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EXPLORING LEARNING AND TEACHING STYLES OF MATHEMATICS AT AN URBAN UNIVERSITY IN SOUTH AFRICA

BY:
SANGHEE CHO

A THESIS SUBMITTED TO THE FACULTY OF EDUCATION, DEPARTMENT OF MATHEMATICS, SCIENCE, TECHNOLOGY, UNIVERSITY OF JOHANNESBURG, SOUTH AFIRCA, IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

SUPERVISOR: PROFESSOR KAKOMA LUNETA

JOHANNESBURG

JANUARY 2016
DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the Doctor of Philosophy at the University of Johannesburg, South Africa. It has not been submitted before for any degree or examination in any other university.

Signature

31st day of January, 2016
DEDICATION

This thesis is the completion of a prolonged, protracted and huge effort to acquire this qualification. With this reason and many others, I am ever thankful to the Lord Almighty; who granted me his wonderful grace so that I could successfully complete these studies.
ACKNOWLEDGEMENTS

First and foremost, I would like to thank God who cared for me and empowered me not only with this thesis but also throughout all the days of my life.

I would like to express my sincere thank to my Supervisor, Prof. Luneta for his help from the proposal stage to final submission. I am deeply indebted to him for his invaluable guidance, support, and patience throughout this project. Best wishes for him every success in his life and work through Christ.

I also love to thank my husband, Christiaan. His love, patience, understanding and emotional support helped me through many difficulties. Without him, I would never be where I am now.

There are many people to whom I owe a debt of gratitude. I am deeply grateful to the members of the faculty of Mathematics and Education for their assistance and support. Above all, none of this would have been possible without prayer supports from whom I love; UBF members both in South Africa and South Korea, my parent, my parents-in-law and my friends. Great thanks to all of them with sincere love.

I dedicate this thesis to the LORD with my life.
ABSTRACT

A conventional lecture course may be helpful to efficiently disseminate a huge body of content to a large number of students. However, it is possible for students to become passive recipients of knowledge. As a result, the traditional lectures can often produce undergraduates without the skills needed for professional success.

One of the recent reforms in mathematics education was the movement towards a student-centered instructional approach. Within this perspective, differences of students can be considered as resources for effective learning and teaching mathematics and learning and teaching style have been given great attention.

There has been much debate about the relationship between, and effectiveness of learning styles and teaching styles. Regardless of the inconsistent results from two constructs, there are many benefits for being aware of learning and teaching styles. It can lead to the improvement of various areas of learning and teaching; provision for different views of learning and teaching; aid for the learning process or enhancement of lecturer training, development and assessment. Considering the diversity of students’ backgrounds and abilities in South Africa, an awareness of the value of learning and teaching style will be helpful for more balanced instruction.

This study sought to weigh the extent to which such a vision exists in the reality of teaching and learning at university, within the context of the relationships between learning and teaching styles. The learning styles of students and the teaching styles of lecturers in mathematics class were examined at an urban South African university. An explanatory sequential mixed-methods approach was used to identify the prominent learning and teaching styles; and to provide different views of learning and teaching for a balanced instructional approach. The sequential explanatory mixed-methods design called for an initially round of quantitative data collection, which was followed by a qualitative bout of data collection.
The quantitative and qualitative analysis shed some light on the relationship between learning and teaching styles for developing balanced instruction to enhance students with multidisciplinary skills. These analyses also provide a view based on learning-conducive environment where lecturers and students perform the integrated mathematics tasks.

From three phases (quantitative, qualitative and integrated analysis), two ways to promote a balanced instructional approach were obtained. Firstly, mathematical tasks should be authentic and meaningful. Given that most courses related to science and mathematics are favourable to ‘intuitive’ students, authentic problems linked to everyday life motivate students, especially the majority of ‘sensing’ students. Using authentic and real-world examples is considered as essential to mathematically empower students with multidisciplinary skills.

Secondly, students are to be familiar with abstract and conceptual-oriented problems in a holistic way. Formal education engages in a logically ordered sequential progression from concept to concept, which is favourable to ‘sequential’ students. Yet concrete aspects in handling the corresponding abstract objects in a holistic way are highly valued in any academic field. In a sense, students should be able to perceive and manipulate concepts and methods through a visual image in both sequential and global way. To lead students to the level where they can make out what they are doing beyond the sequential comprehension, many new attempts would be constructive: open-ended problems and exercises; the overall conceptual framework with visual symbols; presenting problems before offering explanations; deep consideration of the connections between concepts; or contextualised and relevance-tied up concepts.

Given that the university students in this study favour to learn mathematics in a collaborative and participatory way (‘collaborative and participant’ learning style); group-based works are advisable and more collaborative-oriented environment might motivate and accommodate more students. Yet many students did not take full responsibility of their learning (‘Dependent’), which was compatible with the fact that most lecturers used
traditional, teacher-centered styles in university settings. The needs to endorse students to be independent were found from both students and lecturers: ‘to work increasingly with less structured teaching materials and with less reliance on lecturers. To create learning-conducive environment, students should vigorously and reflectively engage in the learning process which leads to active and effective teaching

The results of identifying individual learning and teaching style were doubtful in terms of what they produced. It would be appropriate to consider that learning and teaching style are processing states rather fixed traits. They are affected by their affective characteristics, the nature of subject or topics, and their studying methods and educational philosophy. If lecturers use specific methods and aids in certain mathematics classes respectively — such as the incessant lecturing, the considerable use of visual representations and giving students many opportunity to discuss — could have a great bearing on how students view what they prefer. Any attempt to implement changes in instructional processes should reckon with the interaction between students’ learning style and lecturers’ teaching style along with affective factors (their belief, emotional factors and attitude).
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CHAPTER ONE
INTRODUCTION

The development of mathematical proficiency has been emphasised not only at the level of individuals, but also in the broader society (Groves, 2012). Mathematics lies at the heart of science and technology and a lack of proficiency impacts on the economic performance of societies (Hanushek & Woessmann, 2011). Few would argue about the importance of mathematics skills. It is seen as a basic driving force behind international competitiveness, innovation, and economic productivity and growth.

