand, I am Ok, not all class is Ok. Because not everyone understands it, and even if I might know this, they probably know something that I do not.

I do extra work always, because my mum tells me, but if you give me extra work optional, I honestly think that, maybe 5 people will do it.
Once you told us we have to do a paper, we have to correct it…I did it, I asked my mum, my sister, they corrected me, and I understood everything, and there were a couple of algebra questions which I understood and from that day like half of the algebra topic I already understood because of that just half an hour my sister was explaining. It will work if you tell told them you have to do it, and you told them… For about one day and stuff, I am going to come, but…for example like Imran is sitting next to me, like no, no , no ..It is not because he does not want to, he is not bothered, he knows he is going to learn more, but he does not want extra hours of school. It is just, who cares.

Max
It has been fun when you're teaching us. The way you let us think about... You make us try to figure out how to do it, is really good, it makes us think more. Yeah, it's good, it's perfect. You're perfect, I can't think of anything. I liked the activities, how you made the activities the same procedure with the maths, like they all link together, that was really good, and I also liked how your presentations, how you make us think and how to make everything... Yes, I think I am good in mathematics. Maybe there are a few subjects I'm not really good at, but after... For instance algebra, I don't think I'm as good, but now I'm getting used to how to work with algebra and... It's sometimes difficult to get mathematics, it is like "Oh well." I was thinking of being an engineer, and that means a lot of maths. So I'm happy that I'm getting this opportunity to learn from a good teacher. Yes, we need maths a lot, for many things outside the classroom. Yes, and I'd say like when... It's almost needed in everything. Yes, we did real life examples a lot, and it's helping 'cause now we can see how the whole world has something to do with maths, and it makes it such a huge subject that it's an honour to learn. Actually... For example, like the other classes, I haven't been hearing other students saying that their classes are doing realistic work and that type of thing. And when we tell them that we learned something very nice in maths, like for instance drinking Coca Cola. That was really good, and the M&Ms and... Like, you know, these activities and stuff, and when we come and hear about them, they don't really get a lot of real life into it. They get it sometimes, but we get it the most, because you know that it's the right thing to do.

It's good to talk about your opinion. Yes, my ideas heard in the class. Maybe sometimes, if it's in the wrong time or something, I won't be able to show them my opinion, but afterwards when it's the right time I can show them. Sometimes you do not listen to me, you would tell me to ask my friends. Yeah, it's good, 'cause you're giving me an opportunity to hear from other people's opinions, and if they don't have one I can listen to you, but generally you will tell me to talk with the classmates and see what they're doing so I can learn more.

Maybe, we have chance to talk to others. A little in science, but maths uses it the most, 'cause in mathematics you need... I think that... In my opinion I don't think there is no wrong answer, 'cause it's always like there's billions of answers and billions of ways to... I am not worried if I will get a correct answer. The way we think the method should go, maybe it will be right in the end, but if we're wrong maybe you can tell us the right way or we ask our friends. We will resolve it in the end.

If we have a problem to solve, maybe we try and figure it out, then after a while you would tell us the actual thing, and other people would come to the board and show you what we think. I said sometimes "How am I going to know method if you don't explain?"

A few months ago I used to think that I shouldn't try to do things by myself... I thought you were the teacher, you have to tell us everything, but then I understood that it... Like I have to try. So me trying to find the method out is actually better, but what I would understand more is when you tell us.

From the beginning when I first started, when you started teaching me, I didn't understand much, just... I don't know. And now I can see how... What you mean, 'cause when I was young, when I was first coming to secondary, I wasn't used to the way maths was taught in that way. I see things differently now. Your class is different to the one we had in primary.. The way they talk to students. Like in primary they would tell you straightaway how to do it. And in secondary they let you think, they let you use your brain and actually find out, and that helps us to... I would prefer to do research on the internet, rather than working from the book. I think going on the computer and searching is the best way to learn, for instance on Emaths and MyMaths, and these websites, this is a good way. And I also like the way when you show us on the board. I can understand more on the board than on the computer, 'cause on the computer it doesn't suggest opinion... It doesn't suggest as many opinions, it normally tells us facts on how to do it.

When you mark a question, and a student shows an incorrect procedure, but correct answer... It depends who the person is, 'cause sometimes a person can, for instance cheat from someone else, and just write the answer down. But when you said someone get the answer by mistake... I don't think the person actually did it by mistake would actually regret it, but maybe, yes... Maybe when he was finding the answer out, like showing his working out, maybe he made the mistake there and then just with... If it's a big mistake, yeah, maybe he would lose a mark, but if it was a little...For instance, little mistake is if we did something times something, but then we realize after it wasn't the right thing, and we just divided them together, without tracking it down, maybe they...

Sometimes I think to myself I can find it out by myself, I shouldn't ask anymore. Sometimes I'm a bit shy of the teacher, but now that you're my teacher I can just tell you straight away.

Maybe in multiplication they don't (use the same approach in China). Maybe long ago, like in the past, in the history, countries had different ways to figure out something, and maybe they all, for instance, disagreed. The people which disagreed stuck to their ways. And the people which agreed would be the same as like...Maybe now people do not have to talk about

mathematics and decide, they don't do that because now they know everything... Not everything, they know most of the things, and I'm talking about the history, how maybe they didn't agree together as much, and that's what made them now just stick to the disagreement. Maybe 100 years ago they didn't know as much, and now we have developments, we have computers to do it for us, we have calculators. For instance, for finding the perimeter of a circle...How we started as a triangle and then...

Thank you.

Nothing is over

'You know that feeling when you finish something after a hard work and you have that feeling of emptiness, you are missing something.' My colleague said.

'Yeah, I know what you mean.'

'Well, teaching is nothing like that. When the school year is over there is no emptiness, you just so happy, you want to fly.' She added.

I recall that conversation from my first year teaching, at the end of every school year. How true. It feels slightly different this year. Could I have done anything differently? Should I have done? Now, I wish I did things differently. I had all these mixed feelings in my head.

The lessons are over and suddenly all the work, all the excitement is reduced to that one thing; the end of year exam. The boys did well in the exam. A smile crossed my face. They achieved more than their expected level. Much more. Adil got the level 8. Despite not accepting the exams as an appropriate assessment, I feel relieved that the results are ok. I decided that their exam results are not going to be a measure for their success, but still cannot help feeling that somehow I fulfilled my part in some accountability and obligation department.

Email from Josephine

Hi Dani.

I've been through the document that you sent to me and made some amendments and suggestions. They are all fairly minor. I now have a clearer understanding of how you have constructed your work and why you have been asking me the questions about my impressions. It seems to be coming together well. I find it very interesting and informative.

I must reassure you that the classroom situations seem perfectly realistic and feasible to me. Given the way you have been working it seems perfectly natural that some of the children would object to your methods at times, e.g., not moving on to another topic as fast as they would like or not offering them a ready-made solution to or method for solving a problem. I know from my own experience in the classroom that that comes very difficult to some children and that they take a very long time to adjust. Also children are very outspoken these days - especially

the confident ones and the very bright ones. I wonder if it is more or less predominant in the Arab culture for children to voice their thoughts like this.

It made me consider what my classroom practice was like in comparison to the way you worked. It is now a good number of years since I was actually teaching but I did try to implement a similar regime as far as I could i.e. getting the children to think for themselves and interact with each other about their work and not just giving them a method to find the solution. I tried to teach them and encourage them to become mathematicians. This was inevitably made more difficult by the pressures to complete the syllabus in order for the children to be able to tackle the SATS papers!! I'm not sure if there will ever be a way around this given government, parental and local pressures to tick the boxes - not in the UK anyway. Lots of luck!
Josephine

Chapter 5: Research Question One, Results and Findings: How Effective was the Implementation of the Constructivist Learning Environment?

5.1 Introduction

I can say that this research question is about me. Did I, as the teacher, manage to create a constructivist learning environment in my classroom? Was I able to address the constructivist learning environment survey (CLES) scales appropriately? The effectiveness of the implementation of the constructivist learning environment was investigated in terms of the converting the constructivist ideas into practice. The evaluation of the effectiveness of the implementation of the constructivist learning environment was based on the students' responses on how they perceived the CLES scales - personal relevance, uncertainty, critical voice, shared control and negotiation - to be put into action during and at the end of the year. Quantitative and qualitative data were used to answer this research question. The quantitative data from the CLES Perceived Forms were collected towards the end of the school year, and the qualitative data were presented in the form of the classroom stories. The classroom stories were analysed for the activities and events to indicate that the CLES scales were put in place.

5.2 Descriptive statistics

The data from the CLES Perceived Forms were collected in the final weeks of the school year. Two students did not complete the survey; Oliver left the school before the end of year, while Joshua was absent due to illness. In this section a statistical analysis of the CLES data is presented; the students' responses to the scales were analysed for the mean and standard deviation.

The CLES has a 5-point Likert-type response scale with the following categories: *almost always* (5 points), *often* (4), *sometimes* (3) *seldom* (2), and *almost never* (1). The maximum possible mean score of each scale is 5 and the minimum possible scale mean score is 1. A high score indicates a more effective implementation.

The CLES results are summarised in the following table:

Table 1 ***Descriptive Statistics***

Minimum score = 1, maximum score = 5, n = 19					
Boys	Personal Relevance	Uncertainty	Critical Voice	Shared control	Negotiation
Mean	2.99	4.02	3.6	2.72	4.03
Standard Deviation	1.17	1.02	1.30	1.22	1.23

The following table represents individual CLES scores. The items which had a notably different mean than other items within their respective scale were identified.

Table 2 ***CLES Individual Scores***

	CLES Item	Score
-	I learn about the world outside of school.	2.74
-	New learning starts with problems about the world outside the school.	2.84
-	I learn how mathematics can be part of my out-of-school life.	3.89
-	I got better understanding of the world outside school.	2.63
-	I learn interesting things about the world outside of school.	2.84
-	I learn that mathematics has changed over time.	4.16
-	I learn that mathematics is influenced by people's values and opinions.	3.74
-	I learn about the different kind of mathematics used by people in other cultures.	3.68
-	I learn that modern mathematics is different from the mathematics of long ago.	4.11
-	I learn that mathematics involves inventing theories.	4.42
-	I help the teacher to plan what I am going to learn.	2.00
-	I help the teacher decide how well I am learning.	2.95
-	I help the teacher to decide which activities are the best for me.	2.84
-	I help the teacher to decide how much time I spend on activities.	2.95
-	I help the teacher to decide which activities I do.	2.72
-	It's OK for me to ask the teacher 'why do I have to learn this?'	3.26
-	It's OK for me to question the way I'm being taught.	3.11
-	It's OK for me to complain about activities that are confusing.	3.65
-	It's OK for me to complain about anything that stops me from learning.	3.50
-	It's OK for me to express my opinion.	4.55
-	I get the chance to talk to other students.	4.21
-	I talk to other students about how to solve problems.	4.32
-	I explain my ideas to other students.	4.05
-	I ask other students to explain their ideas.	3.63
-	Other students listen carefully to my ideas.	4.03

5.3 Analysis and discussion

Students were aware that the learning environment we were trying to establish in our classroom was somehow different from their previous experiences with mathematical classrooms. For example, many students recognized that our class, compared to their other classes, provided greater opportunities for discussion. Some students commented that they had never used to debate and discuss mathematical concepts and solutions, as there was just one answer. The analysis is organised around the five scales. The examination of the first Research Question has the following format:

- First, the overall picture of the specific scale implementation is construed from the descriptive statistics.

- Second, the analysis focuses to the specific examples and students' responses within the stories for an enhanced understanding of how and to which extent a specific scale was realised. The remarks that referred to the inclusion or neglect of a specific scale were identified from the classroom stories and, particularly from the foci students.

- Third, I explore why some CLES scores may not have revealed a suitable picture. Individual CLES items were examined and analysed for the mean and standard deviation, and a significant variation between scores for some items within the same scales was noted (see Table 2). These peculiar scores identified by statistical examination were analysed in an interpretative manner; I offer my explanation for the deviations and the ways they impacted the CLES results.

- At the end of the section is the discussion of the meaning of results and the reasons which in my opinion enhanced or hindered the implementation of a particular scale.

5.3.1 Personal relevance

An overall picture

According to the CLES results, the implementation of the personal relevance was weak to moderate. On average, activities used in the classroom were sometimes relevant to the real world. However, a reasonably large standard deviation suggests a variety of students' responses

and their perceptions about the personal relevance of the classroom environment (Mean = 2.99, StDev =1.17).

A detailed examination

A number of stories indicate the inclusion of the questions and projects that could be of personal relevance to the students. When the concept of negative numbers was introduced students were asked about their experience related to negative numbers; we talked about the application of negative numbers in real life, like temperature and the sea level. Manipulatives were used to help create their own understanding of the operations with integers. The use of credit cards and the price of the ticket to Dubai are just some of the examples with a reference to the real world. These examples did not refer to the artificially created situations. Many students had credit cards or frequently travelled to Dubai. Several stories illustrate the projects like the most popular sport, the difference between Coca Cola and Pepsi, and the linear investigation about a path around the mall, which resembled a realistic situation. Collecting like terms was explored using an analogy with a restaurant menu. One lesson talks about the students creating a mathematical question related to an item like a bottle or a box. The lessons dealt with the personal relevance by addressing real life examples, by using manipulatives, by accessing their previous experience regarding the concepts and by encouraging personal constructs.

The story where a couple of boys talked about their perception of the inclusion of the real life examples was created from the interviews with these particular students. Some students thought that that the classroom work included many examples from the real life and a couple of boys believed that the inclusion of such cases was excessive and they were not challenging enough. In contrast, some students thought that compared to other classes, we did not include enough examples from the outside the classroom world. Similarly, the three foci students showed diverse perceptions as to whether the personal relevance was appropriately addressed. Max's comments about the school year illustrate his belief that real life examples were included to a substantial extent. He pointed out that everything in life had something to do with mathematics. Comments from Adil indicate that he experienced some real life examples in the mathematics classroom; however, in his eyes, it appears to be to an insignificant extent. He mentioned a few examples, and thought that word problems are applicational; however, he could not see ways

to relate algebra to real life problems. It is evident from the stories, that Nazir firmly believed that we did not do real life examples in our classroom.

An examination of the individual CLES items

It is interesting that the statement 'I learn how mathematics can be a part of my out-of-school life' had a significantly greater mean than other items in the personal relevance scale (3.89 versus 2.73, 2.84, 2.63 and 2.84). It is worth noticing that this item is the only one that explicitly connects mathematics to the classroom experience. There is a possibility that the students misinterpreted some of the statements. For example, the statement such as 'I learn interesting things about the world outside the school' could be taken out of context and refer to anything but mathematics. Our entire lessons were about mathematics, and the above question may suggest that we may have talked about some interesting things *apart* from it.

5.3.2 Uncertainty

An overall picture

Based on the students' responses in the CLES, the uncertainty scale was implemented very well. On average, students regularly had an opportunity to experience mathematics as a product of various people and cultures. The standard deviation indicates that the perceptions of most of the students ranged from sometimes to almost always; in fact, just one student perceived this scale to be implemented only seldom (Mean = 4.02, StDev = 1.02).

A detailed examination

The classroom stories include some events that indicate that the uncertainty scale was in place in the class. I used every opportunity to communicate with them that mathematics was built by various cultures, and this is what we were doing in our classroom. Additionally, I tried to promote the idea that from the personal perspective one's answers were not incorrect; she would not on purpose offer a wrong answer. The solution one offers depends on his previous knowledge and the reasons are justified within that knowledge; therefore, one needed to respect

everyone's opinion. A number of examples illustrate that the students were given an opportunity to experience mathematics as a man-made entity. For example, in one of the lessons students were trying to construct the relationship between the diameter and the circumference. We discussed the approaches and their shortcomings, and drew a parallel between what we were trying to achieve in our classroom and what people did in the past. Anecdotes and legends about mathematics from different cultures were frequently told; Nazir mentioned the story about Pythagoras, and Max made a reference to the Chinese multiplication. In one lesson we watched the video about Andrew Wiles and the Fermat's last theorem, and discussed how mathematics was created. In the classroom, I referred to the ways I constructed the meaning of mathematical concepts. Interestingly, I could not find many specific references where students acknowledged this aspect of our classroom. Nazir, referred to the lesson in which we discussed how mathematics was created, saying that it was a good, unusual lesson, recognizing the difficulty of the question. Adil referred to the same lesson in his comments, saying that that lesson was not educational, mathematics-wise, but nevertheless good and interesting.

An examination of the individual CLES items

The item 'I learn that mathematics involves inventing theories' had the highest mean (4.42 versus 4.15, 3.74, 3.68 and 4.02) which indeed reflected what was happening in the class; I did not present any rules to the students; I rather guided them to create all meanings and formulas by themselves.

5.3.3 Critical Voice

An overall picture

The CLES results show that the critical voice was reasonably well implemented. On average, the students perceived the critical voice to be implemented sometimes to often; however, the standard deviation indicates a variety of the students' perceptions regarding this scale (Mean = 3.6, StDev = 1.3).

A detailed examination

A few incidents described in the classroom stories demonstrate that the critical voice scale was addressed in the class. On a couple of occasions students raised their concerns about the ways the class was taught or organised. For example, Oliver said that my desk was messy and offered his help. Joshua expressed his dissatisfaction about some teaching strategies. While discussing if he had enough opportunities to express himself, Lucas suggested that maybe we had some behaviour problems as the students talked too much. Given the negativity of some of these comments, these incidents indicate that they felt free to express their opinion about some aspects of our classroom. However, I must say that there were not many such incidents. I felt quite relaxed in the classroom and I was under impression that the boys were able to raise their concerns freely. Students were invited to offer their opinion and talk to me about their obstacles. All three foci students said that they had freedom to raise any of their concerns. Adil articulated clearly that he was able to express his opinion on the way the classroom was run, and recalled that he was asked to write down how he felt about the mathematics classroom. Nazir thought that he was able to offer his opinion regarding the classroom activities. Additionally, he suggested that we may have some behaviour problems as boys were loud and talked too much. The stories about Max show that he frequently expressed his dissatisfaction with the classroom strategies, especially my reluctance to explain mathematical concepts in an explicit manner.

An examination of the individual CLES items

From this analysis, it appears that the CLES indicated lower perception of the critical voice scale than suggested by the classroom stories. Statistical analysis of the individual items showed that the following statement of the critical voice scale had a significantly higher mean (4.55 versus 3.26, 3.11, 3.65 and 3.50) than the other four statements:

> It's OK for me to express my opinion.

The difference in the results could stream from the language in the other statements that could be perceived as negative. The other statements could be interpreted in two ways. For example, let us consider the third statement:

> It's OK for me to complain about activities that are confusing.

From one perspective the statement inquires if according to a student's perception of the classroom, he was feeling free to complain about an activity. However, one may emphasise the student's behaviour, and interpret it as offensive and rude, as he was complaining. The first four statements emphasise the students' actions of questioning the teacher and her decisions, and making complaints about learning environment. These actions may not be always culturally appropriate. The last statement is just inquiring about opportunities (or appropriateness) of expressing opinion.

At one point Nazir said that it was not in his place to make comments about the activities he was not happy with. It indicates that such behaviour would possibly be perceived as inappropriate.

5.3.4 Shared control

An overall picture

According to the CLES results the implementation of the shared control was weak to moderate. On average, the students perceived that just seldom to sometimes they were able to share control of the classroom with the teacher. A large standard deviation suggests a variety of students' responses and their perceptions about this aspect of the classroom environment (mean = 2.72, StDev =1.22).

A detailed examination

The classroom stories describe some incidents where the shared control was addressed. A number of tales indicate that independent thinking was valued and that the students were arriving at the solutions by themselves. I thought that it was one of main features of our class; I was reluctant to explain explicit procedures, so the students were gently forced to construct the meaning of the concepts by themselves. Some decisions the students made were almost too small to notice; for example, on daily basis they were to decide how to group themselves and distribute their work. Some students would work in groups of four, while some would work in pairs or individually. In the story with negative numbers they were asked to choose their homework, while in the story with the fractions they were asked to make a decision about the

inclusion of the lesson on multiplication and division of fractions. The story where the students were marking their tests illustrates that they were given an opportunity for self-evaluation. As the year progressed, several stories illustrate situations where the students were asked to choose their own work. Personal constructs, which gave the students the sense of ownership over their learning, were encouraged. Max was frequently put in the situation to think independently about the problem, while Adil was encouraged to make a decision about the work he wanted to do in mathematics classes; he remembered the incident when he was asked what he wanted to do in the mathematics classes. The stories about Nazir show that he was in the situation to choose his own work. Similarly as with the uncertainty scale, I could not find many instances where students acknowledge that they were in the situation to take control over their learning; Nazir at one point mentioned the situation where he was told that his homework was optional and the tales throughout the year show that they were from time to time put in such a position.

According to the classroom stories, not all students had the same opportunities to select their own work. It appears that I found it much easier to let Adil do what he wanted to do as clearly he understood very well all aspects of the prescribed curriculum. I was happy to let other mathematically able students, like Alex and Fadil, explore mathematics by themselves, as they were also in control of the concepts 'covered' by the scheme of work. My conversation with Nazir while solving the linear relationship problem, illustrates my reluctance to let go of my control over the scheme of work (Thinking does not count). I was worried to follow an opportunity to take the lesson in a different direction. It did not even have much to do with the scheme of work; we already had stepped out of the prescribed curriculum with that lesson. It was more connected with my idea of what was the right order of 'covering' things. When Adil was choosing his extension work I tried to stir him towards similar topics within the same strand; I had my ideas about how and in which order the work should be completed. When we discussed in class if we should do operations with fractions in depth, I hung onto the decision made by the minority of the class as I thought that it was an important topic to be studied; I was not going to let the students just remember the rule. In my eyes they really needed to understand it. I enforced my opinion upon them. At the end of year when some students wanted to do examination papers, it was easy for me to refuse it, as I did not see the educational benefit from that. This is to a great extent in agreement with the students' perception of the weak implementation of this scale.

An examination of the individual CLES items

The following statement of the shared control scale had a noticeably lower mean than the other four statements (2.00 versus 2.94, 2.84, 2.84 and 2.94):

I help the teacher decide what I'm going to learn.

All the statements apart this one, refer to the explicit learning occasions (such as an assessment or activity). The students' responses were notably higher in these cases, which do reflect they had some power over the choice or timing of the activities. Indeed, the students were choosing to work by themselves to a certain level, and were asked to help to create assessments and suggest activities; however, they had little power in deciding what to learn or changing the scheme of the work. We did some extra topics but did not exclude any from ones prescribed by the scheme.

5.3.5 Student negotiation

An overall picture

The CLES results show that the negotiating scale was implemented well. On average, students frequently had an opportunity to negotiate with each other. The standard deviation indicates that perceptions of most of the students ranged from sometimes to almost always. Only one student perceived this scale to be implemented only seldom (Mean = 4.03, StDev = 1.23).

A detailed examination

If I had to choose one feature that dominated the classroom it would be negotiation between the students (and me). I employed a variety of strategies to promote discussion among students: questioning, formal debates, a starter defying intuition, group, pair and collaborative work. A number of tales illustrate that students were given an opportunity to actively interact. It is noticeable that it was promoted that the 'acceptance' of the meaning of a concept needed to be negotiated and validated in our community. In fact, I was worried that we were discussing too extensively; it was very difficult to stop the excited class expressing their opinion. There was

always someone who wanted to say something extra. After working on the idea that mathematics needed to be negotiated and debated I found very difficult to stop them doing so.

The foci students' comments support this explanation. Max thought that his ideas were heard and I would frequently suggest he have further discussions with his friends. The stories about Adil indicate that he believed that the negotiation scale was in place. He commented that the teacher asked if students can explain concepts in different ways and that he had a chance to express his views more in mathematics classes than in other classes. He said at one point that according to his teacher, mathematicians needed to negotiate and discuss the meanings of mathematical concepts. Nazir's journal demonstrates his view that we discussed our work and that he had chance to talk and explain. His comments at the end of year illustrate that he was free to express himself.

An examination of the individual CLES items

Interestingly, the following statement of the negotiation scale scored a relatively lesser mean than other four statements (3.63 versus 4.21, 4.32, 4.05 and 3.95):

I ask other students to explain their ideas.

The question possibly could imply that a student did not know how to solve a problem and therefore is asking others for help; i.e. somehow, it describes the students in a negative light. The students possibly would not want to be portraying themselves as frequently being in that situation. We have seen that, for example, Adil, who enjoyed explaining his ideas to others, would not think about asking other students for help; the questions were too personal for him and he had his reputation to protect as well.

5.4 Discussion

The implementation of the constructivist environment was helped by the fact that my class was more advanced than the other Year 7 classes and I did not face any issues regarding completion of the course on time. While we could not deviate from the prescribed plan and programme, we had enough time to explore it in our own terms, and go beyond its demands. I am aware

that it would not be the case in other classes, and I would have to be more flexible with my plans and responsibilities. Additionally, most of the students had a positive relationship with mathematics and believed that they were good at it; after all they were in one of the top classes. A study that was based on data from the 2012 Program for International Student Assessment (PISA) and involved 5116 adolescents from 384 schools in the United Emirates, examined the relationship of adolescent children's perceptions of their parents' attitudes towards mathematics to their own attitudes towards mathematics and mathematics achievement. The results indicated that the students who perceived that their parents liked mathematics and placed great academic importance on it, reported higher levels of instinct and instrumental motivation to learn mathematics, mathematics work ethic, positive behaviours towards mathematics and performed better on the mathematics assessment than the students whose parents disregarded the importance of learning mathematics (Areepattamannil, Khine, Melkonian, Welch, Al Nuaimi, & Rashad, 2015).