However, many gaps in the supply of, and demand for, mathematically trained workers in a technical and knowledgeable society present crucial economic and social problems along with the continuing imbalances in the gender and racial composition of workforces (Rask, 2010). In reality, the quantity and quality of undergraduate students’ experiences have been heavily hindered by many conditions; outdated and traditional approaches to instruction, high rates of attrition, and inability to cope with student diversity, and so on. Faculty classroom practices in many occasions have retained a traditional lecture orientation (Jeffrey, Walczyk & Ramsey, 2003, p. 566) and instructional change, or lecturing environments, have moved at a glacial pace (Gess-Newsome, 2008, p. 2).

Taking these challenges into account, a significant number of university mathematics departments are more aware than ever of their need to develop effective and innovative curricula and instructional practices. The innovation needs to be capable of supporting students in developing deep conceptual understanding of important mathematical ideas as well as productive dispositions. (Bok, 2008; Rasmussen & Kwon, 2007). How to accomplish this vital task is an open question that offers an opportunity for mathematicians and mathematics educators to work together on the problems of learning and teaching. As a result, what students learn and how they are taught in mathematics courses at university have for many years occupied educators (Mccray,
Dehaan & Schuck, 2003) and there have been numerous calls for reform in mathematics education.

In fact, a quiet revolution has been taking place for the last 20 years in mathematics pedagogy (Brown, 2010, p. 2). One of the recent reforms in mathematics education is the movement towards learner-centered teaching (Brandt, Lunt & Rimmasch, 2012, p. 354). From the learner-centered approach to teaching mathematics, learners are learning mathematics by doing it; they take part actively in acquiring their own mathematical skills and knowledge (Flores, 2010, p. 75). Although a conventional lecture course may be helpful to efficiently disseminate a huge body of content to a large number of students, it is possible for students to become passive recipients of knowledge. They are not involved in the process of learning (Michel, Cater III & Varela, 2009). As a result, the traditional lectures can often produce undergraduates without the skills needed for professional success (Abdulwahed, Jaworski & Crawford, 2012).

Bressoud (2011) argues that “Sitting still, listening to someone’s talk, and attempting to write down what they heard are very poor substitutes for actively engaging with the material and at hand, for doing mathematics”. The Mid-continent Regional Educational Laboratory mentioned the properties of learner-centered teaching as follows (Kilic, 2010, p. 81):

- Emphasises tasks that attract learners’ various interests,
- Contains clear opportunities that let all learners develop their own learning skills and progress to the next level of learning,
- Includes activities that require the students to understand and improve their own viewpoints.

In the light of these properties, it is important for mathematicians and mathematics educators to take into account such diversity in their students’ learning styles and to acclimatise their teaching styles to suit (Louange, 2007). Hence, this study intends to weigh the extent to which such a vision exists in the reality of teaching and learning.
mathematics at university, within the context of the relationships between learning and teaching styles.

1.1 Background to the Study


With regards to the decreasing mathematics pass rate and poor mathematics skills, several aspects have been suggested and examined; general poverty of the school environment, lack of suitable learner support materials, the poor socio-economic background of learners, teachers’ inadequate subject knowledge and poor motivation, linguistic diversity in the classroom, and an inadequate study orientation (Maree et al., 2006, p. 230). Taking the situation in South Africa into account, no one can deny the need for shifts and improvements in mathematics education to make learners science-and-math literate and to meet the requirements of current global markets.

Many improvements have tried to reach a much anticipated stage especially in the developed countries, which require that lecturers make use of learner-centered methods that have various names, such as inquiry-based learning, discovery-based learning, , project-based learning and conceptual understanding in mathematics (Abdulwahed et al., 2012).
At the heart of these ideas is the notion that increased learning will occur where the knowledge and experience of learners are to be utilised in the learning process and where the learners interact with each other and reflect on the subject matter (Kolb, 1984, p. 38; Lewis & Williams, 1994, p. 6). In this context, teachers are not viewed as knowledge deliverers but as facilitators who provide prompt and constructive feedback on student performance and create a learning-conducive environment (Jeffrey et al., 2003; Kilic, 2010). Given that a learner needs to be regarded as an active participant, there has been a big struggle to teach learners from different backgrounds (Sadker, Sadker & Zittleman, 2006), because one cannot adopt a one-size-fit-all approach. Educational researchers and practitioners have consequently been giving greater attention to individual differences; learners’ ability, interests, self-efficacy, motivation, learning styles, teacher knowledge, teaching styles, and so forth.

There are many studies that focus on how a learner’s individual ability to learn as well as the learner’s type of character provide a better understanding of what he or she chooses; or how he or she is inclined to approach a learning situation. All these factors can lead to improved student attitudes (Prince, 2004, p. 7; Preszler, Dawe, Shuster & Shuster, 2007) and increased learning outcomes (Freeman et al., 2007; Wright, 2011).