The classroom stories illustrate that many parents had jobs related to mathematics and were involved in students' mathematics homework (I know now what π is. It is more than 3.14. We do too much real life stuff, Last comments by Nazir). Hatherley-Greene (2014) who worked in a similar environment suggest building rapport and showing an interest in the students' lives are crucial aspects of teaching and learning in an Arabic context. He recommends to change teaching styles, behaviour management and academic progress only after rapport has been established. I feel that I managed to build rapport with my students which helped me with the implementation of my constructivist ideas. I feel I had advantage when compared to many other educators regarding the way I was exposed to mathematics, especially during my early years. I knew that I needed to create my (mathematical) knowledge, and I did not find it difficult to try to project that understanding on students. The results indicate that I did not find all aspects of the constructivist environment equally demanding. I felt at ease with the negotiation scale; my views on the way mathematics should be taught and explored proved to benefit the interactive aspect of the classroom. I enjoyed telling anecdotes and using examples from various cultures, including Arabic. I do not feel that I significantly struggled with the critical voice scale; students were well behaved with reasonable and justified comments. However, I struggled with personal relevance and shared control. Most notably my interpretation of the personal relevance was different from one indicated by the items within that scale. I placed a great emphasis on mathematics as personally constructed, perhaps because of my own

mathematical experience and upbringing. Shared control scales were implemented to a limited magnitude due to my beliefs and interpretations of this scale. Though I did not support technical interest in completion of the curriculum and learning for the exams, I still held onto my perception of how the work should be completed for one or another reason.

Personal Relevance

The CLES indicates the students' perception that the personal relevance was weakly to moderately implemented. The classroom stories indicate that the personal relevance was put in place; however, the response was diverse, depending on the situation. It looks as if the students' perceptions of how the aspects of the personal relevance were addressed depended on the particular lesson and the individual perception of what the personally significant example is. This result appears to be supported by the foci students as well.

The analysis suggests that the implementation of personal scale was hindered by my interpretation of this scale. While preparing lessons I was generally guided by the CLES items; however, my understanding of what was personally relevant for students had a wide interpretation. In the classroom we frequently recalled what had been said and done in the previous lessons, and the PowerPoints included scans of the students' work. In my opinion such actions reflected individual involvement and personally relevant activities. And yet, possibly, it would not be recognised as such as it does not talk specifically about the outside of classroom phenomenon. The elements of Arabic culture were regarded as personally significant. A study in the United Arab Emirates investigated the experiences of new first-year male Emirati students at a college of higher education. The result indicated the use of the students' previous experiences and culture in the context had a positive effect (Hatherley-Greene, 2012). However, despite being possibly personally relevant, the students may not have regarded such aspects of the classroom as the outside the school phenomenon; they were unlikely to leave their culture at the door as they entered the school. Mathematics was partially presented as an individual creation and the students were encouraged to construct their personal meaning of the mathematical concepts, to give their own 'personal touch'. No item in the CLES addressed the personal relevance scale in such manner. Admittedly, my interpretation of this scale did not include many, easily recognised, real life examples. To be honest with myself, I do not think I was entirely 'sold' on the idea of real life examples. To what extent does an art

lesson includes real world examples? Mathematics does not have to be related to real life; art is not necessarily related to real life, at least not from everyone's perspective. By all accounts I tried to paint the picture of what mathematics meant to me; we did many investigations and problem solving activities which do not necessarily present the view of mathematics as a tool in real life. Brooks and Brooks (1993) point out that use of the real life data and primary resources, along with manipulatives are paramount part of a constructivist classroom. While these were used to a certain extent in my classroom, the focus was not on the real world, but on brainteasers, investigations and analysis - mathematics as experienced by me.

Uncertainty

The CLES results show that the uncertainty scale was strongly implemented. The examples illustrated by the classroom stories show that the uncertainty scale was addressed, although, the students did not explicitly acknowledge that aspect of the classroom.

According to the analysis of the classroom stories, the uncertainty aspect of the learning environment was partially fruitful due to many stories and legends about mathematics; it appears that I successfully communicated my view of mathematics as a never-ending story which we were part of. Additionally, the students by themselves constructed the questions, and the meaning of concepts and formulas, and, consequently, had a chance personally to experience the uncertainty of mathematics; it was being created right in front of our eyes. Ernest (1991) points out that the investigation in mathematics classroom not only justifies theorems but create theories as well. Problem solving activities promote logic which is seen as a part of mathematics tradition; however, they include bringing of the novel ideas into resolving process, and allow the learner to be creative. He suggests that inquiries and investigations, along with the view of mathematics as a fallible and humanly constructed entity should be central parts of the curriculum.

Critical Voice

The CLES results demonstrate that the critical voice was moderately to strongly implemented, while from the classroom stories it seems that students had opportunities to express their

opinion freely and complain about the teaching strategies that took place. Many, including foci students, commented that they could tell me anything. A likely explanation for this discrepancy is the wording of the survey items describing behaviours that could be seen as inappropriate in the Arabic socio-cultural context. The statements with the possible negative portrayal of students had significantly lower scores.

The examination of the stories shows that the students were able to raise their voice, and that this scale was better implemented than the CLES indicates. A study conducted by Aldridge, Fraser, Taylor and Chen (2000) showed that students in Taiwan perceived less Critical Voice in their science classroom than did students in Australia and suggested that the Critical Voice scale was influenced by the degree of respect teachers are shown in Taiwan. Likewise, I found that in my class students displayed similar behaviour and it influenced some of the CLES responses. In Arabic culture, teachers and generally elderlies are respected and their views are not to be opposed. The items of the CLES, particularly those related to Critical Voice, which could represent the students as disrespectful had notably lesser marks.

Perhaps, the cause for a reasonable successful implementation of this scale lies in the students themselves. The boys were well-mannered and cooperative throughout the year; I do not recall many incidents where I was concerned about their conduct and I did not have many behavioural strategies in the place. Generally, they were respectful towards each other or the teacher. I felt that it was easy to be myself; I suppose that many teachers feel similar in a well behaved and highly motivated class. I presume that students' behaviour and my response to it helped to develop a trusting relationship in which they were able to express their concerns. Max always behaved impeccably, despite frequently expressing his worries about the teaching strategies. I believe that the boys with their conducts helped me implement this aspect of the constructivist environment. I doubt that I would act in the same way if the class had behavioural problems.

Shared Control

The CLES results show that the shared control was weakly to moderately implemented, while the stories indicate that this item was addressed to some extent. The classroom stories illustrate that many students had an opportunity to suggest or choose the classroom activities within a specific topic. Some of more mathematically able students were able to make a choice about topics, but without distancing themselves from the scheme of work.

There are a number of reasons for a weak perception of this scale. The analysis indicates that the technical interests such as completing the scheme of work for the examination purposes were still playing a significant role in the teaching and learning that occurred in the classroom. I was partially constrained by the expectations from the school which included covering the scheme of work and passing exams. However, I feel, in my classroom, one of the main obstacles to letting students share control was the mastering of the curriculum, not necessarily as prescribed by school, but as prescribed by me.

The students' shared control was constrained by my belief system about curriculum and the way it should be accessed. The result for the shared control was not entirely unexpected. Many studies on the constructivist learning environment reported shared control as the aspect that students perceived to be implemented weakly (Puacharearn, 2004; Taylor et al., 1994), because they represent the biggest change for students (and the teachers); traditionally, they are not asked to participate in the decision making about curriculum. The examination and a non-flexible nature of curriculum could be one of major reasons for a weak implementation of the Shared Control aspect of the classroom (Aldridge et al., 2000). However, in my study the hard nature of the curriculum was not the main reason for limited implementation of shared control. I feel that in my case it was rather my view of how it should be realised. A detailed examination of the stories, suggest that I as a teacher found it difficult to let go of my assumed role. The stories from the classroom indicate that the way I appropriated shared control in the classroom, was guided by my beliefs. While I did not support technical interests of the curriculum by 'covering' the topics within the limited time, used traditional lecturing means, or promoted exams, I still found it hard to let go of control of the things which I found important. I had my ideas of what and how the things should be done, regardless of the school or the students' views. For example, I went ahead with the lesson on multiplying fractions despite the students' opinion not to do it as they knew the rules; I felt it was an important concept. Some able learners chose to do different topics, but, on my insistence they still stayed within the same strand. I still, consciously or subconsciously, thought that my way was right.

Further to this, the classroom stories suggest that the expectation that they were supposed to be in control of their learning possibly was not explicitly explained to the students; I did not find any instances where I openly communicated that kind of role within our learning environment. The only way I communicated my expectations regarding shared control was my explanation

that I wanted the students to think and create the meaning of a concept by themselves, pointing out that I cared about the way they solved the problem rather than the answer, and that aspect of the shared control is not addressed by the CLES explicitly. While the students had some opportunities for the shared control, such an expectation was not clearly communicated to them.

Negotiation

The CLES results indicate that the negotiation scale was effectively implemented. The classroom stories show that the negotiation scale was efficiently implemented and that the students were given an opportunity to actively interact. They felt that they had a chance to express themselves and hear other students' opinions.

The analysis of the stories suggests that the kind of questions asked in the class helped to generate fruitful discussions. Frequently, the questions defied the intuition and had a different answer than anticipated; they challenged the students and made them wonder about the kind of solutions. Many problems had a puzzle form and the students were regularly asked for analysis and interpretation. They were encouraged to bring their own questions into discussions, rather than the questions being supplied by the teacher. These are the strategies used in the classroom that probably intrigued the boys and awoke their curiosity. Constructivist teachers need to encourage students to engage in dialogue by asking open-ended questions, and to offer experiences that provoke contradictions to their perceptive responses (Brooks & Brooks, 1993). Other studies reported negotiation as the aspect which students found to be implemented to the considerable extent (Puacharearn, 2004; Taylor et al., 1994). Perhaps the classroom rules, introduced formally or informally from lesson one, helped to create an engaging classroom. The rules emphasised the need to think; the students did not need to know the answers but they needed to be prepared to think and offer their own explanation.

5.5 Summary of the chapter

In this chapter the first Research Question was answered. Quantitative and qualitative data were used for this question. The results of the Research Question show that the implementation of

the constructivist learning environment was fairly efficient. Based on the students' responses and my reflections, the uncertainty scale and the negotiation scale were implemented well, while the critical voice was moderately in place. The personal relevance and the shared control were implemented moderately to weakly.

Chapter 6: Research Question Two, Results and Findings: How Did the Students Respond to the Constructivist Learning Environment in a Boys' Arabic Classroom?

6.1 Introduction

This research question is about the students' reaction to the constructivist learning environment. The students' responses to the constructivist learning environment was investigated in terms of the extent they embraced the constructivist ideas. In this section the classroom stories were analysed for the data indicating the students' acceptance or resistance to the CLES scales. I reflect on the incidents described and interpret the students' behaviour and actions from my perspective, and offer my interpretations of their involvement with personal relevance, shared control, negotiation, critical voice and uncertainty. The analysis is organised around the three foci students: Adil, Nazir and Max. The examination of the second research question has the following format:

- For each of the three foci students, the analysis of the CLES scale scales - personal relevance, uncertainty, critical voice, shared control and negotiation - is presented. The analysis focuses on the specific events which illustrate the students' receptions of the CLES scales within the stories.

- At the end I cross examine the analysis of the three foci students, and try to identify and discuss any common grounds that affected their attitudes to the learning environment.

6.2 Analysis and discussion

6.2.1 Adil - puzzle solver

Personal relevance

First term. Adil was in control of his knowledge. It was easy for him to connect a new topic to something similar he had done before. From the way Adil presented the linear relationship rule, it appeared that he had seen it before. It was not how he initially attempted to solve the problem.

He later noticed its relationship to linear sequences. He was able to relate his knowledge about linear relationships and our application problem. Furthermore, he understood and explained how the formula was constructed using the problem.

The fact that he compared mathematics to his favourite food, speaks volume about Adil's love for mathematics. He said that solving a mathematics problem was similar to being in the vicinity of a McDonalds's meal towards his mouth. Every person who truly loves mathematics will tell you that it is all about the excitement of solving a problem; there is nothing that compares to that. Solving a problem for Adil was like having a first bite of McRoyale. He questioned answers until he was satisfied with them. They needed to satisfy his evidence, regardless of what was his group's solution, the class' solution or my solution. Mathematics was an enjoyable thing for Adil; he would get enthusiastic because of its beauty; I did not need to use real life examples, or to find his other interests to make it more accessible to him. While Adil was enjoying classroom mathematics, it did not need to be related to the world outside the classroom. Although, his report on his Favourite Sport was immaculate, at no point did he show enthusiasm and excitement. The only incentive probably came from his desire to be the best. After all Adil knew that he should be the best in the class. Personal relevance had a different meaning for him compared to the other students; mathematics by itself was a personal thing for him. Mathematics was his passion, his own thing.

Second term. Adil continued to enjoy the classroom and mathematics throughout the year; it was like a game for him that he wanted to win. He said that the mathematics class was wonderful, especially the algebra part; it was like a solving a mystery for him. On one occasion Adil was described as being proud of his solution which indicated personal meaning of solving mathematical problems. He talked about his love for mathematics and kind of problems he enjoyed doing. He mentioned a variety of the problems he did at home, including Diophantine equations. On many occasions, Adil continued to work on his problems during the break and came to see me after the lessons were over (the problem with reversed digits, the probability investigation with dice). It indicates that solving problems is a personal matter for Adil. One cannot easily let go of a problem and continue the next lesson. We would want to leave the problem, but it does not want to leave us. Adil persevered with the questions until he solved them. Not everyone feels like that about mathematics.

When we discussed the reasons for the rules for multiplication and division of fractions, Adil's explanation suggests that he wanted to understand them. He tried to make sense out of the rules.

The rules were available for them but it did not satisfy him. They were easy enough to be remembered and used and the class had an option not to do multiplication and division of fractions; however, he declined it as he wanted to know how the rules functioned. He was curious to know why the rules worked. We express curiosity about something that interests us. Mathematics was a personal interest for him and he wanted to know how its concepts were created.

To a certain degree, Adil acknowledged applicability of mathematics in everyday life. He said we used it every day without realizing it, like cooking or even breathing. However, he believed that such examples were basic, and that one could not use real life examples in every aspect of mathematics. He personally did not mind using real life problems in the class, but understood that it could be helpful for some students. However, I am not sure if I can classify it as a personally relevant element of his learning; while he found it interesting, he did not really need real life examples. It was almost the opposite with him compared to the rest of the class: the real life examples were more appealing for him because of their connection to mathematics. I did not have to look further to make it interesting to him. Real life examples were more designed to challenge his views about the nature of mathematics, I did not need to 'sell' him mathematics through the real world illustrations.

Adil displayed the ability to connect his previous constructions with the new concept even in the situation with no obvious connection (measurement and algebra). Let us not forget that the boys were only in grade 7 and he demonstrated ability not only to remember a range of concepts but to use them in an appropriate situation.

Uncertainty

First term. Although, it was insignificant that Adil came up with the idea to replace the words 'How are we going to do the investigation?' with 'Methodology', I think it indicated precision and making sure that everything was clear and exact. When analysing the test, Adil noticed that a constructed formula found by how many students was each sport liked on average; not a commonly used concept. It is not something of importance we mentioned in the class, but it

may indicate a desire to attach a note of exactness and clarity to things. He, along with other students developed a formula for finding an appropriate level. Naturally, Adil liked everything to be precise.

Adil demonstrated awareness that the rule needs explanations; it is not enough for the formula to be given but we need to understand it, that there is a reason for it. He understands how mathematics '*works'*; in the linear relationships lesson he justified why the rule worked. He went further to explain how validity of the rule could be checked by substituting 2 instead of n.

On the other hand, Adil's words suggest that he enjoyed new found uncertainty about mathematics by comparing solving some problems to being left on a cliff-hanger. For example, the students thought that 0.999… is obviously smaller than 1, according to the familiar rule of comparing the same units first. He liked that suddenly not everything was as it appeared.

Second term. Adil's words 'I think mathematics is out there, we just have to be aware of it' confirm his absolutist view of mathematics. He thought that everything was certain and followed some rules; we just had to be able to find them. Adil saw mathematics as a game, as a battle of tactics. In his eyes it was absolute: 'I can put the army into it'.

On a number of occasions Adil displayed his assertion that mathematics could be portrayed with formulas (the volume lesson, the π investigation). Despite wanting to know how mathematics worked, and assigning a personal touch to his learning, Adil still had a view of mathematics as an exact and flawless entity; everything could have been described with some rules. The formulas, rules and patterns made mathematics what it was. While attempting to solve the reverse digit problem, Adil did not regard guessing and checking as a valid mathematical approach. While it may had delivered a solution to his problem; somehow, in his eyes, it did not qualify as a real 'mathematical' method. He said that there must be a more sophisticated explanation, which somehow fitted with his precise view of mathematics; an exact science calls for the exact methods. While working on the π investigation Adil did not consider accuracy to be one of the problems in mathematics. He tried to overcome the discrepancy in the experimental data by finding an average and presenting it as the solution. He failed to acknowledge the extent to which the inaccuracy in measurements could be a source of the divergence in the results. I felt he tried to prove his theory that everything in mathematics could be and was fixable. I found fascinating his opinion that symbols were not a part of

mathematics; they existed just to make mathematics easier. Not many people, especially children have such thoughts about mathematics.

Interestingly, Adil thought that mathematics was a subject that could be discussed which was a contradiction to his absolute view of it. I think it could be a consequence of the continuous promotion of discussion as an expected part of a mathematical lesson. He liked debates and expressing his opinion and after all found such activities a natural part of the mathematics lesson. His end-of-year comments indicate that he found other subjects to be less debatable than mathematics (And accordingly if less debatable they could be considered as more certain).

In my eyes Adil was acting as a mathematician, as a mathematician should be. Adil was logical and able to organise his thoughts plausibly. However, that was not all. Saying that someone acts as a mathematician somehow excludes creativity and a personal element; mathematics and acting like a mathematician is much more. You need to be creative, yet in the same time organised. You need to be able to explore freely and think of the unthinkable, and in the same time you scrutinise possible solutions in a structured way. Adil was all that. I think that the starter of the lesson (Thinking does not count) demonstrated his creativity (although, it was not exactly a mathematics problem). I used that problem reasonably often and students always struggle to solve it. I think that creativity is a factor often neglected in the mathematics classroom. Many teachers unfortunately see Mathematics as a set of rules which need to be applied properly, yet, very often I see students (and teachers) not being able to apply these rules correctly. It is not enough to know the rules and how to apply them; one needs to be imaginative and figure out the way of applying all these procedures. Rules and methods are just the formality at end of the process. Adil had intuition and creativity which could not be described by rules. Despite the fact that for the students, until this year, mathematics was quite formal and defined by formulas, Adil did not conform to that.

Adil's words are contradictory. On one hand, Adil said that everybody made mistakes. On the other hand, the teacher was given extra points on his appreciation scale because she was a mathematics teacher. It reflected his thoughts about mathematics and his mathematics teacher; she was in charge of everything, and by not displaying any weaknesses his teacher conformed to the role of a mathematics teacher. She was never confused by students' thinking and she knew where their ideas were coming from. It appears that Adil placed great importance in mathematics and in his teacher.

Critical Voice

First term. Although he never did it, Adil felt that he could raise any issue with me. In his journal Adil expressed his appreciation for the learning and teaching occurring in the class, saying that it was interesting and made him wonder more.

Second term. While Adil felt that I gave them a chance to say what they think, he never voiced his opinion about the classroom activities. The only point that could be interpreted as critical came up at the end of year in his interview when Adil referred to the lesson when we discussed the nature of mathematics, and said that he liked it, but it was not educational from his point of view.

Shared control

First Term. Adil was never asking for a procedure or solution to a question. He wanted to build his knowledge as opposed to me presenting him with the method; in his words, everything was fine as long as I did not explain the questions. In class it was not only that Adil was solving problems in his own way; I noticed that he had been completing MyMaths questions which were not given for homework. It was his decision which topics he wanted to do. Compared to the majority of the class, when given homework, Adil did not think that he needed to do the entire worksheet; he chose a couple of the hardest questions. He was able to evaluate where he was and appropriately choose the questions for his level. At the end of first term Adil said that suggestions from students were welcome as they were all of the same age. However, it suggested that the teacher somehow still had more power because she was older than the rest of the class.

Second term. It is notable through many examples that Adil was doing mathematics on his own at home, not waiting for my guidance. For example, he explained his friends how to collect like terms and at that point in time we had not yet done Algebra. He completed all the past examination papers without my guidance and he frequently completed work on My Maths which was beyond the homework requirement. I find it interesting that he felt compelled to complete past examination papers. Despite his talent he still was worried about exams, and it was obvious that our classroom activities did not necessarily reflect examination type of questions. He expressed the opinion that past papers should not be done in the class; however,

they possibly still fit with his perceived measure of the success, and he did not voice his opinion on that aspect of education.

When we did multiplication and division of fractions, Adil wanted to explore that topic further. Some students were passively waiting for the decision to be made as to whether we were going to have an extra lesson on the multiplication and division of fractions, while Adil he participated in the classroom decision making.

He frequently chose a worksheet from the wall according to his needs without consultation with me. In our first lesson on the circumference of a circle when many students were struggling to accept the symbol π, he successfully chose appropriate questions that extended his understanding. He did the questions on the length of the arc and the perimeter of the composite shapes which were suitable for his needs. By choosing work himself he displayed control over his learning. Adil was always trying to extend himself and was going for more difficult questions.

He was in charge of his learning; he did take things into his hands literally. By the end of year, he was working from his own resources (books and internet). I let him decide by himself and on a few occasions did not even check with him; I knew he was doing something he considered worthwhile. I was there only to discuss problems if he needed someone for that.

Despite his involvement in the decision-making process, it is interesting to note that his end-of-year comments indicate that he may have thought that his teacher had a more complete knowledge and was in a better position to decide what was better for him. Adil trusted his teacher as in his words she was 'a teacher of mathematics' and she 'understands everybody's approach' and was not getting 'confused about different approaches'. Further, the way he used the term 'a teacher of mathematics' suggests that she was somehow more capable than other teachers, as possibly, in his opinion, mathematics, was a subject requiring a greater ability.

Student negotiation

First Term. Adil's participation was fair and he always worked adequately with his group. Adil found debates fun and he appreciated their format sometimes adopted for the class discussions. He politely listened to the other students and thought it was appropriate to share views.

While he questioned other students' ideas and wanted to clarify their thinking, for him it was not about negotiation and solving 'our' problem. He was somehow the leader of his small group but did not necessarily feel that he needed to share his views with them. While working on the tiles problem, the students were invited to explain the question in the name of their group; however, Adil offered an explanation different to Alex's, despite being in the same group. They failed to agree on their group solution, or to indicate that they had a difference of opinion. In a way what they did, did not have to do anything with him. It was his work and his answer. He was developing his knowledge and trying to persuade the class about his solution. However, Ali did not care so much about the social acceptance of his work; he knew intuitively that he was right. Other students' opinion was not important to him. Could I call him mathematically arrogant? Adil did not need to validate his solution socially; he mentioned that he liked to put his hand up to show the teacher his understanding. It was not so much about sharing his opinion with other people as much as making sure that I knew that he knew the question. Maybe the clue for such behaviour lay in Adil's interests; all of the activities listed were individual. Maybe it was his personality and Adil just preferred working individually. Even in the debating session, despite helping his group, he was still more concerned about his mark, rather than overall team mark, asking who got the best individual score. It could be because Adil was aware that he was the best in the class and thought that possibly other students may not be able to contribute much to his argument. Moreover, they were not able to follow his argument. I always felt that he was talking more to me than to the rest of the class.

Second term. Adil communicated willingly with his friends and at times their solution was the group result, which is exemplified with the presentation about the number π. However, from the stories it is noticeable that Adil frequently chose to work independently. For example, he chose not to work with Alex and Yousef while working on the volume question; however, he supported them when they needed his help.

Adil was the assumed leader of his group and even the classroom, and he was aware of it. However, it was not taken without any responsibilities; Adil was always challenged by his peers, presented with their solutions (which he acknowledged many times) and required to justify his opinion. They behaved like scientists. He may have been the best student in the class, but his opinion was not taken for granted. His words suggest that he felt that it was a part of his role to explain his view. Adil said that he preferred to work independently; however, he did

not mind if others teamed up with him. He liked explaining things to other students, but stressed that he did not mind if they did not listen to him; it was their loss. He cared if I listened to him.

He was trying to adopt the stance communicated by me; mathematicians needed to listen to and respect each other.