As mediating variables, learning styles and teaching styles have been an important point over the last 40 years (Clark & Latshaw, 2012, p. 67), and are considered essential characteristics of the aggregate educational processes (Graf & Lin, 2008; Kolb & Kolb, 2009; Syler, Cegielski, Oswald & Rainer, 2006). Yet questions about the congruence of learning and teaching styles and the potential for flexibility in their use have surfaced (Brown, 2003, p. 3). There are no conclusive results and inconsistencies exist as to whether a "matching" between learning style and teaching style produces better outcomes" (Gilakjani, 2012, p. 53).

A substantial number of studies show that student achievement has improved, as indicated by course grade and exam scores, when there was a match between students' preferred learning styles and instructors’ preferred teaching styles (e.g., Charkins,
O’Toole, & Wetzel, 1985; Gilakjani, 2012; Clark & Latshaw, 2012). On the other hand, several researchers concluded that there was no significant relationship between style match and an improvement in academic outcomes (e.g., Coffield, Moseley, Hall, & Ecclestone, 2004b; Tucker, Stewart & Schmidt, 2003). Some researchers mention the reasons why the achievement is not improved; i.e. that student efforts were ignored (Clark & Latshaw, 2012) or the inventory is not well designed (Dembo & Howard, 2007, p. 107). However, regardless of the relationship between the matching styles and the improvement in academic outcomes, many researchers note the importance of matching teaching with learning styles (O’Dwyer, 2008; Larkin-Hein & Budny, 2001; Felder, & Spurlin, 2005) and address the benefits of raising awareness of learning styles and teaching styles. These are as follows:

- Helping practitioners and educators accommodate a variety of learning and teaching (Peacock, 2001, p. 4)
- Providing lecturers and students with a different view of learning and teaching within the classrooms (Abu-Asaba, Azman & Mustaffa, 2014, p. 573)
- For educators to aid the learning process (Gokalp, 2013, p. 1636)

Felder points out that the learning and teaching style model is practically very helpful if balancing instruction on each dimension meets the learning needs of all students in a class (1996, p. 8). Considering the diversity of students' backgrounds and abilities in South Africa, it is necessary to know students' learning styles and lecturers' teaching styles at university level. Van Rensburg (2009) also agrees that educators should incorporate diversity into their model of teaching by acknowledging learning style as student individuality.
1.2 Significance of the Study

Many studies have been conducted to identify learning styles that are more acceptable to the learning of other subjects, while in mathematics there seems to be very little effort in that direction (Sloan, Daane, & Giesen, 2002; Louange, 2007; Moutsios-Rentzos & Simpson, 2010). There are some studies that used mathematics scores as predictors of academic success (e.g., Brookshire & Palocsay, 2005; Smith & Schumacher, 2006). Yet, studies on the relationship between mathematics performance and learning and teaching style are still limited and there is very little empirical research at the collegiate level that describes and analyses the practice of mathematics (Speer, Smith III & Horvath, 2010, p. 99). It was appropriate to discover whether there are specific learning styles and teaching styles in a university mathematics classroom and to examine whether there are teaching styles which lend themselves best to understanding students’ learning styles and to enhancing students’ performance.

Hence this study was initiated by a sense of wanting to know what is really happening in mathematics classrooms with respect to learning and teaching styles. It endeavoured to examine the interplay between them. Such knowledge will be valuable in providing an appropriate outline, which will act as a foundation for further improvement in the balanced teaching and learning of mathematics at university. The findings that could be generated through this study can have certain benefits for teaching and learning mathematics in this country. It may address the gap in the quality of schooling received by students from various backgrounds.

1.3 Theoretical Framework

Many researchers agree that the ideal classroom situation described by contemporary literature is in contrast to current mathematics classroom (Ball, 1993; Hiebert & Wearne, 1993; Stein, Grover, & Henningsen, 1996; Wood, Cobb & Yackel., 1991). Although researchers and mathematics educators support a constructivist view of learning
mathematics, the environment of real classroom is still dominated by the traditional transmission view of knowledge (Wood et al., 1991). Classrooms are filled with many dynamics and complex factors that could be responsible for students’ learning and outcomes.

Student learning is influenced by many variables which educational research is tasked with determining and which feed into the teaching-learning process to enhance its effectiveness. Several studies with different populations have determined how and what variables significantly influence learners’ mathematics performance on the primary and secondary level (e.g., Nenty, 2010; Castro, Pérez, Pérez, García, & García, 2012; Al-Agili, Mamat, Abdullah, & Maad, 2012).

In terms of academic performance at college, numerous studies examined contributing factors of overall academic success (Rhodd, Schrouder & Allen, 2008, p. 58). Some of these studies focus on variables that attempt to measure students’ intellect, while others focus more on non-intellectual variables, such as students’ personality traits, behavioural tendencies, and demographic characteristics. Intellectual variables, such as high school marks, various measures of writing, and technology skills are proving to be functional predictors of overall academic achievement for college students (Willingham & Morris, 1985; Cabrera, Nora & Castaneda, 1993; Eimers & Pike, 1997). The non-intellectual variables including behavioural, demographic, and personality descriptors have also been shown to increase the predictability of success (Wolfe & Johnson, 1995; Nonis, Philhours, Syamil & Hudson, 2005; Ullah & Wilson, 2007).

With regards to the influential variables in mathematics education, Nordin (1992 as cited in Fairus Mokhtar, Yusof & Misiran, 2012) stated that three prominent factors contribute to mathematics learning:

1. Students’ psychological traits such as attitude, anxiety, and other affective factors
2. The mathematics curriculum which may have failed to reflect much relevance to real life application
(3) Qualification and attitude of lecturers that may have failed to cater for students’ individual differences.

According to Suthar, Tarmizi, Midi & Adam (2010), the understanding of the issue, knowledge, skills and commitment of teachers are keys to success in mathematics. There are many studies that find a positive correlation between mathematics achievement and environmental factors, such as interest, attitudes, and peer influence (Fairus Mokhtar et. al., 2012, p. 4133). Even though written accounts of collegiate mathematics teaching exist (e.g., mathematicians’ reflections and analyses of learning and teaching in innovative courses), very little empirical research has described and analysed the factors influencing learning in tertiary contexts (Speer et al, 2010, p 99).

Since declining performance in mathematics is matched by declining numbers of graduates (Steen, 1987, p. 251), a broad spectrum of mathematics educators and mathematicians give a general consensus on: learners’ active engagement in a broad range of mathematical topics, conceptual understanding of the mathematical problems, application of mathematics to real-world situations, and extended discussions of mathematical ideas (Clint, 2012; Gehrke, Knapp & Sirotnik, 1992).

Given that ‘active engagement in learning’ has received notable attention over the past several years (Ali, Jusoff, Ali, Mokhtar & Salamat, 2009), active learning in the undergraduate classroom, as one of influencing variables, involves students doing things and thinking about what they are doing (Bonwell & Eison, 1991, p. 19). It involves the students in solving problems, formulating questions of their own, answering them, and discussing, explaining, debating, or brainstorming during class. Since active learning wakes students up, it leads to not only better student attitudes and achievement but also to improvements in students’ thinking and writing (Felder, Rugarcia & Stice, 2000, p. 208)

The figural representation of active learning developed by Renzulli and Dai (2001) includes learning styles and teaching styles. According to their representation, individual
learners “differentially and selectively attend to and process learning materials based on their prior knowledge, understanding, values, attitudes, styles and resultant motivation” (Renzulli & Dai, 2001, p. 23). At the same time in order for active learning to take place, teachers need to pay close attention to learners’ prior knowledge, motivation, and other characteristics. In a sense ‘style’ can be regarded as one of the influencing variables on academic achievement.

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<td>• Attitudes modified</td>
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Figure 1 Conceptual Framework of Teaching & Learning
(Dunkin & Biddle, 1974)

Dunkin and Biddle (1974) developed a model for investigating the complex phenomenon of teaching and learning. In their model, Dunkin and Biddle addressed the
process of teaching and learning involving four major variable types: presage, context, process, and product (See Figure 1).

As their model indicated, the learning styles of students have been found to affect the educational process and students’ opportunity to learn (Schroeder, 1993; Stripling & Robert, 2012). This implies that effective learning and teaching may depend on how much instructions are designed based on learning and teaching styles. It is because learning and teaching styles are closely linked to learners’ attitude. For instance, if teaching is a single approach and method, then most students develop a negative attitude (Goodykoontz, 2008). The teachers who are aware of their students’ learning styles and design their teaching materials and teaching methods according to them can help students develop positive attitudes.

Many other researchers support the idea that learning style is influential in academic achievement (e.g., Allers, 2007; Clark & Latshaw, 2012; Court & Molesworth, 2003; Iurea, Neacsu, Gerogiana, Suditu, 2011; Peacock, 2001). There are studies which indicate that improved learning may occur when teaching styles match learning styles as opposed to when they are mismatched (e.g., Schmeck, 1988; Fleder & Brent, 2005; Borg & Stranahan, 2002; Komarraju, Karau, Schmeck & Avdic, 2011; Fenton & Ward Watkins, 2014).

These studies point out that learning styles cannot be used to label individual students as they do not describe ability to acquire mathematical knowledge but rather learners’ cognitively established preferred way of comprehending and acquiring mathematical knowledge. The Lecturers however would be at an advantage if they knew their learners’ learning styles. The problems have always been that there is a variety of learning styles in a single mathematics classroom. The question any critical reader would pose would be – is there an “average learning styles” that a teacher can hinge his or her teaching to accommodate the majority of the learners? Research (Battalio, 2009; Carver, Howard, & Lane, 1999; Peacock, 2001; Dreyer, 1998; Iurea et al., 2011; Novin, Arjomand, & Jourdan, 2003) show that there is a learning style that is predominant among most learners.
The adoption of the cyclic component of teaching and learning in addressing learning styles ensures that whichever teaching style the teacher adopts in the classroom, majority of the learners will benefit from the instruction (Busch, 2009), whether it is preferred learning styles or less preferred styles. Figure 2 below explains the cyclic nature of the curricula (Teaching /learning strategies, Content, Student assessment and student learning outcomes). The figure also illustrates teaching and learning styles and how each component relies on the other for effective signage.

Busch explains the cyclic nature of the curricula. The cycle shows that teaching and learning strategies/styles are informed by the content to be taught or learnt. The content being taught must be well assessed in order to obtaining good learning outcomes. The process consists of three phases namely planning, implementation and reflection.
During the implementation phase learning takes place through interactions between a teacher and students or among students themselves. If during the reflection phase it is discovered that learning did not take place or some of the learning outcomes were not achieved, then either one or all four parts of the curriculum can be reviewed and revised during the reflection phase for future implementation and restarting of the learning/teaching cycle (2009, p. 213).

In adhering to the cyclic representation of teaching and learning, the lecturer enables students to understand information presented both visually and verbally and acquire both the systematic analysis skills and the multidisciplinary synthesis skills (Felder & Spurlin, 2005, p. 62).

If lecturers teach exclusively in a manner that favours their students' less preferred learning style, the students' anxiety may increase enough to interfere with their learning. On the other hand, if lecturers do exclusively cater to their students' preferred modes, the students may not develop the mental dexterity required for them to reach their potential (Felder, 1996, p. 1).