When faced with a problem he preferred working individually, saying 'That's when I'm kind of on my own.' He pointed out that Andrey thought that 'we should team up' and 'I did not mind'. Despite stating that he liked working independently, Adil admitted that he enjoyed discussions and expressing his opinion. He was physically a part of a group in mathematics lessons; however, he was able to detach himself and do his own work. He was never rude or abrupt when someone approached for help or argued from a different viewpoint. I had the feeling that Adil treated group work almost as a necessary evil. He was aware of the notion that mathematicians work together and explain their stances to each other and followed it; however, for him it was more natural to work by himself.

6.2.3 Nazir - examination believer

Personal relevance

First term. Nazir did not believe that the work we did in the class was connected to the real life. A couple of times he stated that real life cannot be done in the classroom; these two things could not be integrated. Nazir was taken by surprise with some things happening in the classroom and enjoyed mathematics more than he expected. Many times he said that he liked our class as he was only playing, thinking and talking, which in his eyes did not qualify as real work. Perhaps that is why he liked it.

For Nazir mathematics was a technical thing that was going to help him enrol into an engineering degree. He did not think that mathematics could really help him with anything; it was just a way to get to university.

First of all, my interpretation of real life examples could be different to his. I believed that I used to some extent real life examples in every lesson. However, he indicated that the things may have looked like real life, but they were not. It suggests that he did not believe that such examples could be done in the classroom; it was not really the place to do the real world

examples. In his journal Nazir wrote that in his opinion we did not discuss real life in mathematics lessons. On the other hand, it was obvious that Nazir liked the classroom activities and the social setting. The classroom tales demonstrate that his perception of the mathematics lessons was different than what he anticipated and that he liked them. It suggests that he enjoyed the work. While doing the Favourite Sport Investigation, Nazir got really passionate. Sport was a big part of his life; he played football and tennis and he participated in the interschool football and tennis competitions. Therefore, based on his attitude in the class, the lessons included some things which were of personal relevance to Nazir, as he enjoyed them. In addition, he was relying on his previous work while doing mathematics. He chose to check 10 tiles while working on the Linear Investigation. It could be insignificant; however, many students are aware that calculation with the number 10 could be easier than with other numbers. Additionally, he was trying to solve problems using ratios which he had seen before. He tried to use two approaches he was familiar with and which were possibly proven to be successful in the past.

Nazir was creating knowledge as a part of a group and the class and was trying to persuade others of the validity of his answers. He was happy to accept another students' answer if he thought it was more valid. He created his solutions and listened to others. His responses reflected their ownership of the solution. However, his work was not entirely systematic and he lacked intuition and creativity while solving problems. In the Linear Relationship Tile Investigation, he was faced with two solutions and at one point they were both equally correct in his eyes. After a brief discussion he admitted that Leo's solution is somehow better; however, he still was not entirely sure. After Alex presented the same approach he accepted it with the rest of the class as it still made more sense than other solutions. I am not sure if Nazir achieved some inner satisfaction. Did the solution provide him with the necessary evidence to fulfil his personal requirements for the correctness of the question? All his behaviour suggests was that it was the best possible option.

Second term. Nazir recognized some real life application of mathematics; however, in his opinion we did not do any of these in our classroom. As far as he was concerned such examples do not have a place in the mathematics classroom and he did not care whether we mentioned them or not.

In an indirect way, when comparing his previous mathematics classroom, with our classroom, Nazir described our mathematics classroom as a place where we needed to think. He felt that he had an ownership over the things he did in his classroom. We needed to think and create our knowledge. He was used to a different mathematics classroom and did not relate it to the place where he was supposed to be creative and personally responsible for the reasoning behind mathematical concepts. Nazir placed importance on the understanding of the mathematical concepts admitting that things looked easier once you understood them. His words indicate his shared control and his willingness to take responsibility for his own work. Even more, they indicate his personal involvement in the problem.

On a few occasions when Nazir offered his opinion it could be noticed that he tried to create his personal meaning of a concept. He was upfront with his fraction homework approach, he copied it from the internet, which may suggest hassle free and the absence of the personal attachment to the problem. However, he pointed out that he tried to figure out why the rule worked. Further, he created a personal meaning for the formula, despite acknowledging the inelegance of the solution; the only way he could understand it was first to convert it to decimals and then multiply. Nazir together with Adil were the only students to offer some kind of justification. Nazir found the shortcut in his π homework by asking his sister for help; however, he tried to make a personal sense out of it by relating π to the full circle. When working on the volume and the total surface area of prisms, Nazir tried to explain them in his way. While he was doing it previously, I had the feeling that he was putting more thoughts into it and was trying to satisfy his intuition about it; he declined other solutions because his own solution looked more plausible and he was able to explain it.

Uncertainty

First Term. In his first homework, Nazir compared mathematics to jelly, as it was simple. The word 'simple' could be interpreted in two ways; it could mean easy or it could mean not complex. I think he meant it in both ways. He acts confidently in the class and mathematics was easy for him. Also, he said that it has 'only one answer', which suggests that mathematics was rigid and non-negotiable subject for him.

Nazir contributed greatly to our classroom mathematics. He was a part of a group that was creating and questioning the validity of their solution: he listened to them and together they would choose the most appropriate solution. Further, he was willing to admit that others possibly had a more valid answer. The classroom stories illustrate that he appropriated mathematics as a human construction, as he happily embraced creation and construction of the conceptual meanings. However, I always felt that he thought that mathematics was rigid and exact. Maybe it was his thought that mathematics was only about exams and it would help him get to the university or his words that mathematics was simple as it was about one solution only. When he wanted to analyse his test, Nazir developed a formula as, in his eyes, it was the only way to accurately evaluate his knowledge.

Second term. Nazir came to realise that mathematics was not as straightforward and simple as he thought at the beginning of the year. When faced with an interest-on-interest question, he commented that I was going to prove them wrong again; he admitted the answer possibly was not as simple as it seemed, and it appeared to be a regular occurrence that year.

Nazir liked and appreciated the π investigation; he liked related stories and the way we constructed its meaning. I was surprised by Nazir's response at the end of that lesson; usually he was the one concentrating on exams and not appreciating 'unnecessary' work and explanations. At times he embraced all vagueness and uncertainty of mathematics.

When talking about his preferred ways of doing mathematics, at the end of year, there was some contradiction in Nazir's words. On the one hand he liked discussions as a way to resolve the problem. On the other hand, he did not think that he should question my explanations, or generally any mathematical statements. To my surprise Nazir said that mathematics was the most debatable subject. He explained that other subjects just stated the facts but in mathematics there was always a 'why'-part. It is unusual way to describe mathematics, especially by a person who believed that mathematics should not be questioned and had an examination purpose only.

While his words describe the classroom where students could talk about their constructions, I think they reflected his view that mathematics could be debated forever (which is again in contradiction to his absolutist stance). From his words, it appeared that mathematics was a subject (as opposite to other subjects) that logically led to the disunions and debates. As he

talked about other subjects he became aware that they could be discussed as well, but not as naturally as mathematics.

However, Nazir despite his appreciation for debates still had his absolutist view of mathematics. According to him, maybe in the past people were not sure about mathematical constructions, but today we should not have any doubts; all answers are correct. In his words, he was just a year 7 student; maybe he did not have the ability to understand everything, but surely as he was getting older things would get clearer for him. As he saw it, it was about his (in) ability to understand mathematics or not. A far as he was concerned, mathematics was surely certain.

Nazir entirely enjoyed the lesson about the nature of mathematics. He accepted that it was not only 'sums and equations' that were an important but a philosophical side of mathematics as well. Although Nazir recognized other softer and less certain sides of mathematics, he still interpreted it through absolutist lenses. He justified noisy classes and debates; it was in its nature that mathematics should be debated and discussed. He contradicted himself. He had an absolutist view and believed that there was just one solution, and everything was certain; however, he saw negotiations as a natural part of the lesson.

Critical voice

First term. Nazir wrote in his journal that he felt he could ask me anything. He mentioned that he was disappointed that some students judged each other based on the test marks only, and do not focus on the overall work and effort. I was a bit surprised with this statement. It implied that his opinion about students should not be based only on their test marks; their contribution during the lesson was as important as test marks. I think that it referred to the students in our class, that someone with better marks could be considered as a better mathematician regardless of his class attitude. I tried to emphasise that I was primarily interested in their way of thinking and that their contribution in class was very much appreciated. I did it verbally and made a point of mentioning it while writing reports or during the parent interviews. It could reflect dissatisfaction with the current system in school. In our department there was an emphasis on the final examination which could diminish the students' contribution during the class. I told

students that there were things in school that I did not necessarily agree with, but, nonetheless, while I could express my opinion, I still needed to follow them.

Second term. Nazir expressed his opinion about some things happening in the class. He voiced his belief that following the book was possibly not an ideal way of doing mathematics. He was almost defending me for being put in the position to use the book at times. It was not necessarily a critical voice about the teaching and learning in our class but generally about the use of books in mathematical classes.

Nazir issued me with a gentle warning about behaviour issues in the class, although in a cautious and apologetic way: 'I am not sure if I should say it, but you know how the class is crazy and stuff'. While it was fun being able to express yourselves, he thought 'the class would get out of control'. His interpretation of an open discussion was of a behavioural nature. Although he enjoyed discussion in our class he believed that it should be a quieter place.

He admitted that possibly there could be things to question in mathematics but it is not his place to do so. In his words it would be too difficult for him. He said that the classes were not always beneficial for him as he had already been familiar with the concept, which means that he did not feel that he should express his critical view. Further he justified such behaviour by saying that sometimes other students understood things that he did not know so everything balanced out at the end.

Shared control

First term. Nazir did not participate much in sharing control over things that could impact our teaching and learning. In his journal Nazir wrote that he liked using computers in the mathematics lessons. Additionally, he said that he would like to redesign our room. Although the students did work in groups, the class was set out in rows as I was sharing the room with other teachers. In addition, because of the size of the room and tables, and short breaks it was not practical to change the setting before the lesson. After the conversation with students I changed it for two lessons per week.

In my opinion his shared control was partially displayed in his relationship with Imran and

Joshua. Most of the time, he sat with Archie, Leo and Laith. Occasionally, he was sitting with Archie, Imran and Joshua when they would get carried away chatting about other things and not work. In that case they would end up staying at the break to complete their work. Students were free to decide who to sit with and it was his decision to sit with his friends only occasionally. He did not want to get distracted during mathematics classes and was aware that possible sitting with Imran and Joshua would jeopardise that. However, Nazir did not display a lot of willingness to share control regarding his learning. He had a couple of opportunities to do so; various worksheets were on the wall for students who wanted to challenge themselves, or to do different kind of activities. Nazir did not attempt to do them. He always picked to do work offered/ guided by me. In addition, he rarely did extra work on MyMaths. Nazir enjoyed different kind of mathematics activities compared to his previous experience with Mathematics and was happy to keep everything fun and almost casual.

Second term. During the first term Nazir and Archie decided not to sit with their friends as they were getting distracted. Only on a few occasion they did this. Nazir's decision not to be around his friends was based on his belief that mathematics was to important a subject in which to mess around. I noticed that during this term he started spending more time with his friends which affected his work ethic during the lesson; their efforts diminished and they were not completing their tasks. I suspected that it was his (and Archie's) decision as other boys given the chance would always be in the same group.

On a few occasions Nazir expressed his view that certain things should not be done in the class as they were not coming up in the exams; he did not want to spend more time on the operations with fractions. Additionally, he expressed a desire to do examination papers during the lesson. In a way he participated in the decision making about future lessons. After I offered a solution which he was not happy with, Nazir organised some extra lessons for himself with the purpose to do past examination papers. I think it is possibly the greatest indication of shared control from Nazir; he took the matter into his hands and did what he believed was most beneficial thing for him.

During the second semester, Nazir started choosing to work by himself according to what he believed were his needs. Many times he chose the worksheet from the wall without any consultation. In all instances he went for more complex work which suited his understanding; he was slightly pushed out of his comfort zone.

He admitted that it was not easy to take charge of your learning and do extra work, and that his mum made him do the extra work. He did it by doing a paper and talking to his mum and sister, and acknowledged that his understanding of the topic was more through that. Generally, he did not think that the entire class would follow his example; they would try to find an easier way out and avoid it legally (i.e. formal homework is completed, with optional homework they had an option not to do it). In Nazir's opinion, knowing that you would learn better was not necessarily a motivation in such situations.

Student negotiation

First term. Nazir was happy to discuss the work with his group and classmates. He was always willing to share his views and respected other students' opinions. In addition, he was able to admit when others had a better way of solving them. When discussing a problem with Leo he realised that Leo's answer made more sense and was more appropriate.

I am not sure if maybe, subconsciously, he did not see talking as a way of learning mathematic; on one occasion he said that he spent all lesson thinking and talking, and not doing work. This suggests that mathematics could not be learnt through talking and discussions. It could be a reason mathematics classes were an enjoyable experience for him; from his point of view we did not do much work as we were doing a lot of talking.

Second term. Nazir felt that he had a chance to express himself. His words 'people say the same thing but in different words' indicate that he took time to understand other students in the classroom. His end of year comment shows that he liked class discussions and explaining his views to the rest of the class. It is evident from the stories that Nazir frequently freely expressed himself. I noticed that in his group, the boys challenged each other's opinions and required full explanations. In the classroom, I tried to indicate that this is how scientists work in the real world, and they behaved accordingly.

6.2.3 Max - right answers seeker

Personal relevance

First term. Max enjoyed the lessons dealing with the life outside the classroom. The mathematics of everyday life was more appropriate content for exploring new concepts compared to the more traditional approaches. He relished discussion while working with negative numbers and linear relationships. Perhaps he most enjoyed the Favourite Sport activity where mathematics was 'hidden' (in addition to his sport interest). I suspect it was a mathematical problem where we did not have a correct answer to achieve. He liked the social setting of creating knowledge (despite possibly not seeing the value of it) and using technology in his work (favourite sport lesson, his journal at the end of first term).

Second term. Two stories particularly indicate that Max did not regard mathematics as a personal matter. When discussing a percentage question, Max appeared not to connect two different methods of finding percentages, mental and written. He learnt them as separate entities, not using his understanding of one method to help him with another one. A similar thing happened in the story with the volumes. Max could not recall the formula for the circumference of a circle, despite, successfully solving problems when we did it the first time around. He could not find a way to personalise his understanding of mathematics. Different concepts did not connect in his head. As I see it, we get more involved with the matters important to us, and make an effort, conscious or not, to remember and connect these concepts. Max failed to do so with mathematical concepts, which indicates the lack of personal and inner involvement with mathematics.

At the end of year, in his final comments, Max said that he had appreciated the opportunity to learn about real life examples. From his comments, it appears that he discussed the mathematics lessons, with his friends from other classes, pointing out that he was happy in the class where they did 'realistic work' and 'nice things'.

Uncertainty

First term. The classroom stories suggest that Max believed that people are not ones responsible for creating knowledge. While doing the Linear Relationship Tile Investigations, Max

participated in creating the classroom knowledge. After discussion he accepted Alex's solution as being more logical and valid. However, when presented with a formula, it overruled all his previous ideas and thoughts. In spite of not understanding the formula, it had the most value in his eyes.

Max's attitude in the class suggests that he was afraid that he would learn an incorrect way of solving problems. Many of the activities done in the class were (at least partially) open-ended. However, they still had some closeness to them; the Linear Relationship Tile Investigation had a specific answer, despite the fact that the way of finding the solution was not being prescribed. Although, the students were invited to create their own pattern, many still preferred some structure in the lesson and would want me to set all the work for them. Max was worried about the correctness of his work.

In the class he tried to demonstrate the knowledge according the rules; he correctly recalled the formula for finding the mean, despite, using it in an inappropriate situation. It was important to him to offer some kind of solution. He believed that mathematics was learnt in a hard way; it was a set of rules which I was supposed to transfer to them. Many times he emphasised the importance of the formulas and rules in mathematics. I was supposed to tell them what the rule was. There was no need for the rule to be explained; it was explained just by the fact that it was a rule. His approach to mathematics was demonstrated in his perception of the assessment. Max said that it was very important to calculate the answer to the test question (as opposed to having an explanatory answer). Further, in his opinion, the learning which occurred after the test did not really count; it should not be included in the grade.

On the other hand, his attitude slightly changed when presented with a more flexible situation. When presented with a different solution by Alex, Max questioned his way of thinking. He did not accept Alex's solution on the base of popularity (as Joshua, Ahmad and Tyler did); he admitted it looked better (albeit, still not completely sure). His attitude changed even further when activities became less rigid. Max suggested the use of the Internet for his Favourite Sport Investigation and his report suggested that his research was thorough and well thought out, bringing in many factors outside the school. Max loved basketball and skateboard and that investigation was more relevant to him and he could have designed it in any way. I believe that the total absence of a correct solution gave him confidence to investigate freely. Max felt free to express his creativity.

While working with Negative numbers, Max completed his worksheet and understood ideas presented by Kyle, James and Harry. However, he still demanded an answer from me. It suggests that Max did not believe that the knowledge could be created by people; it exists in a hard, non-tangible form and only could be transferred as such.

Second term. When finding percentage mentally, Max acknowledges the cleverness of his friend's solution. I think that what it represents is a small step towards acceptance of the uncertainty of mathematics; he recognised that his friend thought and created a solution. In the story when we discussed the percentage question, Max asked me to explain the questions, and disapproved of the teaching strategy where I asked them to think first before the explanation. It reflects his view that mathematics could be transmitted through explanations. On one occasion he was worried about changing the question to make it easier to solve. In the same lesson he admitted preferring formula to other methods. It indicates his stance about the rigidness of mathematics; the concepts are precise and exact. Max experienced mathematics in an inflexible way; his behaviour in the class suggests that he believed that mathematics was learnt through the rules. In his eyes I already had access to the right knowledge which I should pass onto them.

At the end of year, Max commented that he liked negotiation and debates. He appeared to appreciate such situations for the learning factor, i.e. talking to others was beneficial for him as he could learn from other students. While he said that he liked knowing what a right solution was, he appeared to acknowledge the uncertainty of mathematics by saying that there were many correct answers. Further, he displayed the belief that mathematics is the product of many cultures because people could not agree on one right way. However, in the end he concludes that these days everything in mathematics is certain because of technological developments.

Critical voice

First term. Max felt that he could express his opinion about the teaching and learning strategies used in the classroom. On more than one occasion he brought up the issue that I 'did not teach them' something. In his journal he wrote that he would prefer it if I taught them, rather than telling them to discuss and think, and that I did not teach them in the right way. At all times he was polite and patient while listening to my justification of the chosen activities and strategies.

Second term. In the comments at the end of year Max said that he felt free to tell me anything. Many times Max raised his concerns with me that my teaching methods were not right, and that I should first explain the concepts and then enquire about their opinion. I do not think it was in his nature to complain, and he would not want to be seen as such. All his objections (and there were many of them) were brought up in a polite manner. Possibly he realised that I wanted to make the most of his criticism and sharing of his feeling of dissatisfaction and frustration with me.

Shared control

First Term. Max craved to be given a procedure for solving problems. He was always worried that he was wrong and felt insecure when trying to solve problems without specific guidance.

He did not like deciding what work to do; he wanted to be instructed by me all the time. He did not even value other students' opinions so much as they could be wrong as he assumed that others wanted first to be told how to solve problems. He preferred me to explain the question over anyone else in the class. I was the teacher and the one with the knowledge. Even choosing homework was a difficult task for him; he preferred doing all questions over making a decision which work should be completed. His only suggestion regarding classwork was a more frequent usage of the computers. He believed that I should prescribe the work for them which would allow him to properly fulfil his job. It could be that such work in the past would deliver results.

Second term. It could be noted that Max was not happy with all teaching methods applied in the classroom, especially the ones that promoted individual problem solving and thinking (percentage two lessons). He thought that I should explicitly teach him. To a great extent it indicates his unwillingness to work independently and lack of shared control. On the other hand, he always asked for help and wanted to clarify any misunderstandings, which means that, despite the lack of belief in his own problem solving skills he did not want the problem to stay unsolved; he took the necessary steps towards making things clear.

At the end of year he remarked that he preferred to think about the question rather than have a ready method. It is in conflict to his preferred teaching style during the year. He acknowledged

our difference during the year and commented that he changed and wanted to embrace problem solving approaches.

Student Negotiation

First Term. Max's participation was good. He was expressing himself freely, despite not knowing if his answer was correct or not. He worked well within his small group and the class as well, participated in the discussions with enthusiasm, and interestingly was not worried about how to express himself, which is in contradiction with his written work. It suggests almost that he did not value class discussion as a form of learning. In the class he argued, respected other students' opinions and was willing to accept defeat. However, he was not so flexible in his written work; he preferred being given an answer to experimenting and trying. It was like mathematics was not properly done through arguments and debates, so he was not afraid to give it a try.

Second term. The episode about percentages showed Max's willingness to solve problems through negotiation. Max had always enjoyed debates and discussion; however, he always insisted that I should be explaining the concepts. That time he approached the discussions expecting to learn something. The story about π indicated that he enjoyed group work and that such situations were fruitful for him. Not only was he an eager participator in all discussions, but he actually gave serious thought to the other students' solutions.

At the end of year Max commented that he appreciated talking to his friends about mathematical problems because it gave him an opportunity to hear other people's views, and learn more. He said that he was not used to teaching strategies where he needed to think and talk to people, but thought that he had changed, and it was the right way for him. From my observations it was not how I perceived him. The classroom stories describe Max as a student who regarded me as the one with the relevant knowledge, and hence with more power in the classroom. He preferred my clarification over someone else's. At the end of year Max appeared to accept negotiation and hearing others' opinions as a way to learn mathematics.

Conflicting data

Many of Max's end-of-year comments were in contradiction with his actions during the year. For example, he appeared to appreciate discussions and hearing others' opinions as a valid way to learn mathematics; however, during the year he explicitly indicated that he valued my explanation most. While Max started accepting negotiation as an effective way to learn, it was not an easy road for him. Additionally, at the end of year, he pointed out that he preferred to think about a problem as opposed to having a technique to apply.

The end-of-year comments were taken from the interview and used in their exact form. While many will argue that they had a greater validity, I would not necessarily agree. I think Max wanted to please me and come across as a polite student (which he was all the time). Exams were over, his marks were good, and possibly at that stage it did not matter to him, if we agreed or not about the teaching methods. At no point Max was ever rude, and that was how he wanted me to view him in such a light. Max wanted to leave in good terms and was trying to portray me as a 'good teacher' and my teaching strategies as 'excellent'. I think Max in some cases possibly tried to predict what I would like to hear and formed his answers accordingly. Perhaps, he did not want to be seen as insolent, and tried to represent everything, including himself, in a nice way.

6.3 Discussion

The second question attempted to find out what the students' responses were to the constructivist learning environment. In this section I re-examine the analysis of students' responses, and explain and discuss any surfacing patterns.

Personal relevance

The analysis suggests that personal relevance was appropriated to different degrees in different ways. It appears that different students found different aspect of the classroom personally relevant. On one side of the spectrum, was Max who enjoyed problems resembling real life and showed initiative and excitement in such situations. For Adil, mathematics was an important part of his life and he thought that mathematics concepts needed to be personally constructed.

He acknowledged that mathematics had its application in the world outside the classroom, but did not show excitement for such activities; his passion was with the logical side of mathematics. On the other side of the spectrum was Nazir who believed that mathematics does not have an application side; its purpose was defined by exams. Even though he did not acknowledge the real world examples in the classroom, he enjoyed them. Additionally, Nazir demonstrated enjoyment while constructing his own personal meaning of mathematical concepts.

My understanding of this scale did not include only the outside the school examples and it seems that this aspect of the constructivist classroom was embraced in line with my interpretation. It appears only natural to expect that specific mathematical activities will have different meanings to different students (and different teachers), and I think it would be unrealistic to expect a uniform response. Students finding different aspect of classroom to be personally relevant and placing different importance on different tasks, is not a problematic matter. It could provide an opportunity to expose students to different sides of mathematics and possibly open up their views about it.

Uncertainty

The analysis illustrates that the foci students maintained their absolutist view of mathematics. Adil believed in the precision of methods and that mathematics can always be described using rules and patterns. He firmly stood by his view that mathematics was certain and out there, waiting to be realised. Nazir thought that mathematics was a certain subject that should not be questioned; it was the problem of his ability to understand it or not. Max's actions suggest that for him, mathematics is a hard, intangible entity which was transferable through explicit instructions. This absolutist view of mathematics may have its roots in students' cultural beliefs. Traditionally, in Arab culture, knowledge has been passed on through generations by means of memorisation and oral transmission. It is accepted as absolute and the emphasis is on the precision and accuracy of the information. The story about the nature of mathematics gives an insight into the students' epistemological premises, and their desires to bring together some conflicting views.

On the other hand, students appeared to develop somehow an opposing view that mathematics was a debatable subject. While Adil and Nazir commented that mathematics was more open to debates and arguments than other subjects, Max acknowledged the difference in opinions and

developed an appreciation for others' constructions as an opportunity to learn. In our classroom a heavy emphasis was on creating personal constructs, and discussions as a way of creating socially acknowledged meanings. The acceptance of mathematical concepts for the classroom use was preceded by negotiations which reflected what is happening in a wider mathematical community. Perhaps these strategies contributed to the formation of the students' view of mathematics as a debatable matter.