Students require multidisciplinary skills to function effectively as active participants in the teaching and learning process. Multidisciplinary skills require students to learn how to function not only in preferred but also less preferred modes of learning. To facilitate and promote this complex and intellectual work, teachers also need to change or adapt their teaching methods and approaches (Reys, Lindquist, Lambdin, Smith, & Suydam, 2007), which is itself closely related to students' learning styles, not only to cater for students of various learning styles but also to empower students' learning. The most important application of learning styles and teaching style is to develop a balanced instructional approach that addresses the learning needs of all of students (in Kolb model terms, to teach around the cycle) (Felder & Brent, 2005).
Hence, the researcher proposes a theoretical framework that incorporates these two elements in an interactive relationship (See Figure 3). The diagrammatical representation of the model is a hypothesized relationship of the learning style, teaching style and other factors based on information extrapolated from literature and research about the envisioned learning and teaching of mathematics. A learner employs his/her preferred learning style when engaging the learning process, which are facilitated and transmitted through a preferred and less preferred teaching style. Both teaching style and learning style are variable in nature, as they are impacted upon by other factors (Environment, Content and other social factors). Factors which influence the learning process are categorised under the umbrella of ‘Other factors’. The ideas presented up
till now were derived mainly from contributions through the literature review; hence they are guided by the theoretical framework before the main data collection stage.

1.4 Purpose of the Study

In classroom settings students are all different and have various learning preferences. They may not be equally likely to succeed in the mathematical domain, since they respond differently to different instructional approaches and the predominant mode of instruction favours some learning styles over others. Any approach that aims to accommodate certain types of students would probably be more efficient, but at the same time it would fail to address the needs of most students. Understanding differences in learning styles and considering various relevant and appropriate teaching styles are thus an important step in balanced teaching and learning. In other words, teaching around the cycle (Felder & Brent, 2005, p. 60), all-around learners (Brown, 2003; Gilakjani, 2012) or holistic instruction (Bernold, Bingham, McDonald & Attia, 2000; Ngambeki, Thompson, Troch, Sivapalan, & Evangelou, 2012) are all relevant.

In the light of taking a balanced approach to teaching and learning, this study explores the learning styles of students and the teaching styles of lecturers in mathematics classes at an urban university in South Africa. Hence this study will gather data through: 1) questionnaires designed for mathematics lecturers (i.e. to gather information on their teaching styles) and students (i.e. to gather information of their learning styles); and 2) interviews with lectures and students that aim to provide evidence about the nature and relationships of certain mathematics teaching and the resultant learning phenomena.

The purpose of this study is to:

1. Identify the dominant mathematical learning styles exhibited by mathematics learners and the teaching styles employed by mathematics lecturers at an urban university in South Africa.
2. Provide learners and lecturers with different views of learning and teaching in order to facilitate a more balanced instructional approach.

For this purpose, an explanatory sequential mixed-methods approach was used to identify the prominent learning and teaching styles; and to provide different views of learning and teaching for a balanced instructional approach. The sequential explanatory mixed-methods design called for an initially round of quantitative data collection, which was followed by a qualitative bout of data collection.

1.5 Research Questions

1. What are the dominant learning styles and teaching styles exhibited in mathematics classes at an urban university in South Africa?
2. What are the suitable teaching styles that effectively address these learning styles?
3. What can be done to reach out to students whose learning styles are not addressed by the common instructional approaches in mathematics classes?

1.6 Definition of Terms

Learning Style:

On account of the diverse nature of learning styles, no single definition has been sufficient to capture the essence of what is meant by the term. According to Cassidy (2004, p. 421), learning style may have both a structural trait (fairly fixed characteristics of individuals) and a processing state (making efficient use of individual strengths and limitations). In light of a structural trait, learning style can be defined as the characteristic strengths and preferences by which learners take in and process information and adapt his/her environment (Felder, 1996). On the other hand, it can be
defined as learners’ role in interaction with peers, teachers and course content, as a processing state (Grasha, 1996).

**Teaching Styles**

Teaching style refers to “the distinct qualities displayed by a teacher that are persistent from situation to situation regardless of the content” (Conti, 2007, p. 76). It is the expression of the totality of one's philosophy, beliefs, values, and behaviours (Jarvis, 2004, p. 40).

**1.7 Ethical Consideration**

This study complies with all academic and research ethics as stipulated by the Senate Committee of Academic Ethics.

For some of the questionnaires, the participants were informed of the aim and the purpose of the study. Anonymity and confidentiality was guaranteed in all cases. The participants, both lecturers and students, were informed of the results of their learning and teaching styles respectively. Confidentiality was also guaranteed by allocating numbers (not student numbers) to students for public use of the collected data.

**1.8 Structure of the Study**

**Limitations of the Study**

One of the limitations of this study is the size of the population which could have influenced the extent to which generalisations could be made. This study was concentrated at one university and using the findings of one university is not sufficient to generalise the results even though might be homogeneity among a large group of
learners. Another limitation could be the type of learning style inventory used. Although two inventories were used, a more accurate picture of university students’ learning preferences might have been discovered if the learning style inventory had been designed specifically for mathematics. Then there is controversy issues related to theories of learning style (Coffield et al., 2004a) and teaching style (Grasha, 1996). The only assumption of learning style and teaching theory which was supported by the results of this study is that there are individual differences in learning and teaching.

This research was divided into 5 chapters.

Chapter 1 has introduced the background to the study that gives an overview of the background to the problem and argued for the significance to conduct the study. The theoretical framework is given and listed the research questions.

Chapter 2 has theoretical framework. In this chapter an extensive literature review is conducted where the core concepts (learning styles and teaching styles) are discussed in detail along with other influential variables on learning mathematics.

Chapter 3 has research design and research methodology. The research design (sequential explanatory mixed method design) and the process of data collection are discussed according to quantitative and qualitative mode.

Chapter 4 has data analysis. All quantitative and qualitative data are collected and analysed and the appropriate techniques are used to process the data. Meta inferences are drawn relevant to the research problems.

Chapter 5 has discussion of results, conclusions and recommendations. The findings of the research are discussed.
CHAPTER TWO
REVIEW OF LITERATURE

2.1 Introduction

The aim of this chapter is to present a theoretical and conceptual framework for this study. Theoretical frameworks provide a particular perspective, or lens, through which to examine a topic and specify the assumptions and beliefs of a researcher about his or her study. Conceptual frameworks include the systematic concepts, assumption, expectations and beliefs that support and inform a study. In an attempt to understand possible causes for insufficient educational outcomes and to improve current situations, it is important to consider the theories of learning mathematics. It includes explanations of observable phenomena when learners are trying to construct their understandings of mathematics concepts; what is considered to be effective and efficient teaching from different perspectives; and to examine the important aspects of learning and teaching styles as individual differences in an educational context along with other influential factors.

Traditional methods of mathematics instruction in higher education have been long embraced: non-interactive ways of teaching mathematics (ways in which the student is the receiver of delivery from the teacher, but only minimally a participant) (Alsina, 2001; Brito et al., 2009; Hillel, 2002; Smith & Wood, 2000). This conventional approach is seemingly dominated by theory without addressing the needs of most students (Abate & Cantone, 2005). However calls for reforming mathematics instruction rooted in constructivist theory have been increased in order to improve learners' conceptual understanding (Abate & Cantone, 2005; Chang, 2011; Jaworski, 1994; Mokhtar, Tarmizi, Fauzi & Ayub, 2010). In this regard, there was a shift of trends in teaching and learning from Behaviourism, passing through Cognitivism, towards Constructivism (Duit & Tregast, 1998; Ertmer & Newby, 2013; Cooper, 1993).
2.2 Theories of Learning and teaching

2.2.1 Behaviourism and Cognitive Learning Theory

With regards to the problem of human learning, theories are conventionally divided into two categories – behavioural and cognitive theory followed by constructivism. These viewpoints overlap in various ways, but they are distinctive enough to be regarded as separate approaches to understanding and describing learning (Ertmer & Newby, 2013, p. 46).

Learning was long considered to be “an accumulation of atomized bits of knowledge that are sequenced, hierarchical, and need to be explicitly taught and reinforced” (Earl & Katz, 2006, p. 3). Behaviorism offers a particular and foundational perspective on how learning occurs and how teaching impacts on the learning process. The assumption of behaviourism is that if students are motivated and teachers speak clearly, learning will take place. It emphasises the ways in which external stimuli influence learning and leads to drill and practice. It is important to manipulate external rewards and incentives, and to create classroom structures that guide and direct the learners’ response so that learning takes place effectively. The importance of including behaviourism in mathematics education was stated by Ernest (2010): behaviourism represents one of the milestones that portray the development of learning theory, starting from individualistic and scientific to socially, since it was the historically leading theory of education.

While behaviourism focuses on the external behaviour of the learner, cognitive theory, on the other hand emphasises the acquisition of knowledge and the mental structures and cognitive process (such as knowledge representations, thinking, memory and perception). It stresses the conceptualisation of learning process and addresses issues of how information is received, organised, and retrieved by the mind. Although these internal structures and process are extremely rich and complex, understanding them will
yield significant insights into the ways that thinking and learning takes place (Schoenfeld, 1987, p. 2).

In the cognitive perspective, learning is concerned not so much with what learners do but with what they know and how they come to acquire knowledge (Jonassen, 1991). The learner is seen as a very active participant in the learning process, transferring and assimilating new information (Wilson & Peterson 2006, p. 2). Shuell states that cognitive psychology has significantly influenced learning theory and research in numerous ways: (a) the view of learning as an active, constructive process; (b) the presence of higher-level processes in learning; (c) the cumulative nature of learning and the corresponding role played by prior knowledge; (d) concern for the way knowledge is represented and organised in memory; and (e) concern for analysing learning tasks and performance in terms of the cognitive processes that are involved (1986, p. 415).

Piaget was interested in the study of the nature of knowledge. He developed the various stages of development (‘Sensorimotor stage’, ‘Preoperational stage’, ‘Concrete operations stage’, and ‘Formal operations stage’) from birth to adulthood where each stage offers descriptions of cognitive development. These stages of cognitive development are given equal acceptance and criticism by cognitive psychologists and educationalists. The main argument is that many of his theories have not been backed up by empirical data (Brown, 1998, p. 122). However, his work on the quantitative development has provided mathematics educators with crucial insights into how people learn mathematical concepts and ideas (Ojose, 2008, p. 26).

Although cognitive psychology redirected its research away from learning between the 1960s and 1980s, it occasionally acknowledged the importance of learning. As a result the cognitive view of learning was criticised to be vague, abstract and lacking a substantive data base (Voss, 1978, p. 13). A number of contemporary cognitive theorists have begun to question this basic objectivistic view and have started to employ a more constructivist approach to learning, where knowledge “is a function of how the
individual creates meaning from his or her own experiences” (Jonassen, Davidson, Collins, Campbell & Haag, 1995, p. 11).