Although, students firmly stood by their absolutist views, it did not seem to have a negative effect on their mathematical appropriation in the class. They adopted the ideas of questioning mathematics in their own terms in different ways, without contradicting their cultural views.

Critical voice

The analysis shows that many students did not raise their critical voice. Adil did not appropriate this aspect of the constructivist classroom at all, while Nazir gently in a casual way said that our classroom was noisy (as an unacceptable feature of the classroom). However, he immediately tried to justify it. Max was one of very few students who expressed his negative views about teaching strategies; although, based on his end-of-year comments, he did not want to be perceived like that. At the end of year he claimed that he had realised how the mathematics classroom was beneficial for him, and that he was not right to criticise teaching strategies.

In the first research question, students' responses indicated that this aspect of the environment was reasonably well implemented so their reluctance to raise their critical voice cannot be contributed to the lack of the opportunities. Possibly, critical voice responses were low as it was unlikely that this aspect of the constructivist classroom was exercised significantly in their other classrooms, so students were generally unfamiliar with it. Another reason for their reluctance to freely communicate their opinions about teaching and learning could be of a cultural nature. Patriarchal systems are still in place in the Arab world. Loyalty to family is very important to Arab people and one's identity is shaped by it. Traditionally, people are expected to respect elders, including teachers, and raising the voice is seen as an impolite act that not only contributes to the destruction of harmony, but bringing shame on the family. Adil and Nazir both commented that they should not raise their voice about anything and just get on. While Max raised his critical voice, in the end he put blame on himself.

Shared control

It appears that different students appropriated shared control to various degrees. Contrary to his belief that I should be in charge of his learning, in my opinion, Adil embraced this aspect of the environment to a great extent and was happily choosing topics and problems to explore. Nazir limited himself to choosing the activities that could contribute to his academic success and a positive outcome of the exams. Both students showed dedication to independent thinking. Max appropriated shared control to what I perceive as a small extent; he needed clarification for the problems he could not understand and asked for it. He preferred my guidance to independent problem solving. It seems that their responses were based on their (perceived) mathematical needs; Adil desired to know and explore mathematics, Nazir wanted to pass his exams, while Max sought to learn 'correct' mathematics. Undeniably, this aspect of the constructivist classroom is difficult and it is not likely that they experienced it significantly in other classrooms. Culturally, teachers are trusted as they are supposed to communicate absolute and true knowledge and, consequently, there is no need to exercise shared control. Accordingly, this aspect of the environment may be perceived more demanding on students than say negotiation. The analysis of the first research question suggests that the extent of shared control was limited by me as I was more likely to let better learners of mathematics take control over their learning, especially with regard to the choice of topics.

Negotiation

It seems that the majority of students enjoyed negotiations. A likely explanation for the success of the negotiation aspect of the learning environment was that students possibly experienced it in other subjects and they were familiar with it. During the year, many students took part in the debating extracurricular activity. Therefore, students may have perceived this characteristic of the environment easier to adopt than other CLES aspects. Brooks and Brooks (1993) argue that having an opportunity to hear the ideas of others and to present one's owns ideas is an empowering experience. Students generally have a desire to be heard and stand up for their opinion.

6.4 Summary of the chapter

In this chapter the second Research Question was answered. Only qualitative data were used for this question. On the basis of the analysis of the second Research Question, personal relevance had a different meaning for different students. Uncertainty appears to be appropriated in contradictory ways. The students continued to hold onto their understanding of mathematics as an absolute matter; however, they developed an opinion that it was a debatable subject. Students raised their critical voice to various levels; however, their perception was that their right to that was limited. Shared control was embraced to different extents, depending on their perceived mathematical needs. Given an opportunity, the students enjoyed active interactions and negotiations.

Chapter 7: Research Question Three, Results and Findings: How Culturally Appropriate was the Constructivist Learning Environment in an Arabic Boys' Classroom?

7.1 Introduction

Culturally relevant teaching and constructivist strategies need to be adapted to the students of a particular classroom. Further, from the previous chapters it could be seen that one's interpretation of constructivism and its application in the classroom is highly subjective. My understanding of the constructivist theory and the way I employed it in my classroom is probably different to other teachers. I cannot generalise the research question and talk about applicability of constructivism in an Arabic context. While, there are characteristics of my teaching and learning that are similar to other teachers' practices, I can talk only about the cultural appropriateness of the constructivist learning environment (as I understood it) in my Year 7 boys Mathematics classroom. In my analysis I reflect on the first and second Research Questions, and try to recognize some cultural effects.

Examination of the third Research Question has the following format:

- First, I look at a big picture and I explore how constructivism theoretically may be in conflict or agreement with some Arabic cultural outlooks.

- Next, I focus on my practice, and describe how the constructivist learning environment that I created in my classroom addressed the elements of culturally relevant teaching. The components of the culturally appropriate pedagogy - reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice, and classroom practices - were identified within my practice using the framework as described in the literature review. The problems that I faced, that were grounded in my insufficient understanding of some aspects of the Arab culture, were addressed as well.

- At the end, I discuss the cultural appropriateness of constructivism in an Arabic mathematics classroom in terms of the difficulties I faced in my classroom.

7.2 Exploring the conflicts and agreements between constructivism and Arabic cultural aspects

Culturally, Arab children are unlikely to oppose their family members or the elders, as it would be seen as an impolite and shameful act, and some students' actions within the classroom appear to be affected with this outlook. The cross-examination of the results and the discussion for the three research questions shows that this cultural aspect may have affected some aspects of the study. The breakdown of the critical voice scale of the CLES showed that while students thought to a great extent that they were able to express their opinion in the classroom, the score for the statement that the mathematical explanation was confusing was considerably lower. Possible explanation lays in the wording of this specific item as it could question her ability to teach; complaining about your teacher may be seen as a sign of disrespect towards her. Students only sporadically expressed any kind of dissatisfaction with the learning environment. Raising critical voice, as seen on examples of Adil and Nazir, is not an aspect that will be easily embraced as it may not be appropriate in the Arabic cultural and social context. Max expressed his opinion about the classroom but he did not want to be seen in such a light. He wanted his behaviour not to be shared with his father. In the end he claimed that expressing his opinion was wrong and happened before he was mathematically mature. For Arabs, saving their face is very important aspect of their lives.

In a constructivist learning environment, students of Arabic origin may feel uncomfortable with the notion of creating knowledge by themselves especially for mathematics, which is traditionally seen as a subject with certainty. Traditionally, Arab people tend to trust their elders and are unlikely to try to create their individual opinion and oppose their family or the leaders. The analysis of students' responses to the constructivist environment suggests that their reaction was possibly hindered by their cultural beliefs. In my class a couple of students expressed opinion that my explanations are of a greater validity than those of other students', and desire to hear an explanation primarily from me. The Arabic societies with their collectivist view and a high power distance index are expected to adopt traditional teaching styles (Najm, 2015). As the culture has been heavily influenced by Islam and the Qur'an, students may favour the memorisation method. Learning through debates and arguments is a contradiction to traditional ways of memorising facts. Through the year, despite their engagement and enjoyments of such events, some students expressed their disbelief that they could learn something through discussions with others, and called for an explicit explanation (Credit cards

are good, How did you think of that, Never heard of a teacher who first ask students to think, I know now what π is. It is more than 3.14.). It suggests that constructivist way of thinking and creating the meaning personally would not be natural for many.

On the other hand, some constructivist's characteristics could be in an agreement with Arabic culture. As mentioned elsewhere the Arab culture is highly collective and family and friends are of a great importance. Loyalty to the family and nation is very important and the priority is given to the group goals over personal achievements. Consequently, the students from the Arabic background may prefer cooperative problem solving approaches. For example, the stories document Max's support and loyalty to his friends (Credit cards are good). Generally, students worked successfully within their groups and supported each other (Thinking does not count, Football is the best, Display, I know now what π is. It is more than 3.14.).

7.3 Identifying the elements of culturally appropriate teaching within my constructivist learning environment

In the past, the implementation of the western curriculum assumed an acultural view of science and mathematics. The assumption was that science and mathematics learning is a consequence of logical thinking rather than understanding. Even the evaluation of learning in non-western countries used the western standards. Researchers judged the ability of non-westerners to comprehend concepts and evaluated their learning based on the Western standards. A fear existed that a successful education may alienate students from their culture (Musgrove, 1982, in Cobern, 1996). Non-western people may view (western) science as way of losing their own identity (with a reason), and consequently find it unacceptable. Constructivism assumes that non-western students will have different views of nature and science and mathematics, and focuses on the process of interpretation of the concepts (Cobern, 1996). Many researchers consider constructivist strategies to be a part of culturally relevant teaching as they recognise the value of various cultural views. In the USA, a study conducted during a course on multicultural education, involved teacher candidates researching and presenting a range of teaching strategies, including differentiated instruction. The findings suggest that in order to be effective, differentiated instruction has to be both culturally responsive and constructivist. It demonstrated how teacher candidates developed the skills needed to develop culturally

responsive and constructivist-differentiated lessons (Hamza & Hernandez de Hahn, 2012). Villegas and Lucas (2007) state that the conception about culturally responsive teaching is grounded in constructivist views of learning. Constructivist approaches give students opportunities to 'actively engage in learning and integrate new ideas into their own ways of thinking'. Students learn to 'think critically, become creative problem solvers, and develop skills to work collaboratively' (Villegas & Lucas, 2007, p. 30). Based on the literature review of culturally relevant teaching, these are the elements I should be able to identify in my practice (Gay, 2002; Villegas and Lucas, 2002):

- Reflective nature of teacher
- Respectful and caring environment
- Knowledge about the students
- Critical thinking and social justice
- Constructivist classroom practices

The ***reflective nature of the teacher*** is a part of the constructivist classroom. As I embraced constructivism and tried to implement it in my classroom, I started reflecting on my practice. At the beginning, my reflections were about mathematical concepts and specific instructional strategies and activities used in my classroom. Many times my new knowledge confirmed my former experiences and acted as a validation of the activities used in my classroom. The implementation of the constructivist way of teaching and learning required from me to reflect on the ways I was learning throughout my life. By reflecting on my own learning process across different subjects and motivational goals, I tried to understand the students' ways of learning and their actions in my classroom. I considered the challenges in my life and the ways I dealt with them. I found myself trying to resolve current problems by reflecting on the particular events from my life, which, suddenly were seen through different lenses. I needed to understand patterns in my thoughts and behaviour, in order to move forward, and understand my students. As I was growing as a teacher, a greater emphasis was placed on the hidden values within my classroom. My former thoughts were frequently tested and made me consider the norms which were taken for granted. The implementation of the constructivist approach required me to think about the myths within society and the school environment which affected my assumptions of others (including teachers and students). To implement constructivist approaches within her classroom, the teacher engages in the reflective practice of own learning and tries to promote such practices among her students.

A ***respectful and caring environment*** is one of the aspects of the constructivist classroom. The following steps were used in order to build relationships with the students: 'What makes me happy?' - task (p. 112), one-to-one time during breaks or after school, talking to students in the school yard and during the class, and taking part in the afterschool activities and events. Throughout group work, discussions and open-ended activities, student voices were heard in our class. By modelling respectful behaviour and insisting on everyone paying attention to others while speaking, caring and support for students was shown. This kind of encouragement and support improved students' self-esteem and helped their participation in the activities.

Students learnt to listen and respect others' opinion, and learnt from each other. Some teachers believe that constructivist approaches lack rigour, as constructivist teachers do not necessarily communicate basic facts to children using direct instructions. They see such knowledge more relevant than developing problem solving skills. Strategies such as investigations, problem solving activities and using students' experiences as a starting point are demanding for students. The expectation that the student constructed mathematical knowledge by themselves, as opposed to me telling them, was continuously communicated to the students. A setting with high expectations is one of the main characteristics of a caring environment. By acknowledging students' prior ideas and knowledge, and allowing their responses to drive the lesson, the students recognise themselves within the classroom, and are given ownership of their learning. Further, constructivist strategies promote critical thinking and higher order thinking. Accordingly, students are encouraged to actively create their knowledge and search for ways to integrate it into their previous experiences; they are not perceived as passive learners. By reflecting on their ideas, pupils continuously build their knowledge.

The ***knowledge about the students*** and the connection between their school work and their out of school life are one of main focuses of constructivists approach. Within our classroom activities related to the students' real life experience and interests provided appropriate connections with their prior knowledge and mathematical content. Social constructivism proposes that home and school lives are just two of the students' subcultures. Students will perform better academically if the classroom is similar to their everyday life. However, if the students' home culture is significantly different from the classroom, they may become disengaged from the classroom practices and the transition from home to school culture will not be smooth. Aikenhead (1996) suggests in that case the teacher needs to identify and cross

cultural borders in order to optimise the learning situation. In my opinion, students' culture and previous experiences and personal relevance have a wide interpretation. There are many aspects of the students' culture and background that could be utilised within the constructivist teaching and learning environment. Arabic culture is a great source of the relevant ideas that could be used in a mathematics classroom. After learning about the language difficulties of my students we considered appropriate ways of presenting mathematical ideas, and the language mathematicians use to express themselves. Our lessons focused on organising ideas as well as the subject matter. Arab culture contributed to many areas in mathematics which helped create the lessons. Using a variety of strategies I enquired about the students' interests that could be used in the classroom.

However, my knowledge about the students did not always produce a culturally appropriate classroom as I failed to take into account some culturally relevant knowledge about students' preferred teaching and learning styles. My teaching and learning did not take into account Islamic epistemological premises while approaching the lesson planning. For Muslims, knowledge is truth. It suggests an absolutist attitude towards understanding of the world, which was to a great extent observed among my students. Traditionally, preferred teaching and learning strategies were the oral transmission of knowledge and memorisation. My primary concern was the construction of their mathematical knowledge, and I considered students' previous experiences which were mainly with regard to it. I believe I successfully sought their understanding of prior understanding of the concepts; however, I did not consider to the same extent their previous experience regarding teaching styles and strategies. For example, I was aware that some students were experiencing discomfort with the teaching activities that I used possibly because of their preference for traditional learning styles of lecturing and an explicit explanation of the concept. It was reflecting their previous mathematics practices. Still, the classroom stories demonstrate that I partially disregarded their previous experiences and did not slow down with the implementation of the constructivist strategies. While I was applying my constructivist ideas to the learning of mathematics concepts, and was starting with the familiar examples; I did not apply the same ideas with regard to the preferred learning styles and delivery of the curriculum, and did not start with familiar methods. When I reread the classroom stories it appears that (some) students were abruptly pushed into the new learning environment. Further, it seems that I did not consider fully their status of English as second language learners. I always thought that my students were 'regular' second language learners,

like me. My assumption was that they were generally fluent in their first language and had various degrees of efficiency in English. Halfway throughout the study I realised the difficulties faced by my students when learning in English; they did not rely on Arabic at all. In many aspects, the students were probably more efficient in English than Arabic. The strategies would be more inclusive and suited to their needs if I had realised the extent of their comprehension of Arabic language.

Critical thinking and social justice are addressed by the critical aspect of constructivism. A constructivist teacher is in a position to challenge the myths of hard control and cold reason within her classroom, and uncover the technical nature of curriculum and assessments (Taylor, 1996). Mathematics is often seen as a culture-free construct and under such disguise promotes western way of teaching and learning. Constructivism acknowledges that mathematics has diverse meanings in different parts of the world and recognises the involvement of various cultural groups in creating it. The teacher's role is to build cultural bridges between classroom and home culture to help students learn and accept multiple views of a concept. In our classroom students had a chance to express concern for their own learning and question my teaching strategies. Their voice helped them deconstruct (I hope at least partially) the belief that mathematics is a set of rules that needs to be taught in a certain way. They had the chance to see mathematics as the construct of many cultures where no culture and opinion is more superior to others. Their voice helped them realise that the teacher is not the controller of the classroom and their learning. In our classroom I tried to include issues from the community (for example, fast driving), that could empower students to think critically. These activities helped the students develop their social awareness and helped them experience mathematics as a component in solving real life problems.

On the other hand, the classroom stories reveal that I experienced some difficulties implementing this facet of the culturally relevant teaching. It could be noticed from the stories that I approached the implementation of the constructivist learning environment as a correct thing to do. In my mind I did not have any doubts that I was doing the right thing. I was hoping that students would adapt to my 'right way of thinking' and eventually embrace the way I was teaching. I even did not notice that attitude of mine back then. Rereading the stories a number of times prompted me to remember my arrogance. Despite my belief I did not start my research with already being equipped with all necessary knowledge about the critical thinking. My

learning occurred during and after my fieldwork was over; I really was not right to contradict and disapprove of the students' approaches to teaching and learning.

I experienced some difficulties with the implementation of some social concerns. I needed to confront some issues of awkwardness without being interpreted as racist and stereotypical. For example, while working in Qatar, I experienced strong disagreement with the way some foreign workers were treated. I was not even aware of the issue before I moved to this Middle Eastern country. As social justice is subjectively interpreted, one cannot assume that others have the same perception of it. My views needed to be changed and adapted to the new situation. Yet, I did not know how to do this. I tried to address some of the issues within my classroom but I felt it was on a small scale; I was struggling to create strategies which dealt with the empowerment of minorities, as the activities previously used in my classroom, proved to be unsuccessful.

Constructivist classroom practices are culturally relevant. Ideally, curriculum within the constructivist classroom should be flexible and dynamic and able to accommodate the students' needs. Constructivist approaches adopt the view that values and culture are important aspects of society, and no value or culture is more superior or correct than others. While the formal curriculum may not be culture friendly, a constructivist teacher should be able to integrate students' background and interests to make it more stimulating. In my classes I tried to choose activities which were related to the students' background and interests. We talked about Arabic influence in mathematics and they had an opportunity to investigate various mathematicians and topics contributed by the Arab world. Examples included the Arabic number system, geometry and Islamic art, and algebraic examples. For example, the word algebra comes from the Arabic word 'al-jabar' and Arab mathematicians were the first to introduce symbols within algebra. The display board had mathematical terminology in the Arabic language, the posters of mathematicians from around the world and a newspaper display included examples from sport and finance current issues. Constructivist strategies of building on prior knowledge, using examples relevant to students and actively engaging in creating knowledge are strategies important in the culturally appropriate classroom. Strategies that provide students with the opportunities to debate and question their own beliefs, and listen to the opinions of others are beneficial in a culturally diverse classroom as the students become actively engaged in their learning and aware of differences in views and approaches. In the classroom we strove to understand why procedures work and tried to explain mathematical concepts in a variety of

ways. By including students' background and culture, a constructivist teacher makes classroom work relevant to students and gives them an opportunity to feel successful. Students' education, culture and experiences become relevant to them.

7.4 Discussion

The results suggest that constructivist learning environment as implemented in my classroom was culturally appropriate to a certain extent. Culturally relevant practices such as, the reflective nature of teacher, a respectful and caring environment, knowledge about the students, critical thinking and social justice and constructivist practices were recognised within the environment created in my classroom. However, constructivism as interpreted by me may be in conflict with some aspects of the Arab culture, and consequently, I faced some difficulties. I failed to include some important aspects of the students' background regarding their preferred teaching and learning styles, into my practices and to deal appropriately with some social, political and ethical issues.

Theoretically speaking it was not problematic, and it felt almost artificial to identify culturally relevant practices in my classroom and check them from the list. I believe that the issue here is not that of the suitability of constructivism in an Arabic classroom. A better defined focus should be on exploring the struggles I experienced to make (my) constructivism more culturally appropriate in my mathematics classroom.

Difficulty in identifying appropriate knowledge about students' background could be a reason for the struggle to make my constructivist teaching more culturally appropriate in the Arabic social and cultural context. In order to apply the constructivist strategies in my classroom and to make them culturally relevant, I needed to get to know the traditional and academic background of my students. My definition of constructivist strategies and appropriate background knowledge of my students may not be the same for other teachers. One lives within her cultural norms and very often accepts them without thinking; I cannot really step out from my experience and evaluate my behaviour.

There are two main aspects of the students' background which I did not take into account appropriately during the implementation of the constructivist learning environment. First, I

became aware of the language difficulties of my students during the study; I did not realise that they were not efficient in Arabic. Baker and Taylor (1995) suggest that the linguistic background of the learner and the similarity of learner's language with the language of science education affect learning. We were in Qatar, an Arabic speaking country, and nothing indicated that my students were not competent in Arabic. When I moved to Australia I experienced the feelings of anxiety and discomfort in unknown situations, including the classroom where I struggled to communicate. I thought that my experience when I migrated to Australia would help my understanding of the Arab culture and the language difficulties faced by my students. I realised that only in the later stages of my study the extent of proficiency that my students had in their first language. Second, I thought my knowledge about Islam was relevant. I had never thought that my religion may have impacted on my academic side. However, religion had impacted on the education and academic development of my students. Baker and Taylor (1995) recommend considering carefully the cultural background of the learners and their traditional norms in a science classroom. I had been teaching in Qatar for four years prior to the research, and was prompted to learn more about Islam and its views of knowledge only after some responses from students during the research. It had never crossed my mind that knowledge may help me within the classroom; possibly, because the way my religion is integrated into my life is significantly different. Despite all my life experiences, I feel that my knowledge about my students and their culture was still superficial.

How do you define appropriate knowledge about the students? You can never have a complete picture about the students. I think it helped that I was from a 'different' cultural background as well and could relate to some challenges faced by the students. On the other hand, it could have obstructed me from gaining a more complete picture about the students; possibly, I was too arrogant in my belief that I had experienced it all, and knew what to do. And, what about other teachers who cannot relate to such experiences? Many teachers will understand culturally relevant teaching as cultural sensitivity or cultural respect. Was I just culturally respectful to a certain degree? As I said before, one cannot step out from one's own experience. Personal growth is a long process.

Further to this point, I found it problematic to explore ethical and social issues within a culture different than mine. How does one find the way to communicate complex social, political and ethical issues? Teaching in an ethnically diverse classroom faces increasingly complicated social, political and ethical issues (Brown, 2007). My thinking and planning came from the

social and family norms to which I was exposed during my life. Moral and ethical values are subjectively and culturally constructed; it is a difficult task to put aside your values and experience, understand the stance of others, and bring up some important social issues. The values of my host culture were different from my own and I struggled to address the problem of the empowerment of minorities in an adequate way.

To what extent I am morally accountable and which ethical values can be implemented in a culturally diverse classroom? What if my values are significantly different from the students' beliefs? I certainly do not have a right to oppose the students' traditional values, and possibly clash with their parents' role. In the past I happily invited parents to my classroom and took their ideas on board; however, I never thought that they would have a major problem with the structure and delivery of my lessons. Now, I am not sure about that.

7.5 Summary of the chapter

In this chapter the third Research Question was answered. Only qualitative data were used for this question. The analysis of the third Research Questions painted my classroom as culturally appropriate in many of its facets. However, I faced some difficulties mainly regarding social and ethical issues, and taking into account all relevant aspects of the students' culture regarding their preferred teaching styles.

Chapter 8: Summary, Implications and Limitations

8.1 Overview of the thesis

This study aimed to implement the constructivist learning environment in an Arabic boys' mathematics classroom, to evaluate the success of the implementation and the students' reaction to the environment, and to determine the appropriateness of the environment in an Arabic socio-cultural context.

Chapter 1 provides the overview of the research. Theoretical framework, background of the problem, the purpose of the study and research questions are presented.

Chapter 2 presents my interpretation of the literature relevant to the implementation of the constructivist learning environment in an Arabic classroom.

Constructivism has become one of the most influential forces in mathematics and sciences education over last four decades (Alsharif, 2014; Fosnot, 1989; Malone & Taylor, 1993) and this research gave me an opportunity to enhance my understanding of constructivist theory and its application in teaching and learning. The forms which influenced the study are radical constructivism, social constructivism and critical constructivism. Constructivism promotes that a cognising subject is taking an active role in the process of learning rather than being a passive recipient of knowledge, and focuses on the way in which learners construct viable and useful information (von Glasersfeld, 1995; Noddings, 1990; Treagust, Duit & Fraser, 1996). Despite the learners creating their own meaning of new experience, the process is affected by the social setting of which the learners are a part. In order for (mathematics) education to benefit from constructivist theory, a moral framework is created to deal with the existing myths of rationalism and objectivism that support already established systems and authority, and promote mathematical knowledge as absolute and untouchable (Taylor & Williams, 1993; Kincheloe, 2008).

The pedagogical implications following from the three facets of constructivism are nature of knowledge, reflexivity of the teaching, learning approaches that promote conceptions of knowledge, and the social construction of knowledge (Ernest, 1995). Characteristics of constructivist strategies include: taking students' former knowledge into account, maximising social interactions, providing a variety of sensory experiences, small group learning, interactive discussions, problem centred work and an opportunity to ask questions, evaluate arguments

and reflect on their knowledge (Malone & Taylor, 1993). Learning is affected not only by a student's cognitive skills, but by his or her beliefs, ideas and conceptions of knowledge. Teachers' beliefs and personal values play a central role along with the teachers' knowledge of subject matter. There is an emphasis on the process of learning rather than the final answer.

Along with constructivism and its practical implications, Chapter 2 discusses some characteristics of the Arabic culture that could have affected my students and their learning. The majority of the Arabs are Muslims and for them Islam represents a regulation for various aspects of their lives. For Muslims, the main source of knowledge is the Qur'an and it represents truth. Arab culture is collectivist, where the needs of a group or tribe are prioritised over the needs of individual's loyalty to nation, the family integrity and prevention of shame are prerogative. Diglossic nature of Arabic language and the recent boom in the use of English as an instructional language in many schools resulted in many people not being fluent in their mother language. These traits were present to various degrees among students (Qatari and foreign) within our school.

Chapter 2 offers my personal understanding of the aspects culturally relevant pedagogy: reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice and classroom practices. Culturally responsive teaching considers students' cultural background, their values, past experiences, learning styles and ways of communication, to create a caring and appropriate learning environment. A culturally responsive teacher goes through process of self-reflection and examines her own, and others' background, values and beliefs. She cares about her students and expects excellence from them. Appropriate strategies deal with the issues of poverty problems, gender, social justice and freedom, which traditionally were ignored from the fear of stereotyping. In a culturally responsive classroom such issues and their effects in society are challenged and critically evaluated. The inclusion of diverse strategies and practices makes teaching and learning more interesting and stimulating, and provides an opportunity for all students to learn and understand perspectives of others. Applying constructivist strategies in a classroom allows children to think critically and develop problem solving skills. Ongoing and formative assessments such as observations, portfolios, diagnostics tests and students' self-evaluations are a part of the culturally relevant classroom.

Chapter 3 describes in detail why the interpretivist paradigm was my chosen paradigm. It supported the ways I wanted to collect and analyse my data and gave me freedom to capture and write about moments which shaped my impressions about the students. Even the quantitative data collected through the CLES were analysed using an interpretivist stance. In Chapter 3 I recall some events from my childhood that reflect the environment in which I was growing up. They depict my relationship with my family and the ways they shaped me as a person and teacher.

Classroom activities and curriculum organisation were guided by the scales of the Constructivist Learning Environment Survey: personal relevance, uncertainty, critical voice, shared control and student negotiation. The personal relevance scale was executed by employing strategies to explore their previous knowledge and using activities, which, in my opinion, were related to students and their interests. Questions including the Arabic culture were seen as examples of personal student relevance. Uncertainty was communicated by using mathematical examples, anecdotes and legends from around the world, and by demonstrating through my teaching that mathematics conceptions are created not transmitted. Some of the strategies used to promote shared control included: select your own problem, choose three options before asking me for help, and create a question, given the answer. Critical voice was executed through students' encouragement to make meaningful suggestions and voicing my opinion about the myths of hard control present in schools and classrooms. Negotiation was promoted by encouraging interaction among students and using mind-bending questions in my teaching.

The research combined qualitative and quantitative methods. The quantitative data were collected through the CLES and descriptive statistics was used to analyse students' responses from the survey. The qualitative data were obtained from the observations, students' and my personal journals, mathematical and non-mathematical tasks and interviews, and presented through the stories. The stories were analysed for the CLES scales using interpretative means. Students' involvement in the class, the effectiveness of teaching methods and the appropriateness of the teaching strategies in an Arabic cultural context were evaluated.

The class was observed for one teaching year and three students from the class: Adil, Nazir and Max were chosen for a close-up observation. Main reason for that was that in practice I could not conduct an inclusive analysis of the entire class. Apart from Adil, whose mathematical

behaviour reminded me of my own at that age, other students were chosen randomly. The classroom observation provided me with an opportunity to create the explanations of the happenings in the context of the natural classroom life and dynamic, not as an isolated event. After the initial excitement, students forgot my role as the researcher; I needed to remind them every time I needed some clarifications regarding their behaviour. These observations together with information from interviews and my reflections served as a basis for the classroom stories. I did not record every lesson, just the conversations and remarks that stroke me for some reason. Little comments that shaped my opinion about my students, and assigned them with characteristics I thought I saw in them. The legitimacy of my fieldwork was guided by the quality criteria of trustworthiness and the legitimacy of my story-like presentation was guided by verisimilitude and usefulness.

In Chapter 4 the classroom stories are presented. The stories give an insight of what was happening in my classroom and how participants reacted to changes.

Chapters 5, 6 and 7 provide results, analysis and discussion of the research questions. The success of my implementation of the constructivist learning environment is evaluated, the students' responses to the environment are analysed, and the cultural appropriateness of my classroom strategies is assessed.

Chapter 5 starts with descriptive statistics of the CLES. Detailed analysis and discussion of the Research Question One offers the interpretation of the CLES results, and focuses on the specific examples which refer to the execution of a particular scale. Additionally, individual CLES scores are analysed using interpretative means. In my discussion I am trying to identify the reasons for my success or failure to implement the CLES scales in my classroom.

In Chapter 6 the classroom stories were analysed for the data indicating the students' acceptance or resistance to the CLES scales. The examination is quite comprehensive; I scrutinise and interpret all presented students' responses and construct their reaction to the aspects of our constructivists learning environment - personal relevance, shared control, negotiation, critical voice and uncertainty. At the end of the chapter I cross-examine students' individual analysis and try to recognise any emerging patterns.

In Chapter 7 I analyse cultural appropriateness of constructivism in an Arabic context from two standpoints. First, I explore how some traits of Arabic culture may be in conflict with

constructivist ideas. Then, I analyse the learning environment in my class and try to identify the components of the culturally responsive teaching - reflective nature of the teacher, caring and positive environment, knowledge about the students, critical thinking and social justice, and classroom practices - within it. Through my reflections, the reasons behind my failure to accomplish some aspects of culturally responsive classroom are discussed.

This chapter presents the overview of the thesis, the summary of main findings and emerging propositions and implications, the limitation of the study, the recommendation for future studies and the significance of the results.

8.2 Summary of the findings

The first Research Question sought to evaluate the effectiveness of the implementation of the constructivist learning environment. On the basis of the analysis, it appears that the constructivist learning environment was reasonably well implemented, especially for negotiation and uncertainty scale. A critical voice was moderately to well implemented, while shared control and personal relevance were implemented weakly to moderately.

The second Research Question attempted to find out the students' responses to the constructivist learning environment. On the basis of this analysis, personal relevance had a different meaning for different students. In relation to the uncertainty aspect of the environment, the students held onto their absolutist view of mathematics. In addition, they formed somehow contradictory belief that mathematics was of a negotiable nature. They raised their critical voice to various levels; however, their perception was that their right to that was limited. The students embraced shared control to a different extent, depending on their perceived needs. Given an opportunity, the students enjoyed active interactions and negotiations.

The third Research Question sought to identify how culturally appropriate the constructivist learning environment was in an Arabic boys' classroom. On the basis of my analysis, the practice in my Year 7 class addressed the components of the culturally appropriate teaching to a certain degree; however, I experienced some problems in relation to social and ethical issues, and appropriating knowledge about my students' preferred teaching style.

8.3 Propositions following from the results and analysis

In this section I revisit the results, analysis and discussions of the three research questions, and try to develop a deeper understanding of the environment created in my classroom, and the responses of me and my students. As a result four propositions emerged. They represent the implicit research results not directly addressed by the research questions, but somehow woven in the analysis and discussion of the three Research Questions. I am not sure if the 'proposition' is an appropriate term I want to use in this situation. The term 'corollary' would possibly be a better defined term (A corollary is a proposition following from a proved proposition with a little or no additional proof). The discussion of the propositions has been already addressed in the analysis and discussion of the three Research Questions.

I do reiterate that these propositions developed as I attempted to explain and reflect on the events in my classroom; however, educators wishing to create a constructivist learning environment in their classrooms may find them applicable.

- *The creation of the constructivist learning environment is feasible in an Arabic boys' mathematics classroom.*

The results, analysis and discussion of the three Research Questions show that the constructivist learning environment scale were put in place to a certain degree. The study presented the evidence that teaching practices can influence students' learning and view of mathematics. Students particularly embraced uncertainty and negotiation aspects of the learning experience.

- *Students in an Arabic boys' mathematics classroom are influenced by their cultural background to a certain degree.*

My interpretation of the events and subsequent discussion of the three Research Questions points out that the students' actions and responses may have been influenced by their background. Obviously, things are rapidly changing and many of my students had been educated in the western way most of their lives, and were exposed to various teaching styles. However, people still may not be willing to adopt the new and modern way of thinking because of its liberalism and opposition to the traditional ways. While students embraced some new ideas, they still found way to interpret them through their cultural outlook of the world.

- *The CLES could be used in an Arabic classroom to provide an acceptable description of the learning environment.*

The students' responses to the CLES (actual form) were in alignment with the classroom stories to a great extent for the personal relevance, uncertainty scale, shared control scale and negotiation scale, while the critical voice was supported to a smaller extent.

The wording of the CLES could be differently interpreted than intended. For example, the study on a trial of the revised Constructivist Learning Environment Survey (CLES) highlighted a problem associated with the interpretation of the use of negatively worded items (Taylor, Fraser, & White, 1994). Taylor et al. (1994) generated plausible explanations for anomalies by adopting an interpretative research framework. In this study, the discrepancy between different sources of data partially appears to be a consequence of the ways the language of the CLES may be interpreted. The statements, predominantly from the critical voice scale, that could be understood to represent students in a negative light had a significantly lower score than anticipated and an interpretative inquiry was used to account for the difference between the CLES and qualitative data.

- *(Non-Arab) teachers' cultural backgrounds and beliefs affect the operability of the constructivist learning environment in an Arabic boys' mathematics classroom.*

It is anticipated that teaching and learning is affected by the teachers' personal beliefs about the subject area and the ways it should be taught; the teachers cannot put aside their experiences and teach objectively. A number of studies showed that there is a significant relationship between teachers' beliefs and their practices (Stipek, Givvin, Salmon, & MacGyvers, 2001; Thompson, 1984). In this study my views of mathematics and mathematics teaching and learning influenced various aspects of the environment. Personal characteristics of teachers are an important part of the complexity in which their teaching is created; teachers are humans with personal characteristics and subject to a range of influences through the communities of which they are a part and these aspects of teachers' personality need to be considered in creating teaching and learning for benefits of their students (Jaworski, 2012). My experience of mathematics as a riddle which is to be challenged and solved influenced my lessons heavily. My cultural background affected the study as well. I felt that the relationship between students and me was one involving mutual respect and trust. Regardless, I still found it difficult to cross some cultural barriers and deal with some social and ethical issues in the classroom.

8.4 Implications

- ***Implications for (my) practice***

Constructivist strategies

Before I started my research I was mainly guided by radical constructivism probably because it accounted well for the ways I was learning mathematics. I did not need a greater proof than my own (successful) learning mathematics experience that it was an appropriate way to approach mathematics education. The research illustrated that the teaching strategies informed by my interpretation of various facets of constructivism, especially radical constructivism, influenced students' learning and produced an effective learning environment. As a result, the approaches described in this study will continue to be part of my practice.

However, the research taught me to adopt a more flexible way of looking at things. I used to think that a good lesson is one in which I make sure I do not tell students how the problem should be solved or why the procedures work. Frustration on the part of students (and me) was (more than) occasionally a part of my experience. Some of them frequently asked for explicit explanation and I had to find ways to make them attempt solving problems in a different way. I came to understand that mathematics has a different meaning for different learners. I learnt that it is ok if I have to provide a heavy guidance for some students. In order to optimise students' learning the teacher should start with familiar procedures and strategies and slowly move towards student centred activities. Depending on the learner's previous knowledge, motivation and metacognitive skills and even the teacher's personality, discovery learning can be either minimally guided or heavily supported by a teacher and everything in between depending on the needs of the students. From a constructivist perspective, it is about making an optimum decision based on teachers' subject and pedagogy knowledge and the students' needs (Taber, 2011). There will be students who will never take solving mathematical problems in a personal way. No change should be abrupt.

Culturally relevant teaching

The study helped me see culturally relevant education in all its complexity. Culture is not only something that influence one's actions, but something that a person wants to be influenced by.

Acknowledging and using cultural difference in classrooms is crucial for mathematics education. It is important to make students feel heard and respected, make them be a part of the classroom life and see relevance of mathematics to their culture. Mathematics needs to be learnt and experienced in students' own terms. We are all in this together. By considering students' beliefs and background we are able to create meaningful learning experiences and help them regard themselves as a valuable part of classroom (and society). It can have a positive impact on students' classroom experience, and help combat inequality in education and society. Any sensitive ethical and social issues need to be raised gently. My role is to empower my students to think critically, not to change their cultural outlooks.

The teacher needs to be careful not to stereotype. Some of the happenings in the classroom I interpreted through the cultural light; however, one needs to avoid generalisation about all students of different culture, in this case of an Arabic origin. The cultural characteristics and traits could be present to various degrees in different context and should not be assigned to individuals. Lessons need to incorporate social issues from the community in a gradual manner by providing an opportunity for learners to reassess their views, and reflect on their own understanding of society and stereotypes. It benefits the learning of mathematical concepts and helps that all students feel safe in the environment and are aware that they are able to raise their critical voice.

Shared Control

I am the one with greater mathematical knowledge and classroom experience, and one who is to intermediate between school demands and my students, and as such am responsible for many aspects of the learning environment. However, many aspects of the learning environment could be and should be negotiated, including topics, teaching strategies, activities, students' and my roles, ways of assessing students. The meaning of the CLES scales is another aspect of the classroom that should be negotiated. The study indicated that students (and me) had different interpretations of the CLES scales, especially of the personal relevance scale. Possibly that aspect of the environment should be discussed with the students and the definition and choice of what is a personally meaningful activity should be decided together. Sharing with students the rationale for the teaching and learning methods can create a cooperative learning environment, optimize the effect of the constructivist approaches, and promote shared control.

- ***Implications for the CLES***

The CLES offers an efficient, inexpensive and quick way to asses one or more aspects of a constructivist learning environment. It was designed in a Western context, and the research revealed some concerns over its use in the Arabic socio-cultural context with respect to the critical voice scale. I feel that in order to optimise its applicability in an Arabic classroom, the wording of the items that could be interpreted as describing a student in a negative light, should be altered. For example, instead of the item 'It's OK for me to complain about activities that are confusing', more appropriately phrased statements would be:

I can tell my teacher about activities that are confusing.

My teacher is happy to talk to me about activities which I find confusing.

Similarly, the item 'I ask other students to explain their ideas' could be replaced with:

I can ask other students to explain their ideas if I want to.

Another way to resolve this obstacle would be a clear description of all the individual items as agreed between students and the teacher. For example, each item could be defined by a list of relevant activities and strategies. As mentioned in the first implication, students and the teacher may have a different understanding of the personal relevance scale, and consequently, the items within this scale may not reflect students' (or teacher's) opinion what a personally relevant activity is. Therefore, along with the negotiation of the meaning of this scale, I would recommend the wording of the individual items to be negotiated and changed accordingly. A modified version of the CLES may produce a more optimal picture of the classroom. A study in the United Arab Emirates that investigated the effect of games in the college-level mathematics classes administrated separate English and the translated versions of the questionnaires. The researchers felt that questionnaires presented in both languages would increase reliability as the students' first language was Arabic but the language of instruction was English (Afari et al., 2013). Depending on the language proficiency of the learners, the adapted questionnaire could be presented in both languages, English and Arabic.

- ***Implications for teacher education***

Nature of mathematics

In the web of relationships involved in the teacher's ideology, Ernest (1991) sees the personal philosophy of mathematics as the most influential. If any teaching reform is to take place, beliefs about the nature and learning of mathematics are to change, and that requires teachers' increased reflection and autonomy (Ernest, 1991). Mathematics teacher education should include a course on the nature of mathematics. Majority of teachers consider mathematics as a bullet proof science with all procedures and formulas in place and are not concerned with the questions about mathematical nature. Many are not even familiar with the axiomatic nature of mathematics. Exposure to 'irregular' mathematics like non-Euclidean geometry may help change absolutist views. Additionally, the course should include the ways mathematics was created in various cultures. A possible strategy that can help considering the ways mathematics was created is to treat every different solution as a little 'discovery' in old fashioned sense, and to prompt teachers-learners to create new ways of solving it. New teachers, the same as our students, need to get an opportunity to create new problems to understand mathematics as a personal matter. It is not necessary for teachers to change their understandings of nature of mathematics; however, it is important to make them think about it, recognise their stance, consider other views and recognise its impact on mathematical education.

Culturally responsive education

A study conducted in the state of Victoria in Australia (Premier & Miller, 2010) reported that the majority of pre-service secondary teachers considered that their teacher education courses lacked a focus on cultural and language diversity in schools. Many teachers felt it was not a part of their responsibly, it was somehow the responsibility of ESL teachers. Despite an increasing number of students coming from a diverse background, many educators still did not know how to deal with related issues, starting with the language needs of the students. For example, at Curtin, it is possible to complete a Graduate Diploma in Education (*Curtin Courses Handbook*, 2017) without selecting any linguistic units. Through education, teachers should get an opportunity to become aware of the beliefs they bring to the classroom, to overcome stereotypes and prepare them to work with diverse students (van Houtte, 2011). Teachers'

education should accommodate courses not only about various cultures and societies, but on ethical, political and social questions that address (teaching) issues like racism and social inequality.

A number of studies demonstrate that many teachers believe that culturally relevant practices are of high importance in mathematics classroom education. Many teachers have a genuine desire to employ practices that are culturally appropriate; however, many of them misunderstand culturally relevant practices as culturally sensitive (Kelly-Jackson, 2008). Creating culturally relevant mathematics classroom is a complex process and may be at odds with one's stance on how mathematics should be taught and its nature (Leonard, Napp, & Adelke, 2009).

One way to implement professional development on culturally relevant practices is to see culturally relevant teaching in practice (Villegas & Lucas, 2002). Collaborating with the teachers from the community can help to better understand students' needs and their pattern of thoughts. It is crucial to have a deep understanding of students' background not only factual information, and such insight could be provided from someone who understands the community from within.

Somehow I think it is easier for teachers who have experienced their education as being of 'other' culture; they may have a better understanding of students' struggles and feeling of being alienated. Teachers' beliefs about multiculturalism are a result of their upbringing and personal experiences rather than their schooling and academic experience (Varian, 2008). One cannot just learn from the book or a traditional professional development course to learn about the importance of culturally relevant teaching. In order for all teachers to empathise and see the importance of including students' background and values in everyday practice, they should be placed in a situation where they are different ones. Teacher education courses should offer opportunities of working in a different country where the main language of instruction is not English. A person needs to experience a situation of not being able to rely on her mother language, to understand how it feels. Being placed in a situation in which your values are not regarded as a norm may help understand others' perspective.

Many mathematics teachers still see mathematics as a culture-free entity where colour blind approaches are seen as a fair way to go about education, not realising that in that way western

ways of thinking are being promoted. Teacher education courses should include research on diverse cultures and teachers could be asked to create and solve problems, and teach a topic by considering different values and norms. Further to this point, teachers need to accept themselves as learners and be prepared, to learn and grow with their students. They need to reflect on their practice, on their culture and assess carefully where their beliefs come from, and recognise that other cultures' thinking and understanding could be entirely different to their own. The changes need to come from within.

8.5 Limitations of the study

There are a number of limitations of this study that affected interpretation of the results. In this section I explain the nature of the limitations and the extent to which they affected the study, and try to justify the reasons why I conducted the study the way I did.

How do you define limitations of your study? There are supposed to be flaws of the thesis and aspects that I could not or omitted to control.

The first thing that could be characterised as a limitation is the particularity of the school, and the uniformity and a small size of the sample. It was a private, international school, with strict rules regarding the mixing of the different-gender students. With these features, the school is unlike other secondary schools say in Australia, and not an appropriate representative of the population of the schools. There were only 20 students in the class and all the students were boys with a high socio-economic background. I found all boys to be fairly well behaved.

In the case of this study, can a small sample be regarded as a limitation? What is a limitation from one perspective is not necessarily so from a different angle. A larger, more diverse and more representative sample, possibly including other schools would allow a greater generalizability. On the other hand, a larger sample would have prevented me to do a kind of research which I wanted to do. Perhaps, I would be still able to write the stories; however, their foci would be different, I would not be able to do a close-up investigation of Adil, Nazir and Max. Admittedly, I cannot help but find some patterns in my classroom. However, I am cautious to warn the reader that they are the patterns observed specifically in my classroom, and that their application in other educational settings should be carefully considered, depending on the needs of the participants and the researcher.

My role as the teacher and researcher in my own classroom could be regarded as a limitation. One can consider my dual role as source of bias which could affect the validity of the research. However, the nature of my research acknowledges my background and possible prejudices, and recognises their role in creating my interpretations. Being a teacher researcher allowed me to conduct a closer investigation and gain an inside view of my classroom. I let the reader know about my upbringing and predispositions to help him or her evaluate my interpretations. The reason I found my role problematic and limiting was of a technical nature; I could not record my observations as quickly and comprehensively as I wanted. The experience was very demanding as I had other responsibilities in my life, including teaching other classes.

I feel that a limitation of the study that could have been controlled by me is that the CLES (actual form) was administered only once, at the end of year. The distribution of the CLES (preferred form) at the beginning of the year would help getting to know the students and assist with the lesson preparation. Completing the same form at the end of year would provide me with another way of tracking down the changes in individual students, and help with my interpretations of the students' actions. However, I wanted to have a smooth start with my research class and that is the reason I avoided distribution of the CLES at the beginning of the year. At the start of the year the students had just entered secondary schooling, and I did not want to start with the survey which could have been experienced as tense and official. I was to spend a year with them and wanted to form a trusting relationship. Another explanation does not portray me in such a good light. I may have been arrogant in my belief that I was going to change the classroom for the better and consequently did not consider the need for checking students' opinion and their preferences regarding the aspects of the constructivist environment. The change in me regarding the power distribution in the classroom and the students' needs and inclination towards certain characteristics of the learning environment was shaped during the study.

Yet another limitation regarding the CLES was the accuracy of the information. The wording of some statements could present the students in a negative light and the corresponding responses may have been different than intended. In this study I tried to overcome this problem by explaining any unexpected and irregular results, in an interpretive manner. Rewording some statements to suit the socio-cultural Arabic context would help overcome this limitation. Additionally, personal relevance items could have been taken out of context as apart from one item, they do not explicitly refer to mathematics.

One of the limitations of the research was the timing of the analysis of my data, particularly the quantitative data. The interviews were planned independently on the CLES because of my personal circumstances, and the analysis of the survey took place much later than anticipated. Consequently, I was not able to receive the students' feedback regarding their survey responses. The feedback would possibly allow a more complex statistical analysis, and the students' explanations would help my interpretations.

A limitation of the study is the lack of the data presenting the students' cognitive development and their construction of the concepts. The limited number of stories captured to a small extent the students' reasoning and the ways they built their understanding; there is not much evidence and data of how the students went through the conceptual creation or the conceptual change. The stories were mainly concentrating on the students' reactions on the changes, as the original focus was not on the constructions of the concepts.

A limitation of the thesis could be my attempts to fit it with the well-established organisation of a conventional thesis: introduction, literature review, methodology, results and analysis, discussion and conclusion. The traditional structure of the thesis was used for scientific research, and I feel that it may not have been the most appropriate way for this thesis. Because of the nature of the research I found it difficult to separate the discussion from the rest of thesis, particularly from the results and analysis; for example, I was discussing and evaluating unexpected findings and conflicting explanations in my analysis. Perhaps my logical nature wanted to follow some prescribed steps and I needed to establish some order in my head. Well, I managed to assemble my thesis mostly according to the default structure; however, at what cost.

A major delay in bringing study to an end due to personal reasons and work commitments could be considered as a limitation. During this time I changed as person, and adopted an extra, parental perspective in my life, which influenced my interpretations and analysis.

8.6 Significance

This research is significant as there is not much research conducted on the appropriateness of the implementation of constructivist learning environment in mathematics classroom in Arabic countries (Afari, 2012). The study presented the evidence that the constructivist learning environment could be established in an Arabic classroom, and that teaching practices can influence students' learning and view about mathematics. The findings can make teachers aware of some Arabic cultural aspects that can affect teaching and learning, and identify strategies that can improve the classroom environment, and make constructivist approaches more culturally appropriate in a similar setting.

A contribution of the study is the suggestion of its possible modification to classroom environment surveys, particularly the CLES when assessing a classroom in an Arabic sociocultural setting.

Perhaps, a significance of this research is reflected in the way this study was presented. I tried to represent students' and my actions as I experienced them, together with all the weaknesses to show what is 'really' happening in the classroom and research. Others will read this thesis as it was told from my perspective, and hopefully come to understand teaching, research and the Arabic culture through different lenses. It can help teachers address issues in their classroom, become more reflective professionals and start transformation without the fear that they need to succeed in one particular way, or that outcome needs to be flawless.

8.7 Further research

The future studies could involve samples that represent a range of sociocultural groups of different ages in an Arabic context in order to complete a more comprehensive picture of Arabic learners and the ways they are affected by the culture. For example, a similar study could be conducted in a mathematics girls' Arabic classroom. Boys and girls are two different subcultures within the same milieu. It would be interesting to see if the aspects of Arabic culture have the same effect on the girls' learning.