2.2.2 Constructivism

The shift to a constructivist approach has led to increased attention being given to personal interpretations of the world based on individual experiences, knowledge and interactions. Although two learners might be exposed to exactly the same information in the same way, they build up their understanding in different ways as active participants. The different ways of assimilating information happens because the individual develops tension and anxiety, called cognitive conflict that is a basic component of the learning process (Rowell & Dawson, 1979). Good instruction tastily enables learners to think in order to settle their disturbed state in relation to their prior understanding.

In constructivism, the learner, as an interpreter of the world, constructs new ideas or concepts based upon his/her past and current knowledge, social interactions, and motivations. In other words, new learning builds on prior experience and knowledge. In making the effort to appropriate new information, learners attempt to connect old knowledge with new information (Cooperstein & Kocevar-Weidinger, 2004, p. 142). In contrast to the behaviorist argument, even though the learner is sitting still and is quiet, there is no guarantee that his or her mind is actively engaged in learning. Every interaction with the learner doesn’t mean that learning is taking place. (e.g., Mathematics Learning Study Committee, 2001). Learning is viewed as a process of constructing understanding, during which individuals attempt to connect new information to pre-knowledge, so that ideas have some personal coherence. Individuals construct this understanding in many different ways, depending on their interests, experience, and learning styles (Earl & Katz., 2006).

Constructivism asserts two main tenets as expressed by von Glasersfeld (1989b, p.162): (1) knowledge is not passively received but actively built up by the cognizing subject;
and (2) the function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality. Ernest assumes that the first tenet is the fundamental principle on which ‘simple constructivism’ rests and represent a significant step for construction of knowledge (2010, p. 40).

Constructivism is approached from different perspectives: personal (Kelly, 1995, & (Piaget, 1972), radical (Von Glasersfeld, 1985), social (Vygotsky, 1978), critical (Taylor) and contextual (Cobern, 1991). Radical constructivism came from the idea that the cognitive construction continues adaptation to the experiential world for the clearer concepts or mental precepts (Belbase, 2011). Von Glasersfeld uses Spencers’ formulation of the ‘Theory of Evolution’ as a mechanism for the construction of knowledge (1989a). The mind is like an organism that experiences continuous evolution like Darwin’s theory of natural selection. The main difference between the evolution of concepts and biological evolution of species is that with the evolution of concepts it is possible for concepts to adapt through the process of accommodation and assimilation of new experience (Giannakopoulos, 2012).

Ernest claims that radical constructivism values multifaceted pedagogy to individual construction (1995). The role of the teacher in radical constructivism (a facilitator or a guide) is assuming “to provide guidance for knowledge construction of the students that is tentative not towards absolute determination” (Von Glasersfeld, 1990, p. 37). This clarifies that the teacher cannot dictate for one right answer, but he/she can help students for possibilities of multiple solutions to a problem. It will be critical for the teacher to create an environment in which students are given enough opportunities to develop their ideas through participation in activities, experiments, or observations. The role of students in radical constructivism (constructors or co-constructors) is active participation. Not just following the teacher’s instruction, they need to explore ideas themselves with fellow students and the teacher in active participation. Students and the teacher do not only seek right answers to a problem, but they distanciate from the problem with possible perspectives, theories, and philosophy (Belbase, 2011).
Cobb (1990 as cited in Belbase, 2011) summarized the five points of the effectiveness of radical constructivism in mathematics learning and teaching: (1) learners’ construction of mathematical ideas relies on their prior experiences. Students can construct mathematics by themselves without any cooperation of experienced peers or adults; (2) when learners acquaint with new knowledge they actively construct and reconstruct upon their ideas or prior knowledge instead of internalization which is linked to the repeated practice; (3) there may not be a fixed pattern or sequence of learning mathematics – like learning a rule at first and then applying it in context. The opposite can also be true, that is learning from context or experiences and deriving a rule from it; (4) it is important for students to have flexible and reasonable learning opportunities. However, the teacher should be cautious about students’ personal constructs which sometimes might mislead them to a wrong assumption and solution to a problem; and (5) radical constructivism has many ideas to offer in teaching and learning of mathematics that social constructivism does not offer.

These qualities of radical constructivist teaching and learning mathematics can produce various ideal methods that focus on individual creative construction rather than teacher’s imposition. In a sense, the learners’ differences can be considered resources for effective learning and teaching mathematics, and not as obstacles that need to be overcome. In the past, the differences between learners were considered as being fixed conditions that determine how much and how fast a learner can learn. And yet if teachers insist on a single way of learning or thinking, learners’ differences are deficits problematizing the process of developing knowledge.

However another fundamental problem was raised by the theory of radical constructivism: (1) how to account for the social aspects of learning mathematics. The social domain including cultural factors, linguistic factors, interpersonal interactions, and the role of the teacher cannot be ignored; and (2) how to reconcile the private mathematical knowledge, skills, learning, and conceptual development of the individual with the social nature of school mathematics and its context, influences and teaching. One approach to this problem is to propose a social constructivist theory of learning.
mathematics. This is a theory which acknowledges that both social processes and individual sense making have central and essential parts to play in the learning of mathematics.

While radical constructivism sees the individual as a meaning-maker, social constructivism sees ‘meaning as first sociocultural to be internalised by the subjects’ regulation within discursive practice’ (Lerman, 1996, p. 147). Social constructivism is based on the idea that knowledge construction is a social activity rather than an individual process. The fundamental principle of social constructivist theory is linked to Vygostsky’s theory of the Zone of Proximal Development (ZPD) (Wertsch 1988, p. 67). According to the ZPD theory each individual possesses certain knowledge (core knowledge) at a given time in her or his life which assists to perform tasks of a certain level of complexity. Individuals can deal with tasks of higher levels of complexity while associating with more knowledgeable peers/adults and during the process they will be able to acquire more knowledge (area between the two concentric circles). In practice learners gain the understanding in a different way through thinking that construct his or her knowledge rather than from what is transmitted by the teacher.