The future researchers can conduct a similar study focusing on the students' cognitive development. It would be good to understand how students construct the meaning of concepts and whether it is affected by the Arabic socio-cultural context.

It would be beneficial to do a study of the effect of the education in English language at the expense of Arabic language and culture. Recently, there has been a severe decline in the use of Arabic language in the Middle East countries; although, Qatar's schools switched their main language of instruction from English to Arabic. Until recently the language of instruction for science and mathematics was English (Ellili-Cherif & Alkhateeb, 2015). Many schools in Arabic countries use English as instructional language and this may have possibly affected the students' cultural identity. While knowing English in today's world seems like a necessity, Arabic learners are not meant to forget their language and lose their identity.

The future research could include the effect of parenthood on teaching. I felt that becoming a parent changed me as a person and made me think about some issues related to education which I did not consider previously.

8.8 A final note

The greatest significance of this study is not only about improving my practice, but about my change as a person. At the beginning of the research in my role as teacher I primarily concentrated on students' cognitive skills and building mathematical concepts. I was mainly influenced by radical constructivism. This study helped me realise that I need to understand my students' cultural backgrounds. Patterns of thoughts are different for different cultures and the ways I see and interpret things are different for other societies. The study helped me to re-evaluate my principles and beliefs and become aware of the hidden expectations not only in the classroom that required students and me to behave in a certain way, but in my personal life. This study is a journey of my transformation as a person and a teacher.

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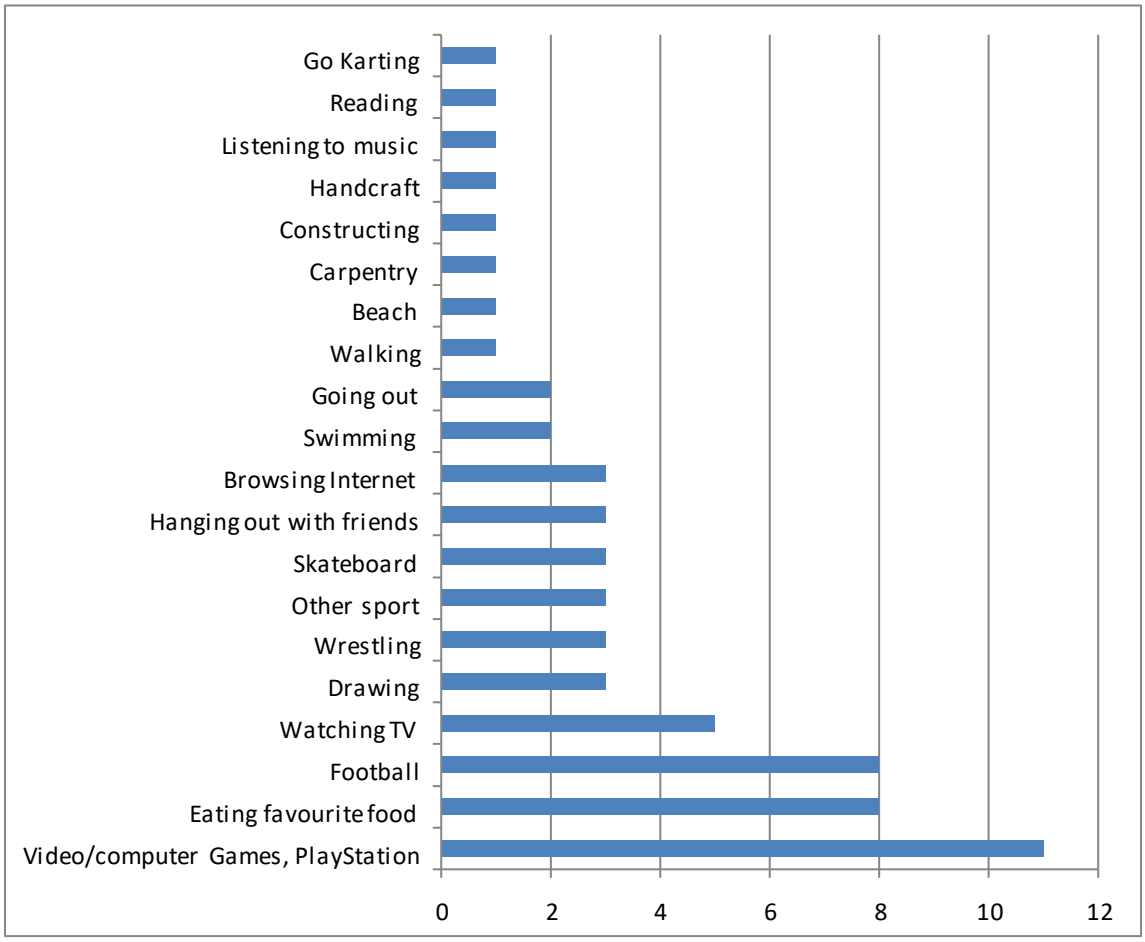
Appendices

List of appendices

Appendix 1: Students' interests

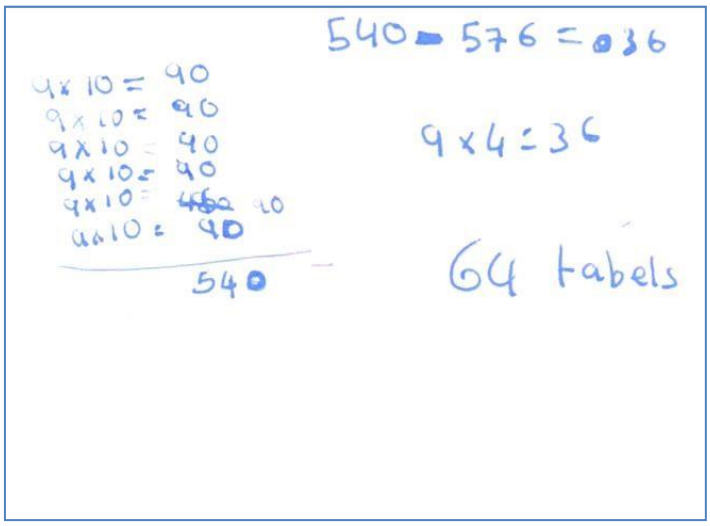
Appendix One includes a chart which represents students' interests in my class.

Table 3 ***Students' Interests in the class***

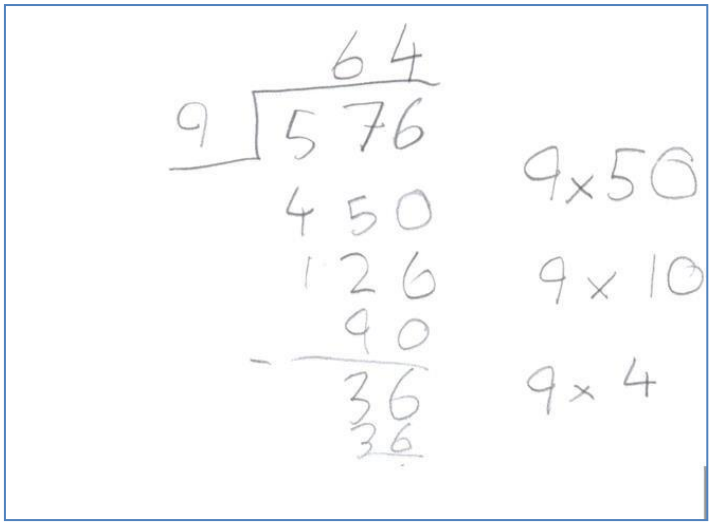


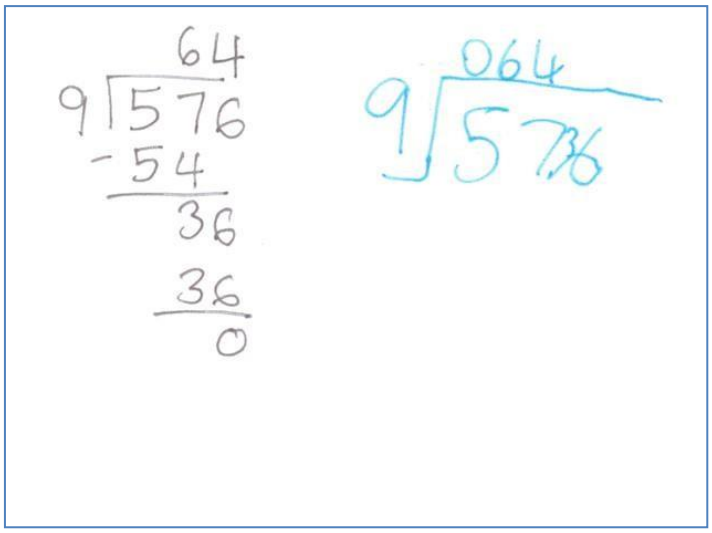
Appendix 2: Examples of PowerPoints slides

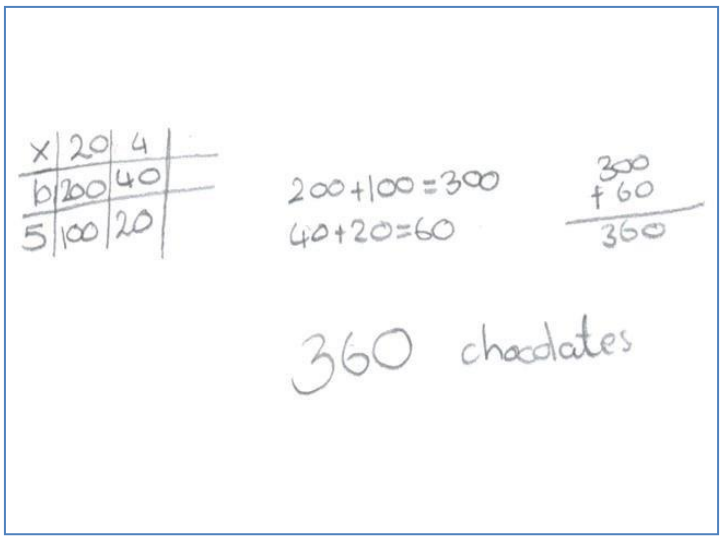
Appendix Two includes some examples of PowerPoint slides with students' work used to promote a discussion.



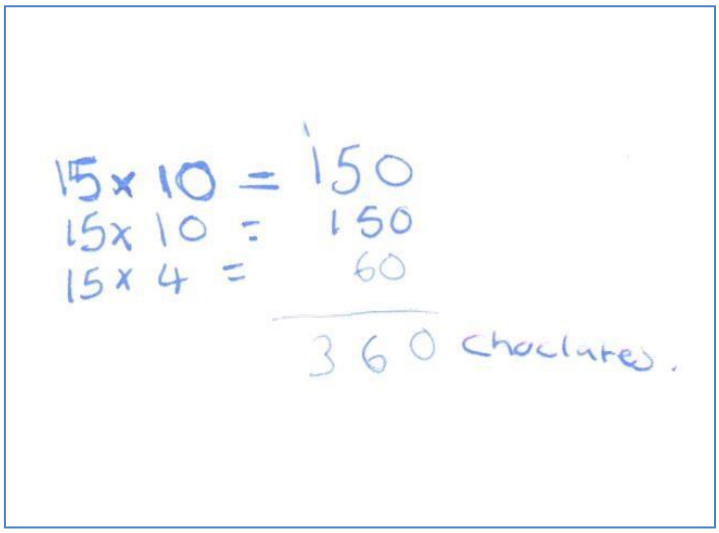
We discussed different ways of dividing numbers, and tried to identify reasons why some people would prefer each of the presented ways.

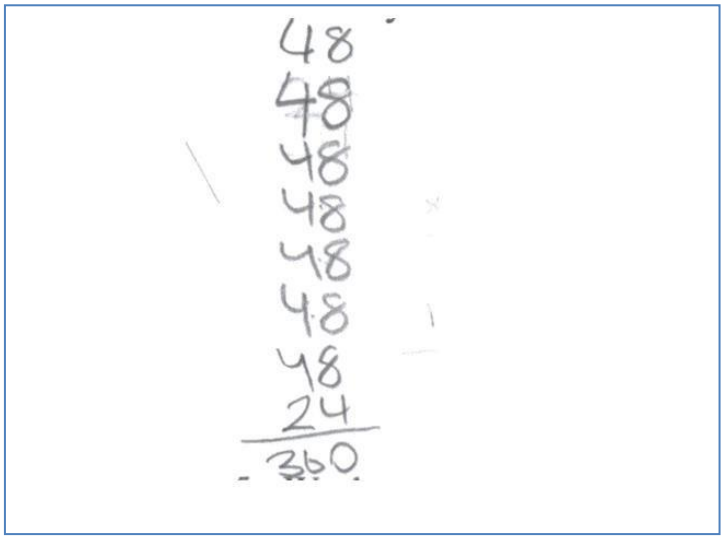


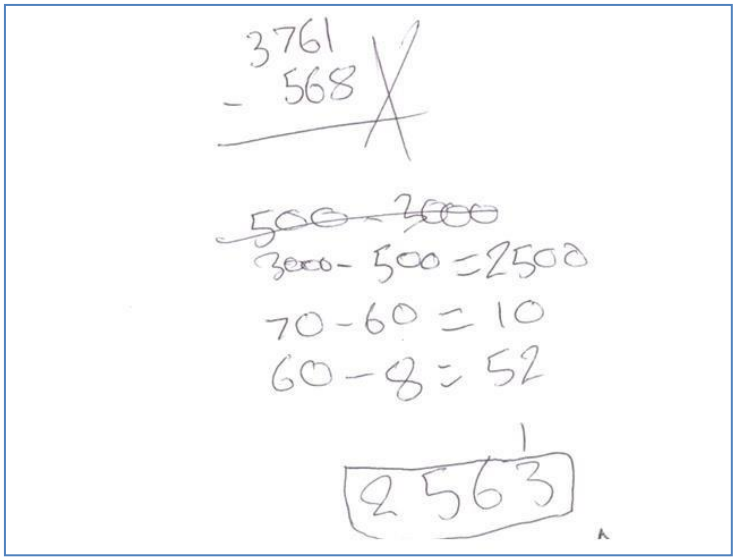




We discussed different ways of multiplying numbers, and tried to identify reasons why some people would prefer each of the presented ways.







We discussed what went wrong.

Appendix 3: The Constructivist Learning Environment Survey (CLES) Actual Form

The Constructivist Learning Environment Survey Actual Form

Name:_____

What happens in my mathematics classroom?

This questionnaire asks you to describe important aspects of the mathematics classroom which you are in right now.

There are not right or wrong answers. This is not a test and your answers will not affect your grade. Your opinion is what is wanted. Your answers will enable us to improve future mathematics classes.

Thank you very much for your kind assistance.

Learning about the world

In this class …	Almost never	Seldom	Sometimes	Often	Almost always
1. I learn about the world outside of school.	1	2	3	4	5
2. My new learning starts with problems about the world outside the school.	1	2	3	4	5
3. I learn how mathematics can be a part of my out-of-school life.	1	2	3	4	5
4. I get a better understanding of the world outside school.	1	2	3	4	5
5. I learn interesting things about the world outside of school.	1	2	3	4	5

Learning about mathematics

In this class …	Almost never	Seldom	Sometimes	Often	Almost always
1. I learn that mathematics has changed over time.	1	2	3	4	5
2. I learn that mathematics is influenced by people's values and opinions.	1	2	3	4	5
3. I learn about the different kind of mathematics used by people in other cultures.	1	2	3	4	5
4. I learn that modern mathematics is different from the mathematics of long ago.	1	2	3	4	5

5. I learn that mathematics involves inventing theories.	**1**	**2**	**3**	**4**	**5**

Learning to speak out

In this class …	**Almost never**	**Seldom**	**Sometimes**	**Often**	**Almost always**
1. It's OK for me to ask the teacher 'why do I have to learn this?'	**1**	**2**	**3**	**4**	**5**
2. It's OK for me to question the way I'm being taught.	**1**	**2**	**3**	**4**	**5**
3. It's OK for me to complain about activities that are confusing.	**1**	**2**	**3**	**4**	**5**
4. It's OK for me to complain about anything that stops me from learning.	**1**	**2**	**3**	**4**	**5**
5. It's OK for me to express my opinion.	**1**	**2**	**3**	**4**	**5**

Learning to learn

In this class …	**Almost never**	**Seldom**	**Sometimes**	**Often**	**Almost always**
1. I help the teacher to plan what I am going to learn.	**1**	**2**	**3**	**4**	**5**
2. I help the teacher decide how well I am learning.	**1**	**2**	**3**	**4**	**5**
3. I help the teacher to decide which activities are the best for me.	**1**	**2**	**3**	**4**	**5**
4. I help the teacher to decide how much time I spend on activities.	**1**	**2**	**3**	**4**	**5**
5. I help the teacher to decide which activities I do.	**1**	**2**	**3**	**4**	**5**

Learning to learn

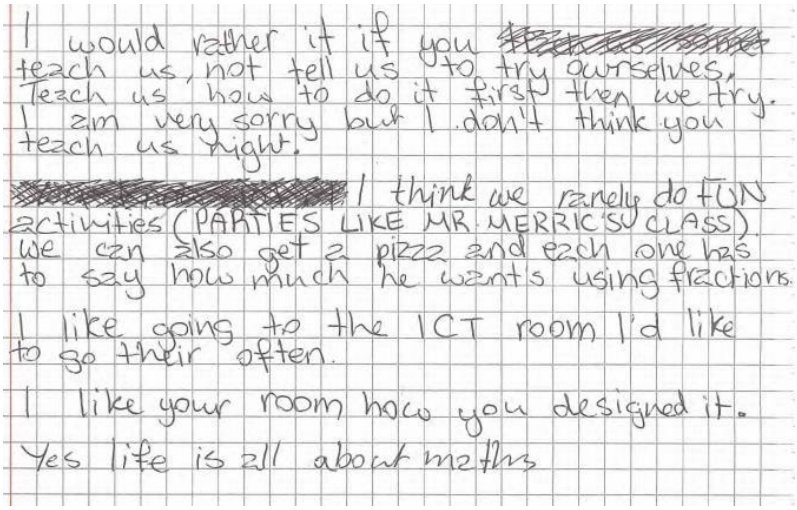
In this class …	**Almost never**	**Seldom**	**Sometimes**	**Often**	**Almost always**
1. I get the chance to talk to other students.	**1**	**2**	**3**	**4**	**5**
2. I talk to other students about how to solve problems.	**1**	**2**	**3**	**4**	**5**
3. I explain my ideas to other students.	**1**	**2**	**3**	**4**	**5**
4. I ask other students to explain their ideas.	**1**	**2**	**3**	**4**	**5**

5. Other students listen carefully to my ideas.	**1**	**2**	**3**	**4**	**5**

Appendix 4: Examples of students' responses to non-mathematical tasks

Appendix Four includes some examples of students' responses to non-mathematical tasks.

Max


I would rather it if you [redacted] teach us, not tell us to try ourselves. Teach us how to do it first then we try. I am very sorry but I don't think you teach us right.

[redacted] I think we rarely do FUN activities (PARTIES LIKE MR MERRICS CLASS) we can also get a pizza and each one has to say how much he wants using fractions.

I like going to the ICT room I'd like to go their often.

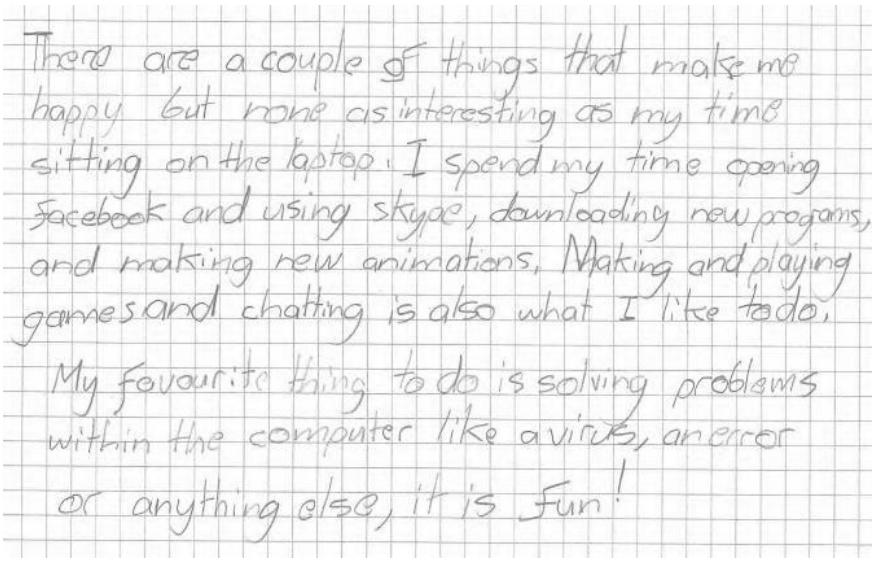
I like your room how you designed it.

Yes life is all about maths

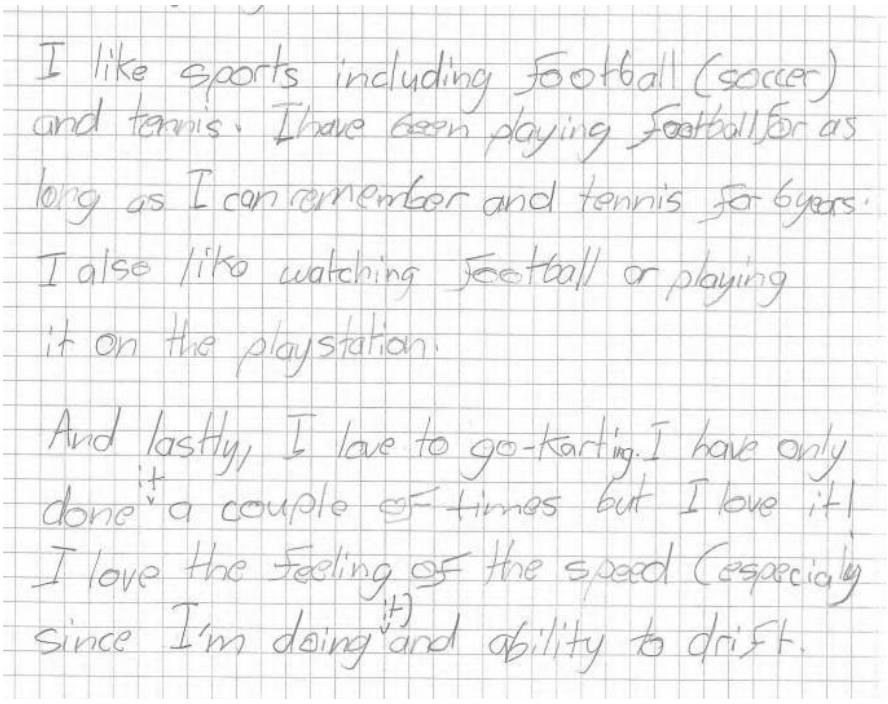

I LIKE PLAYING BASKETBALL, SKATBOARDING and

THEY WOULD BE PEES BECAUSE I HATE

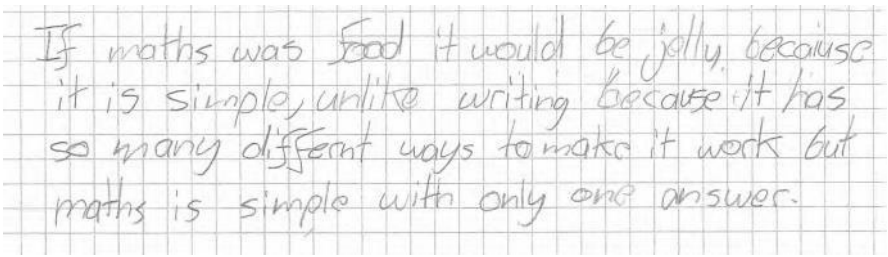
Nazir

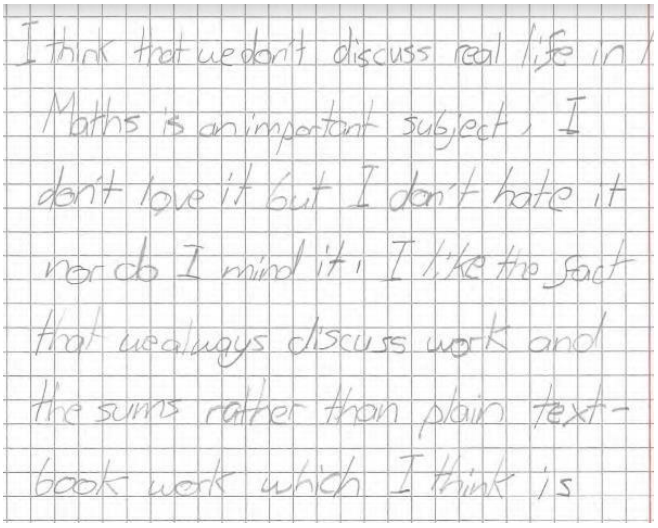

There are a couple of things that make me happy but none as interesting as my time sitting on the laptop. I spend my time opening facebook and using skype, downloading new programs, and making new animations. Making and playing games and chatting is also what I like to do.

My favourite thing to do is solving problems within the computer like a virus, an error or anything else, it is fun!

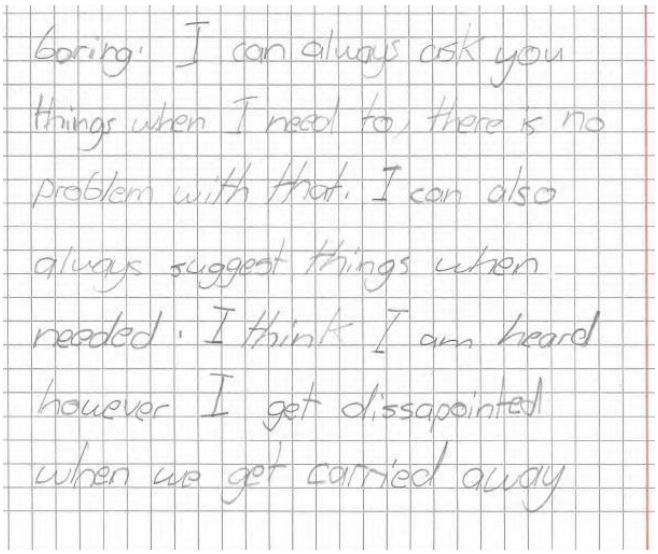

I like sports including football (soccer) and tennis. I have been playing football for as long as I can remember and tennis for 6 years. I also like watching football or playing it on the playstation.

And lastly, I love to go-karting. I have only done it a couple of times but I love it! I love the feeling of the speed (especially since I'm doing it) and ability to drift.


If maths was food it would be jelly, because it is simple, unlike writing because it has so many different ways to make it work but maths is simple with only one answer.

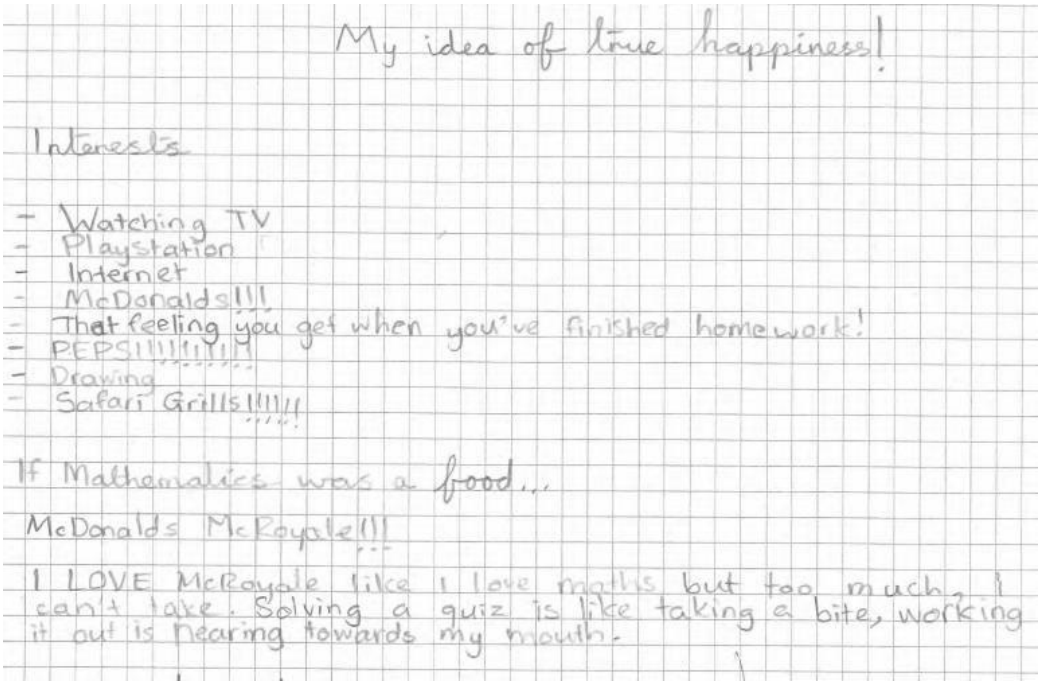


I think that we don't discuss real life in Maths is an important subject, I don't love it but I don't hate it nor do I mind it, I like the fact that we always discuss work and the sums rather than plain text-book work which I think is boring. I can always ask you things when I need to, there is no problem with that. I can also always suggest things when needed. I think I am heard however I get dissapointed when we get carried away



On the exam marks. I mean like that students misjudge others by their marks and never focus on the peoples class-work efforts. I would like it if we took the computer more often and more time talking about random topics and more activities. I would also like it if we redesign

Adil



My idea of true happiness!

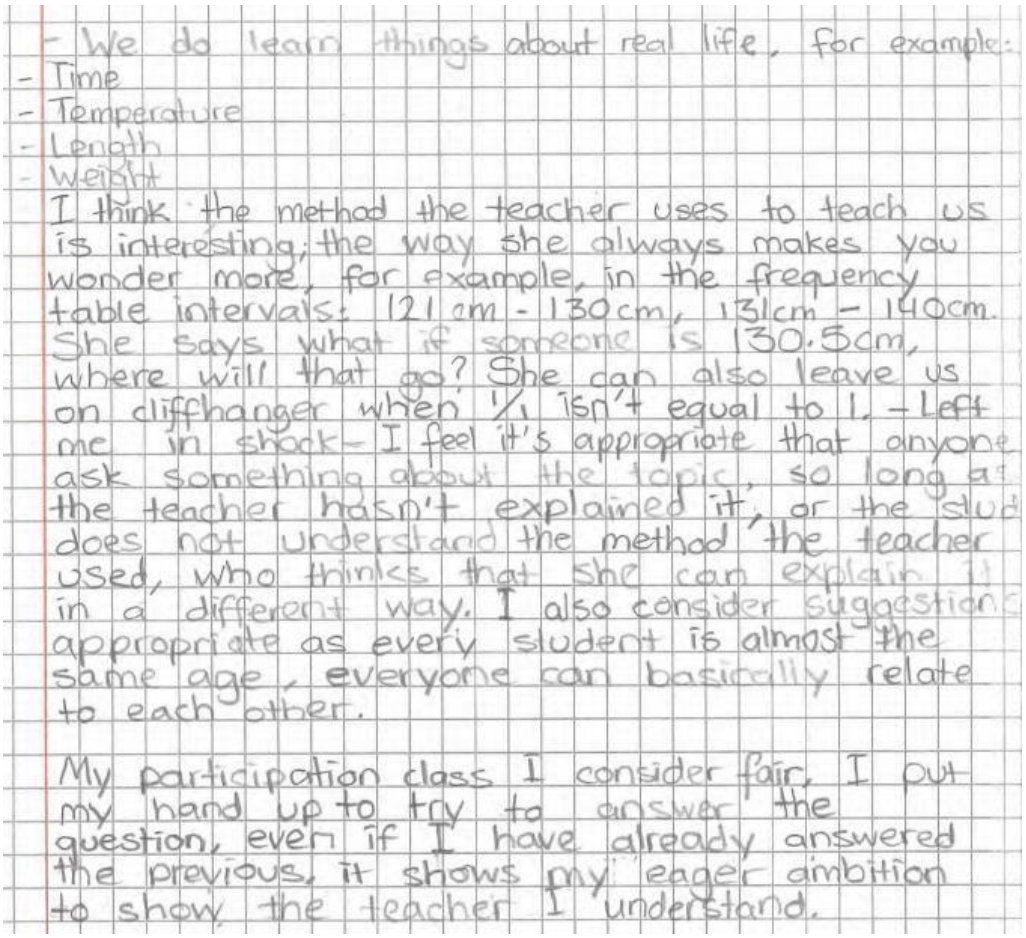
Interests

- Watching TV
- Playstation
- Internet
- McDonalds!!!
- That feeling you get when you've finished homework!
- PEPS!!!!!!!!!!
- Drawing
- Safari Grills!!!!!!

If Mathematics was a food...

McDonalds McRoyale!!!

I LOVE McRoyale like I love maths but too much, I can't take. Solving a quiz is like taking a bite, working it out is nearing towards my mouth.



- We do learn things about real life, for example:
- Time
- Temperature
- Length
- Weight

I think the method the teacher uses to teach us is interesting; the way she always makes you wonder more, for example, in the frequency table intervals: 121 cm - 130 cm, 131cm - 140cm. She says what if someone is 130.5cm, where will that go? She can also leave us on cliffhanger when 1/1 isn't equal to 1. - Left me in shock - I feel it's appropriate that anyone ask something about the topic, so long as the teacher hasn't explained it, or the stud does not understand the method the teacher used, who thinks that she can explain it in a different way. I also consider suggestion appropriate as every student is almost the same age, everyone can basically relate to each other.

My participation class I consider fair, I put my hand up to try to answer the question, even if I have already answered the previous, it shows my eager ambition to show the teacher I understand.

Appendix 5: Students' interviews

Appendix Five presents transcript of interviews with the three foci students: Adil, Nazir and Max. The students are referred by their pseudonyms to protect their confidentiality.

Interview with Adil

Teacher: Today is 7th of June, my name is Daniela McDermott and your name is?

Adil: Adil ____.

Teacher: Adil ____. Well, Adil thank you for being here. I just explained the whole procedure, that I'm doing this because of my university requirements, you understand that you're doing completely voluntarily these things and just... I'm hoping you can help with your answers. You understand that you can call some other teachers or parents to be present. You understand that?

Adil: Yes.

Teacher: Okay. Let's start. Tell me anything you think about mathematics class this year?

Adil: Wonderful.

Teacher: Tell me about... Why do you think... What do you think went particularly well for you? Any activity any...

Adil: Well, Miss, the algebra part, that was fun.

Teacher: Why did you find it fun?

Adil: Miss, because it's kind of like a mystery. It's like one step is actually working it out, but the other step is actually finding out what the number is.

Teacher: So, you like algebra most... You like algebra? Is there anything... Is there any particular activity you like or it is just because you like algebra you like everything about...

Adil: Simultaneous equations.

Teacher: Oh, you like simultaneous equations. Oh, we can do this probably as well, we have enough time. Is there anything going on in the lesson this year that you thought, "Oh, well, I don't think it helped me really"?

Adil: Well, Miss, some of the things isn't exactly educational, math-wise, like today... But, Miss, it's generally good 'cause you're just giving us something extra.

Teacher: Okay, so... Yeah. I have to say today's discussion was totally different than... It was one of these things which I was hoping to help me to create different activities. So, basically that you would really like to concentrate more on mathematical things in class.

Adil: Well, Miss, I have to say today was interesting. Miss, I think you were trying to interpret different student's opinions.

Teacher: Yes, I remember, actually, you were quite firmly saying that mathematics is out there, we're just there to...

Adil: Be aware of it.

Teacher: Find it. We are probably just not aware of that, as you said. So, can you just explain me more what do you think by that? Give me some examples or anything.

Adil: Miss, if I step, I just step like this, not really like this or like this. And Miss, for example, coordination like running, how many times you're supposed to do it slowly or something. Things like this.

Teacher: But I understand your opinion, but I would like to kind of ____ want you to more explain your reasoning for that opinion. They are quite strong words. I think you actually used the words "Mathematics is out there, they're just not aware of this."

Adil: Well, Miss, we basically use it every single day, it's just some things are so minor we don't even realize it's mathematical.

Teacher: Okay, so just like ____ when you say like I think... Obviously some people paused you, I think it was ____ Haitham saying that we made all theories, we made all things. So, do you agree with Haitham, like he says "We made everything." Or do you think, "No, no, we did not make it, we were just not aware of this, we did not make anything, we just found it," kind of.

Adil: Yeah.

Teacher: This is what you think, that we actually found mathematics rather than made it, rather than build it?

Adil: Miss, usually we use mathematics every day. So, anybody could have used mathematics without actually realizing it was there.

Teacher: Yeah, I think I know what you mean. So, I can see what you think. So, let's say... What do you want to be Adil, later when you grow up?

Adil: An engineer.

Teacher: Engineer? Not mathematician, you want to engineer?

Adil: Miss, I don't know!

Teacher: I'm joking, I'm joking.

Adil: Like there's things in the mathematical field that we should be... Have a great knowledge of, both Science and Math.

Teacher: Math? So, you are aware that mathematics is really needed for engineering, you know that. Do you think mathematics is generally needed for everyday life? I suppose engineering is everyday life for someone.

Adil: Miss, kind of. For example in cooking. You're supposed to measure the things or how many there are and all. And, Miss, very indirectly our respiratory system kind of depends on that.

Teacher: So, it is related. Well, I suppose you can relate it to ____ Albert Einstein, yeah. You think to science as well is related.

Adil: Yeah. Miss, like... Miss here, you're supposed to hold it for a few seconds like inhale exhale, inhale exhale...

Teacher: So, you can probably find some formula which kind of does it. Yeah, I can see. I mean do you think we do enough mathematical problems related to everyday life in the class, or not enough? Or do you think we should do more? Maybe we should do less? Or...

Adil: Miss, it's just basic things we're doing. The word... In some, they basically have word problems, but in algebra it's not really common. It's like I have a number, if I multiply it by six and add nine, it is the same result as if I multiply it by seven and subtract two, therefore, X=11.

Teacher: So, if I understand you well, you're saying that maybe for easier problems we can have some everyday life example... But we can't do this for every single thing. Is it what you're saying?

Adil: Yeah, you can't do it for everything.

Teacher: So, do you think, in our class... Do you think we should do more or less everyday life problems?

Adil: Well, Miss, for me it's not really a problem, but maybe for the other students... This is the reason they find math hard.

Teacher: Do you think we should use probably for other students?

Adil: Yeah.

Teacher: Yeah, I can see, yeah, that. So, if you compare this ____ for other types of subjects like say, I don't know, History, English, Geography, Science... Do you think we use about the same number of everyday life problems as other subjects? Or maybe we do a bit less, or maybe a bit more? Or...

Adil: History, not really, 'cause we go back in time, basically. We don't really do anything about now.

Teacher: Okay. What about Science or English?

Adil: Yes, Miss, kind of. Like the reaction of hydrochloric acid with sodium hydroxide makes a salt... Water and sodium chloride which is salt.

Teacher: So, you would interpret it as everyday life problems?

Adil: Yes.

Teacher: I have to say it's kind of a different question because what I consider as kind of problem which is related to our life, some other people think "Oh, it's not really that." So, it is kind of sometimes different... We'll just go another couple of minutes and obviously ____ you're excused automatically today. So, what about... Do you think in this class you have enough chance to express your opinion?

Adil: Yeah, Miss. Actually, I recall you giving us a sheet in fact to write down how we feel about math. And then I remember in our math book you said to write down what you want to do more of, or something. So, I put algebra.

Teacher: Oh, you put algebra? [chuckle] So, we did. But I don't mean only me, I mean do you feel that generally, me or other students in class... Or maybe Andrew, Pravin or Yusuf, that they will listen to your opinion that you have chance to say what do you think, generally, in the class, or maybe you thought that people generally didn't listen to you.

Adil: Miss, I didn't really mind if people didn't listen to me, Miss, as long as you did. 'Cause that was really...

Teacher: Why do you think so? Are you under impression that other people... Did not listen to you? Or...

Adil: Miss, I don't know, really.

Teacher: Let's say, from your point of view, did you have a chance to talk about things?

Adil: Yep.

Teacher: Okay. But you're kind of not really worried if someone doesn't listen to you? Well, yeah, I suppose...

Adil: It's their loss, it goes on their report.

[laughter]

Teacher: So, tell me, do you think actually that you prefer to talk to people when you're doing some... Solving problems, or do you prefer to do kind of by yourself?

Adil: Miss, I kind of like explaining to people my way... This is when I kind of like them to listen.

Teacher: Okay. So, this is kind of... I understand, you like explaining your way, but when you do problem, do you prefer like, "Yeah, I have to do this by myself, I really don't... "

Adil: Well...

Teacher: Do you prefer kind of to do problems by saying, "I want to solve it and then maybe I'll explain it"? Or do you prefer to discuss it ____?

Adil: Miss, it kind of depends. One of those astro-numeral... The countdown thing that you give us a bunch of numbers and then we're supposed to make this number... That's when I'm kind of on my own.

Teacher: Okay. What about, say, that that question you did yesterday, do you think it is the same... Either you're doing by yourself or with Andrew? Or do you think...

Adil: Well, I started it then he started and then he just thought we should team up, basically.

Teacher: Did you prefer teaming up with him? Or did you...

Adil: Miss, I didn't mind.
Teacher: You didn't mind? I have to be honest with you, when I was younger, I did not really like much talking to other people. I did prefer doing questions by myself. But I'm just interested to see what other people think. So, if you can compare mathematics to other class, do you think that you have the same chance in maths or other classes to express yourself? Or maybe a bit less here or maybe a bit more here? Or...

Adil: Miss, I think a little bit more here because, well, math is basically all about different solutions and other people... Miss, you said something about other mathematicians listening to each other and all... When one is speaking all the rest should listen...

Teacher: They have to listen, yeah...

Adil: For example, in science there's not really much to talk about. Well, there's nothing to debate, really.

Teacher: Nothing to debate? You think mathematics is probably ____, you can easily debate, but you cannot really easily debate science, so it's kind of because mathematics is all. Yeah, this is why you can talk in mathematics.

Adil: Miss, the reason I find math easy is because there is an exact answer... There's only one answer. One plus one is only two, nothing else. But in English, that's where it's a little confusing. I'm not that good, but I'm alright. It's like, "You could have either put this" or "You could have either put that."

Teacher: So, do you think kind of... From what you're telling me, you possibly think mathematics is a little bit more logical. It's not easy to get so confused with mathematics. You know what you have to get to get into the things and that's it?

Adil: Well, Miss, I am going to put the army into it. Miss, Math is basically about Battle Tactics, but the others require that you actually have a knowledge of things, like the weapons and all. But here, you only need to know the actual way to get the answer. You don't really know the actual questions they're going to ask you or like what exactly they're going to get.

Teacher: So it kinda feels strategy is important here as I understand, not like... Yep, I think I can see what you mean. So, let's say it, like I do a question on my board, let's ____ take a problem, do you prefer to try to attack it all by yourself or do you prefer me actually explaining the question on my board?

Adil: Miss, I think I'm quite independent. I mean, I quite understand it. Well, I'm rumoured to have a little bit higher knowledge of mathematics than most of them because, well, I'm a little more energetic to learn more about math than the others.

Teacher: You're just very talented darling, it doesn't have to be like, you know, it's, not a shame. Admitting that you're better and you can say that. So, do I understand what you're saying that actually, you don't possibly need me always? Does it mean like...

Adil: No, no, Miss. I...

Teacher: No, no, I'm just trying to figure out of it because it could be a way for you to learn. So what you're trying to say is that, so you are independent to figure out the answer by yourself?

Adil: Well, Miss kind of. There are some things I kind of paid attention to like graphs and how to draw the curve. Miss, that was something I didn't rea... Miss, it's just because I kind of have previous knowledge over these and I was kind of expecting something more challenging.

Teacher: Alright, expecting more challenges? So, how do you think we can resolve it because I notice sometimes you need more challenging after the class.

Adil: Well, Miss today in our lesson I noticed in year nine, like Miss, can I just get the book?

Teacher: Yes, you can get the book. I did notice that you did something different, I noticed that.

Adil: Miss, simultaneous equations.

Teacher: Okay, yeah...

Adil: Page 42. Miss, they're really simple, like, this is kind of the stuff we did in class, but once, when I was Yahoo answers I actually showed you how I worked out that question. The...

Teacher: Yes, I know.

Adil: The Scandinavian movie ticket. Miss, that's the type of things I kind of like. When they're switching around and there's different values 'cause here it's quite easy 'cause they have the same thing.

Teacher: Why do you find it easy if they just have the same thing?

Adil: Miss, you can just take it off and then... Well, it's kind of easy comparison because, well, here you can tell that to a... Miss, I don't exactly know how to get this. Wait...

Teacher: But you feel this is somehow easy because it's just one. Why?

Adil: Well, yeah.
Teacher: Why did it make it easy?

Adil: Well, Miss it's like $5x + 2$ and then $2x + 2$, you just take away 2 and then you get... It's only a matter of... It's like Diophantine equations. Those you have to experiment. Well, in my opinion, you have to experiment these.

Teacher: So did you read anywhere about the methods to do this or you just kind of... You tried to figure all these?

Adil: Miss, I actually have an algebra book at home.

Teacher: Okay. I can see what you think. So, I noticed you're doing something else, but I know you're always doing something kind of useful so, I just didn't want to interrupt you, I just noticed that. So do you think you have chance in the class? Actually, if you find something easy, do you think you have chance in the class to do something trickier? Or do you think you are sometimes stuck with kind of easy question?

Adil: Honestly Miss?

Teacher: Yeah, honestly just tell me what you think? Do you think I give you sometimes... Do you think you have enough chance in class for me? Do you think I'm providing you with something?

Adil: Miss sometimes, you give us extension work like for a challenge or something?

Teacher: You mean like that? Or...

Adil: Yeah. Miss, but in the actual thing, Miss, not exactly. Well, actually Miss, sometimes you actually do because those questions would be fractions. I didn't really know how to solve. But then, I discovered you're supposed to make them the same and then just disregard the actual fraction, so...

Teacher: Okay. But generally, you think that sometimes you have chance to do something challenging, but sometimes you don't have chance in class to do something challenging?

Adil: Yeah.

Teacher: Yeah. Would you like to have more chance to do something challenging in the class?

Adil: Well, yes.

Teacher: Yes. Of course. Of course. Well, is there anything else you would like to tell me? Anything you think that can help me like... I think we did have good chat about everything, honestly.

Adil: I guess that's it.

Teacher: And do you think... And during the year, if you really didn't like the way I did something, you think you'll be able to come to tell me? Do you think... Or would you just say, "No, she's a teacher, she possibly knows the best," or do you think...

Adil: Miss, I think the way you teach is excellent. I put you as Miss Smart in the teacher appreciation...

Teacher: Why do you think so?

[chuckle]

Adil: Miss, 'cause you're both a teacher of Mathematics and then you kind of understand everybody's approach of doing everything. Miss, there's nothing that really confused you about different student's approach.

Teacher: Okay, I can see what you think. Okay, so you do you think I'm kinda good in Mathematics?

Adil: Yeah.

Teacher: You think I can sometimes make mistake?

Adil: Well, Miss, everybody makes mistakes.

Teacher: Everybody? Well... Yeah, well, thank you Adil, thank you. I appreciate what you said. Is there anything else you think you feel like... I may come up with some questions where, "Ooh, I wanted to ask her that," but I have to say that you actually... I think you did quite good here, and I think that's quite a good year and I think did quite good work, and I know you'll continue like that. Well, thank you very much, I'll stop it here.

Adil: Thanks Miss.

Interview with Nazir

Teacher: Today is 7th of June, my name is Daniela McDermott and your name is?

Nazir: Nazir.

Teacher: Nazir, tell me you thoughts about mathematics class this year?
Like what do I think about maths in this class or what do I think about maths in general? Let us start with what do you think about maths in this class, and then we can have a chat about mathematics in general?

Nazir: Usually in primary and this stuff, it was really obvious, we did not do too much thinking, we just had to understand what we were supposed to do. And it was a race, who was going to finish first. It was really easy. And questions themselves, like each question would take 5 seconds.
So do you think this class was different?
When we first came into secondary, also in the induction day last year, we actually had a class discussion about the question, we had a debate and stuff. That never happened in primary it was new for me. I had it with my sister, because she likes maths and stuff, but I did not do this as a class, with a teacher or something.

Teacher: Ok, so this is, you think, a difference between primary and secondary?

Nazir: Yeah, and also the fact, not always, but mostly, that we mostly spent time at the whiteboard and rarely at the book. And with the book, I feel it, we only did to ensure that whole class knows exactly how to do it. Even though, that is not sure that maybe everyone that is not their own work. But still, even though, I know some people do that, but at the end they figured it out, because you can see it in exam, you cannot cheat in exam.

Teacher: So, what do you think, what particularly worked well for you this year, like any activity or any theme we did in the class, you thought, o well, I learnt from this?

Nazir: We did group discussions, as once you got to the text book the questions took you longer. And when it is longer, and when it is more questions, it is not boring, you like it, and when you understand, but when you do not understand, by the time you finish one question, and it is hard, it is even harder to keep doing more questions.

Teacher: So you do not find particularly enjoyable working from the book?

Nazir: Miss it is ok to do it but, for example today, after you told me to leave, I did not leave until I finish two more questions, because I wanted to finish. On the board it was fun that you can express your opinions, by yourself, and also when you answer back to someone, you would say back do you understand that, it was, even though that the class would get out of control, but you so learn by the end of the lesson.

Teacher: So was there any activity which you did not benefit from? You though, it was not my style really?

Nazir: No.

Teacher: What is by the way your style? For example we have a problem on the whiteboard. Do you prefer me to show you exactly how to do a question, or do you prefer to think a little bit about that?

Nazir: I prefer we think about that, because some time, I prefer if I know what you are going to say, even though I know you do not learn from that. But in the end you would say something that I did not know, like, why are you doing something, even in maths, you cannot really ask why?

Teacher: Why do you think so, that in mathematics, you cannot really ask why?

Nazir: To find out why, all the people like the guy who called Pythagora stupid, all the work he does and stuff.

Teacher: But you said that you cannot ask why? Do you say that there is no a reason?

Nazir: There is a reason, but it would be something that it would take me too long to understand, and I am already fine with not asking why.

Teacher: So you think for you as a student it is enough to know how or you are not particularly bothered?

Nazir: If you tell me 1+1 =2, I know why because double of 1 is 2 but actually, this is simply example, but when it is very complicated, not this example, but when you have another example, I do not want really to ask.

Teacher: So you actually do not want to ask, I can actually tell you the reason for 1+1 =2 is not so simple, I did it at university, and I remember a theorem, 1+1=2, prove it. And it does go for a few pages, why is 1 + 1 = 2. And obviously it is too complicated.

[Chuckle.]

Teacher: What you are saying that for some simple things it is ok for you to know why but if things get difficult you prefer, you do not want to know.

Nazir: It will make things just more complicated.

Teacher: You are happy not too make things more complicate, you just want to be able to do it. I suppose this is what is important for exam.

Nazir: Yeah.

Teacher: Ok, what is the difference between the way you learn mathematics and the way you learn other subjects?
Nazir: In other subjects, for example science, the teacher explains on the board, and then we ask questions, but we do not show opinions, because usually, ____. in science you can show opinions, but is important fact not opinion.

Teacher: So you think if something is a proven fact you should not have an opinion about that?

Nazir: No, there is not something you should not understand after you have read it properly, like in maths, for example what we did today, x squared + y squared = z squared, like I get it, x times by itself, plus y times by itself equal z times by itself, like I get it, why ? There is a why part. In science, for example, if you say, the roots get nutritions and water from the soil, there is nothing to question in that. There is nothing to share your opinion in that. In maths, for example, when you ask, the whole class, put their hand, Andre, me, …

Teacher: You think, in mathematics you can always create a little problem out of something, like, x squared + y squared = z squared, . you can always ask why, why, why is that.

Nazir: Yeah.

Teacher: You just mentioned something about expressing you opinion, do you think in the class you had a chance to express you opinion?

Nazir: Yes Miss, until the lesson finishes.

[giggle]

Teacher: Until the lesson finishes, what do you mean by that?

Nazir: Miss, I am not saying that lesson should be two hours, but I am saying usually people say the same thing but in different words.

Teacher: OK, I can see you think despite people thinking that they are expressing different opinion, at the end they all talk the same thing

Nazir: And they even do not know it.

Teacher: Oo well, that is a subjective thing. Do you feel in the class you would prefer to have more chance to express your opinion, or do you feel, I had a chance to talk?

Nazir: Miss, I have a chance, but, there would not be anything else I want to say, unless I had more time to think, if i had more time to think, that would mean more explaining, that would mean more explaining for everyone, and that would just go forever.

Teacher: You think it can go forever?
Miss do you remember yesterday, or couple of days ago, the lesson finished and we still had a lot to say, if we had two hours, we would not finish.

Teacher: Trust me I often feel like that, I could have done do so much more, but you have to choose what to do. Again if you compare to other classes do you think you have more or less chances in mathematics to say what you think?

Nazir: Miss, not more, it is the most.

Teacher: Ok, you feel you have most____.

In other subject I don't think I even share my opinion about anything, like in English, you do not share your opinion, because your opinion will not be wrong and your teacher do not care, like in maths you have to find out if your opinion is write or wrong, in science, like I said, in history, yes you can (almost surprised), of course you can give your opinion, but we are still year 7, we can' t still disagree with something that is in your textbook or something.

Teacher: Does it meant that actually in mathematics that you are certain that there will be just one answer that will be correct? This is what you are saying, correct me if I am wrong, you share your opinion at the end and hopefully believe that you will get at the bottom of the problem, that you will come up with one solution.

Nazir: Yes miss we are still in year 7, and most, nearly, a lot of things in mathematics have already been figured out. If it were, if this happened 2000 year ago maybe we could have still, there would not be a right answer, because nobody still proved it. But we know that there is an answer, but we are not sure what is this is yet.

Teacher: That is an interesting comment, what you are saying, that probably 2000 years ago people really did not know if something was correct or not correct.

Nazir: They still had to prove it.

Teacher: What about today, do we better now, or we still have to prove it something?

Nazir: We know what we are taking in year 7. Because, Maybe if there is something in year 12, maybe there is something that is too complicated, that people are not exactly sure about but mostly, like 80% they are sure.

Teacher: Obviously we have just year 7 stuff, we do not have all mathematics, mathematics is huge, but if you talk about general mathematics, do you think that there are possibly things we are still not sure about.

Nazir: In my head it is very complicated, but if you get a year 10 and look at year 7 stuff, yeah it is easy, but there is something complicated.

Teacher: So you think actually if you even get to university there will be still stuff, when you look at back, o yeah that is easy, that is year 10 stuff, but there is still other stuff am not sure about.

Nazir: Yeah.

Teacher: Do you think generally think in whole mathematics there are some things in mathematics that even the best mathematicians are not sure about?

Nazir: Sorry?

Teacher: Are there some things in mathematics that even the best mathematician sure not sure about?

Nazir: Obviously, can be that hard thing to figure out everything to do with maths, and how many years it has been around.

Teacher: Was this interesting debate you had the other day, how mathematics was created?

Nazir: That was good one.

Teacher: What is your opinion about that? How mathematics was created?

Nazir: Miss it is usually it is good thing for a change, we usually just discuss sums and equations, this is a big question.

Teacher: What do you think? How it was created? It is a huge question.

Nazir: How I think it was created? For example like God thought Adam and Eve whatever everything about life including maths, but not in the term of maths in like other stuff that was later on called maths, and later on developed into what we now take in school.

Teacher: I can see what you are saying, so you are saying that actually Adam and Eve and other people talked about life, but correct me if I am wrong, maybe the way I see it you are saying, that as the time went on, the people started seeing maths in these things.

Nazir: Yeah. And started kind of writing simple and everything. Obviously they did not teach their children 1 + 1=2, and saying over and over again, but they had the same principle in what they been teaching their children.

Teacher: That is quite interesting theory. I can tell you this is very tricky question. If I have asked the teachers around, all of them would have divided opinion, so I guess there is no right or wrong answer for that. Quite interesting. Is there anything else we should talk about? O yeah what do you want to be when you grow up, I forget to ask that?

Nazir: I have no idea, no idea. Miss I do not think I am gona be a doctor, or engineer or a pilot which most people want to be. Miss I lot of people say that. Most people say they want to be a doctor and they do become a doctor. How many doctors are there in the world? This is a boring job. I want something different.

Teacher: _____?

Nazir: Not necessarily, but something in that field, where there is no a lot of people. If I hear someone different job I am eager to know more that. But for example doctors, a lot of people in my family are doctors. My sister wants to be a doctor.

Teacher: I can see you want a different kind of thing. What about…? Do you think that generally you need mathematics in some other profession or outside the class?

Nazir: Yeah miss, for example banking, you need every day in life.

Teacher: Do you think we mention some of these problems in the class, or do you think we should mention them bit more?

Nazir: Miss like where we could use maths?

Teacher: Something, like outside the class. Do we mention any of real life thing in our class, or not so much.

Nazir: Not so much, but it would not be that awesome if we ha, it is ok, I do not really care if we have or not.

Teacher: Why do you say it would not be so awesome?

Nazir: Because, like miss I do not really mind if we have not or not.

Teacher: I like it if we do, but I am not gona be sad if we do not.

Nazir: What about other subjects? Do you have more real life things in your other subjects? Like history…

Teacher: Miss in English like last lesson, and the stuff before, we were discussing how then we write stuff what makes us angry, we spent all lesson discussing about what makes us angry, and other things and stuff, and also the teacher, I had nine thing to say.

Teacher: And the teacher got really angry.

[laughter]

Nazir: No, she told wait for today, but today I did not say it.

Teacher: I can see. Is there anything else you feel you should tell me? Is there anything else that you feel I should know in order to teach better next year?

Nazir: Miss I am not sure if I should say it, but you know how the class is crazy and stuff.

Teacher: Yes, crazy?

[Giggling]

Nazir: Yes, in other classes and stuff, like, like (thinking, trying to find words to explain), In maths it has to be like that, because we have to talk, like if you tell us do in your own, ¾ of the class would not understand, only the people who already know, so we have to talk. If you have to talk then obviously something is gona happen.

Teacher: Ok, I can see what you think. What about generally, if you thought that you had problems with something during the year, and I do not mean the problem you did not understand something, I mean the problem, like you think, like, Miss I do not think we need to do percentages, or Miss I think we should do this, would you be able to come to tell me.

Nazir: Miss there were a couple of topics that we did, that I already understood, and I really did not learn anything, but it is not fair for me to tell you, but Miss I understand, I am OK, not all class is ok.

Teacher: Why do you think it is not fair for you to tell me that?

Nazir: Because Miss not everyone understands it, and even if I might know this, they probably know something that I do not..

Teacher: What about anything you think I could have done or I should have done to encourage doing a bit extra work? Do you like to do extra work, or do you think, do you feel kind of happy, or 'oo well, I will do extra work for homework'.

Nazir: Miss I do extra work always, because my mum tells me, but Miss if you give me extra work optional, Miss I honestly think that, maybe 5 people will do it.

Teacher: So you do not think I would promote extra work in the best way, if I only say it is optional? Do you think I have to say Nazir, you have to do this?

Nazir: Miss, remember once you told us we have to do a paper, we have to correct it.

Teacher: Yeah?

Nazir: Miss I did it, I asked my mum, my sister, they corrected me, and I understood everything, and there were a couple of algebra questions which I understood and from that day like half of the algebra topic I already understood because of that just half an hour my sister was explaining.

Teacher: Yeah? So you think it is the best if I can say it is optional extra work?

Nazir: Not always Miss, but it will work if you tell told them you have to do it, and you told them.

Teacher: I think I understand, you think it is hard to sit down and do extra mathematics, 'uu it is fun'.

Nazir: Miss, for about one day and stuff, Miss I am going to come, but…for example like Imran is sitting next to me, like no, no , no ..It is not because he does not want to, he is not bothered, he knows he is going to learn more, but he does not want extra hours of school. It is just, who cares.

Teacher: Thank you very much Nazir, I think we chatted for quite long time. Is there anything else you want to tell me?

Nazir: No Miss.

Interview with Max

Teacher: Well today is the 6th of June. My name is Daniela McDermott. And you are?

Max: Max.

Teacher: Max, thank you for being here. I just explained you our procedure...

Max: Yes.

Teacher: And you know why I am doing this, for university purposes. We'll just start I guess. Well, could you tell me any impressions about mathematical classes here.

Max: It has been fun when you're teaching us. The way you let us think about... You make us try to figure out how to do it, is really good, it makes us think more. Yeah, it's good, it's perfect.

Teacher: Is there anything kind of... You'd say you're really kind of, are not really too happy about? Remember, it's going to help me for future students...

Max: Maybe, when for instance when there's something... You're perfect, I can't think of anything.

Teacher: [chuckle] I'm not perfect, I'm going to... Anything kind of you can think like... Okay we'll talk about that later. Is there anything you particularly liked about...?

Max: I liked the activities, how you made the activities the same procedure with the maths, like they all link together, that was really good, and I also liked how your presentations, how you make us think and how to make everything...

Teacher: Okay. What do you like... I'm not sure, what are you going to do later in life? Do you have any plans like what you're going to do?

Max: I was thinking of being an engineer, and that means a lot of maths.

Teacher: You already know that.

[chuckle]

Max: So I'm happy that I'm getting this opportunity to learn from a good teacher.

Teacher: We'll see next year. Who's going to teach you next year? I don't know. Well, a trust is more about students, less about teachers, it's more about you. You already know that you

need a lot of maths for engineering, so you actually... Do you think that you need maths outside of the classroom?

Max: Yes, a lot, for many things.

Teacher: Oh. First to start engineering?

Max: Yes, and I'd say like when... It's almost needed in everything.

Teacher: Do you think we kind of, do in class enough examples from outside the class?

Max: Yes, a lot, and it's helping 'cause now we can see how the whole world has something to do with maths, and it makes it such a huge subject that it's an honour to learn.

Teacher: Math, yeah. ____ I loved mathematics when I was younger, now, like... I really love it now but still, there are many things in life I have to do, not only mathematics. So thank you so much. If you compare say, this class with other classes, do you think that you have..?. Do other classes have more real life examples or do you think the same as mathematics, or...?

Max: Actually... For example, like the other classes, I haven't been hearing other students saying that their classes are doing realistic work and that type of thing. And when we tell them that we learned something very nice in maths, like for instance the...

Teacher: ____. I'm blanking.

[laughter]

Max: That was really good, and the M&Ms and... Like, you know, these activities and stuff, and when we come and hear about them, they don't really get a lot of real life into it. They get it sometimes, but we get it the most, because you know that it's the right thing to do.

Teacher: Wow. I think maybe sometimes I think so. [laughter] Well, I just wonder... Okay, next thing. Do you think you have enough chance in the class to talk about your opinion, like do you have chance to express your opinion in the class? Or do you think...

Max: It's good.

Teacher: I don't think only to me, I don't think only, do I have chance to... So you talk to Kareem and to Fazel and friends, do you think that generally your opinion is being heard in the class?

Max: Yes, they are. Maybe sometimes, if it's in the wrong time or something, I won't be able to show them my opinion, but afterwards when it's the right time I can show them.

Teacher: Okay, you mean... Well, I think I suppose ____ you think sometimes I don't have time to listen to you?

Max: Yes.

Teacher: So how do I deal with that situation? Do I say...

Max: You would tell me to ask my friends.

Teacher: Okay, ask your friends or something like that.

Max: Yes. Yeah, it's good, 'cause you're giving me an opportunity to hear from other people's opinions, and if they don't have one I can listen to you, but generally you will tell me to talk with the classmates and see what they're doing so I can learn more.

Teacher: Do you think it's similar in other classes, or it's just mathematics, like I don't know what's happening say in English, or History?

Max: Maybe a little in science, but maths uses it the most, 'cause in mathematics you need... I think that... In my opinion I don't think there is no wrong answer, 'cause it's always like there's billions of answers and billions of ways to...

Teacher: I turned my phone off but I did not expect anyone to come. So you think it's all right if ____ mathematics that we have more chance to check other students than maybe some other classes. So, do you think that you are good in mathematics?

Max: Yes. Maybe there are a few subjects I'm not really good at, but after... For instance algebra, I don't think I'm as good, but now I'm getting used to how to work with algebra and...

Teacher: Oh, it's a bit harder topic. So do you generally think it's something difficult to get mathematics, or kind of, "Oh well?"

Max: It's, "Oh well."

[laughter]

Teacher: Oh well, that's okay. That's a very good answer, so not too bad. So let's say if you have to do a question, do you think that it's... Do you prefer say, me to do a question on my board and then you see math and so then you do it by yourself, or do you prefer to sort of try to figure out by yourself, so what would be kind of your more favourite way of doing things?

Max: Maybe we try and figure it out, then after a while you would tell us the actual thing, and other people would come to the board and show you what we think.

Teacher: Okay. I remember just once I think... Okay, checking through, and I just thought, I think... Probably all this is change ____, but I remember you said something like, "How am I going to know method if you don't explain?"

Max: Oh yeah.

Teacher: Can you just tell me what you... Tell me a little bit more about that.

Max: Yes. A few months ago I used to think that I shouldn't... I thought you were the teacher, you have to tell us everything, but then I understood that it... Like I have to try. So me trying to find the method out is actually better, but what I would understand more is when you tell us.

Teacher: Okay, you still prefer me, after all. No, I understand that, I have to know these things. So you still, like you would like to try, but you still would like me at the end to confirm are you okay or not okay, and to explain so you can kind of compare. Yeah, I understand that, what you think. So, what if I ask you, for example, I'm not sure what's happening in the classes, let's say, what your favourite way...is What do you think is actually the best way to do mathematics? Do you think the best way possibly would be, I give you a set of books and ____ ingredients, like questions and answers? Or maybe, do you think maybe the best way probably would be to go on internet and do research and then...

Max: Do internet, yeah.

Teacher: Or maybe, do you think the best way is for me to explain first, or maybe... What do you think would be the best way for you to get knowledge?

Max: I think going on the computer and searching, for instance on Emaths and MyMaths, and these websites, this is a good way. And I also like the way when you show us on the board. I can understand more on the board than on the computer, 'cause on the computer it doesn't suggest opinion... It doesn't suggest as many opinions, it normally tells us facts on how to do it.

Teacher: Okay. I can see where you're coming, so yeah, I understand. I think I have someone else's... Remember a couple days ago we did this question, the students actually did the incorrect way of working, but at end got the correct answer by accident. So do you think was that? Should I so I say he's correct or not? If I mark exams, say it happened in exam, what should I do with that question?

Max: Maybe like... It depends who the person is, 'cause sometimes a person can, for instance cheat from someone else, and just write the answer down.

Teacher: Okay.

Max: But when you said someone get the answer by mistake...

Teacher: By mistake, yeah.

Max: I don't think the person actually did it by mistake would actually regret it, but maybe, yes...

Teacher: Maybe some are, you'd think that some people wouldn't.

Max: Maybe when he was finding the answer out, like showing his working out, maybe he made the mistake there, and then just with...

Teacher: Well depending... You mean what kind of mistake he made. It could be just a simple mistake where you could be kind of... Where you that you...

Max: If it's a big mistake, yeah, maybe he would lose a mark, but if it was a little...

Teacher: What would you consider a little mistake, for example?

Max: For instance, if we did something times something, but then we realize after it wasn't the right thing, and we just divided them together, without tracking it down, maybe they...

Teacher: Okay. Yeah, so you think... Okay, I understand what you mean. Do you think like during the year, like say if you weren't happy with some of my teaching, do you think you were able to tell me this, or do you think... You just thought, "No, I shouldn't tell you anything?"

Max: Sometimes I think to myself I can find it out by myself, I shouldn't ask anymore. Sometimes I'm a bit shy of the teacher, but now that you're my teacher I can just tell you straight away.

Teacher: You think that you are more able to tell me now than a couple months ago, or maybe because you know me better now and you could tell me. Well do you think say that... Do you think mathematics here, what people do is the same say as mathematics in China?

Max: Maybe in multiplication they don't...

Teacher: Oh yeah, 'cause they do a Chinese multiplication. [chuckle] Okay, you think... Okay, why do you think people do it in different way? How come that they do their multiplication in the Chinese way? Why do you think it happened?

Max: Maybe long ago, like in the past, in the history, countries had different ways to figure out something, and maybe they all... For instance, maybe disagreed. The people which disagreed stuck to their... And the people which agreed would be the same as like...

Teacher: Yeah, I understand what you mean. So do you think actually that the countries or people talk about mathematics and decide, "Oh well, that's alright, that's not okay," or what do you think, what's happening? The way you describe things.

Max: Maybe now they don't do that because now they know everything... Not everything, they know most of the things, and I'm talking about the history, how maybe they didn't agree together as much, and that's what made them now just stick to the disagreement.

Teacher: Okay, okay I know they just... Okay. So, yeah I can see what you're saying. They could agree or not agree, well that's their choice. So do you think that we have more mathematical things now than say 100 years ago?

Max: Maybe 100 years ago they didn't know as much, and now we have developments, we have computers to do it for us, we have calculators.

Teacher: So you think that actually we do... We know actually more now than we did like...

Max: For instance, for finding the perimeter of a circle...

Teacher: Oh yeah, yeah, yeah.

Max: How we started as a triangle and then...

Teacher: Yeah, yeah, yeah, we did it in class. So well, is there anything else you would like to tell me? Anything kind of you think could help me?

Max: I don't think... From the beginning when I first started, when you started teaching me, I didn't understand much, just... I don't know. And now I can see how... What you mean, 'cause when I was young, when I was first coming to secondary, I wasn't used to the way maths was taught in that way.

Teacher: Okay, so they do things differently primary, like...

Max: Yeah.

Teacher: If you compare say, our class with class from primary.

Max: Yeah, it would be different. The way they talk to students. Like in primary they would tell you straightaway how to do it.

Teacher: Okay.

Max: And in secondary they let you think, they let you use your brain and actually find out, and that helps us to...

Teacher: You're not worried that maybe you can get wrong answer? Do you think you're worried about that or...?

Max: If you check our... The way we think the method should go, maybe it will be right in the end, but if we're wrong maybe you can tell us the right way or we ask our friends.

Teacher: So you think at the end we'll try to resolve things, at the end.

Max: Yes.

Teacher: Well Max, again, thank you very much for doing this interview to me.

Max: Thank you.

Teacher: This is my second interview so hopefully I did something okay. I'll stop it now.

Appendix 6: Ethics

Appendix Six includes Human Research Ethics approval forms, the consent form and the participant information sheet.

Human Research Ethics approval forms

memorandum

Curtin University of Technology

To	Danijela Cvoro, SMEC
From	Pauline Howat, Coordinator for Human Research Ethics, Science and Maths Education Centre
Subject	Protocol Approval **SMEC-08-10**
Date	14 April 2010
Copy	Bill Atweh, SMEC Divisional Graduate Studies Officer, Division of Science and Engineering

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Minimal Risk (Ethical Requirements)" for the project titled "*THE EFFECTIVENESS OF TEACHING AND LEARNING IN THE CONSTRUCTIVIST LEARNING ENVIRONMENT IN MATHEMATICS HIGH SCHOOL CLASSES WHERE STUDENTS ARE ENGLISH AS SECOND LANGUAGE LEARNERS*". On behalf of the Human Research Ethics Committee I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **12th April 2010** to **11th April 2011**.

If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately. The approval number for your project is **SMEC-08-10**. *Please quote this number in any future correspondence.*

Pauline

PAULINE HOWAT
Coordinator for Human Research Ethics
Science and Maths Education Centre

Curtin University

Memorandum

To	Danijela Cvoro, SMEC
From	Pauline Howat, Administrator, Human Research Ethics, Science and Mathematics Education Centre
Subject	**PROTOCOL APPROVAL – EXTENSION**
Date	15 April 2011
Copy	Bill Atweh, SMEC

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your Form B progress report for the project *"The Effectiveness of Teaching and Learning in the Constructivist Learning Environment in Mathematics High School Classes where students are English as Second Language Learners."*

Approval for this project is extended for the year to 3rd April 2012.

Your approval number remains **SMEC-08-10.** Please quote this number in any further correspondence regarding this project.

Please note: An application for renewal may be made with a Form B three years running, after which a new application form (Form A), providing comprehensive details, must be submitted.

Thank you.

Pauline

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

Curtin
University of Technology

Curtin University of Technology

Science and Mathematics Education Centre

Participant Information Sheet

My name is Danijela Cvoro and I am your child's Mathematics Teacher. I am currently completing a piece of research for my Doctoral Thesis of Doctor of Mathematics Education at Curtin University of Technology.

Purpose of Research

In this study I want to teach in a different way that makes the students more involved in activities. I will try to create activities where your child can learn about the world outside the school and have control over his/her learning.

Your Role

I am interested in finding out how does your child feel about the classroom activities and how effective his/her learning is going to be. I will be observing your child and his/her reactions in my class. At the end of study I will ask him/her to complete a questionnaire about the class which will take about 20 minute. During this semester there will be an interview which will take approximately 20minutes. I will ask your child questions about our class and his/her involvement in classroom activities.

Consent to Participate

Your child involvement in the research is entirely voluntary. He/she has the right to withdraw at any stage without it affecting his/her rights or my responsibilities. When you have signed the consent form I will assume that you have agreed for your child to participate and allow me to use the data in this research. If you do not want your child to participate in the study he/she will be involved in the class but no data will be collected from him/her.

Confidentiality

The information your child provides will be kept separate from your personal details, and my supervisor and I will only have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for five years, before it is destroyed.

Further Information

This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval number SMEC-08-10). If you would like further information about the study, please feel free to contact me on xxxxx or by email: xxxxx. Alternatively, you can contact my supervisor Professor Bill Atweh on xxxxx or by email xxxxx If you have any concerns about the study please feel free to talk to me or xxxxx on xxxxx or xxxxx,

Thank you very much for your involvement in this research, your participation is greatly appreciated.

Consent Form

Curtin University of Technology

Science and Mathematics Education Centre

The Effectiveness of Teaching and Learning in the Constructivist Learning Environment in Mathematics High School Classes where students are English as Second Language Learners

CONSENT FORM

- I understand the purpose and procedures of the study.
- I have been provided with the participant information sheet.
- I understand that the procedure itself may not benefit my child.
- I understand that my child's involvement is voluntary and he/she can withdraw at any time without problem.
- I understand that if my child refuses to participate in the study he/she will be involved in the class but no data will be collected from him/her.
- I understand that no personal identifying information like my child's name and address will be used and that all information will be securely stored for 5 years before being destroyed.
- I have been given the opportunity to ask questions.

• I agree for my child to participate in the study outlined to me.

Parent Signature _____ Date_____

Student Signature _____ Date_____