With respect to knowledge acquisition from this perspective, Jonassen (1992) introduces three stages of gaining knowledge: the introductory, advanced and expert (see Figure 4).

In the introductory stage, the learners have very little directly transferable prior knowledge about a skill or content area. The second phase of knowledge construction is the advanced knowledge acquisition where the learner acts as an apprentice and is able to solve more complex problems, domain or context dependent. Expertise is the last phase whereby the learner has acquired more rich interconnected knowledge structures. Constructivist learning environments are most appropriate for advanced knowledge as experts need very little instructional support (Jonassen, 1992).
The prime focus of learning/teaching in the social constructivist view is to engage learners in productive mathematical thinking, analysing, and synthesizing of new ideas through the social construction of knowledge. Since there is no simple and best rule for pedagogical practices or choices in order to foster constructivist learning, the active participation of learners in the mathematics classroom is emphasised to construct knowledge. “Constructivist classrooms are structured in such a way that learners are immersed in experiences within which they may engage in meaning-making inquiry, action, imagination, interaction, hypothesizing, and personal reflection” (Gray, 1997, n.p.).

Cobb, Wood & Yackel (1991, p. 162) state as follows in terms of social interaction in class:
Constructivism, at least as it has been applied to mathematics education, has focused almost exclusively on the processes by which individual students actively construct their own mathematical realities. However, far less attention has been given to the inter-personal or social aspects of mathematics learning and teaching. How does mathematics as cultural knowledge become “interwoven” with individual children’s cognitive achievements? In other words, how is it that the teacher and the children manage to achieve at least temporary states of inter-subjectivity when they talk about mathematics?

The fundamental work in mathematics class should be an integrated elaboration of the role of individual processes of constructing as well as the processes of social interaction in the class (Cobb, Yackel & Wood, 1992, p. 28; Bauersfeld, 1992, p. 467). In other words, inter-subjective construction of shared knowledge should be recognised and accepted in a mathematics classroom.

In this regards, multiple approaches are appropriate for teaching and learning mathematics and it should depend on student numbers, available resources, and the general trend in the school system. Social constructivist learning is effective in small class sizes where there are enough resources to use and enough time to engage students in creative and constructive activities.

The following is a summary of commonalities of constructivism as a learning theory: (1) knowledge is created by a learner, not received from an external source (Reynolds & Muijs, 2001, p. 11; Wood et al., 1991, p. 591). In this sense learners are not ‘empty vessels’ to be filled with knowledge by teachers; (2) new learning is to be based on learners’ informal and previous knowledge as a result of reinforcement or adaptation because knowledge is constructed from previous experience (Baroody & Ginsburg, 1990; Ishii, 2003; Mergel, 1998; Wood et al., 1991); (3) the ‘autonomy’ and initiative of learners in relation to what to learn, why to learn, when to learn and how to learn are promoted so that they take responsibility for their own learning (Ishii, 2003, p. 2). For
this, teachers must provide opportunities for learners to express their own thinking; (4) learners need to be aware of the goals. This awareness of goals refers to the difference of goal between teachers and learners and the need for learners to understand and value the intended goals (Ishii, 2003, p. 3) and (5) teaching involves the use of raw data and primary sources and the use of manipulative and interactive materials are usual (Ishii, 2003, p. 2; Noddings, 1990, p. 16).

Behaviourist approach is on one end of a continuum and constructivist approaches at the other end. “The position in which educators find themselves on the continuum will definitely influence the way that they teach, assess and structure a teaching-learning environment” (Du Toit & Du Toit, 2008, p. 4).

Hence, as the view of learning mathematics has been changed, the practice of teaching mathematics needs to significantly be amended. In the past a learner was considered ‘a receiver of mathematical knowledge’. Yet they are currently seen ‘a constructor to understand mathematical concepts and to apply them in other context’. This changed notion of a learner’s role has major implications for the teaching and learning of mathematics.

2.2.3 Learning and Teaching Style in Constructivism

In support of a shift to a more constructivist stance toward learning, the learners’ differences can be considered resources for effective learning and teaching, and not as obstacles that need to be overcome. With the constructivist perspective, the individualised educational experience has been given growing attention (Lubart, 2005). Robinson states in his book ‘The element: How finding your passion changes everything as follows (2009, p. 376):

The fact is that given the challenges we face, education doesn't need to be reformed -- it needs to be transformed. The key to this transformation is not to
standardize education, but to personalise it, to build achievement on discovering the individual talents of each child, to put students in an environment where they want to learn and where they can naturally discover their true passions."

Robinson points out in the National Advisory Committee on Creative and Cultural Education report (NACCCE, 1999) the importance of individual diversity for the creative and innovative education relating to economic development. Considering education as an organic system, he suggests that it is necessary to promote diversity, to foster curiosity and to awaken creativity. In his view, individualised education is essential for creative approaches to learning.

Various studies have found that individualised instruction is beneficial for slower or average students. Jones compared an individualised educational approach with a traditional average-student-oriented approach (1948). The experimental group under the individualised teaching showed significant improvement than the control group under the traditional teaching, in general and for each subject area (reading, arithmetic and spelling). Similar results were observed by Pratt and Mastroianni (1981) in a review of research on schools using individualised educational programs, which they compared with traditional control schools. Students who were individually educated gained on average four times more than students exposed to traditional approaches to education.

Having a different move to individual differences and quality education, Grigorenko, Jarvin, Sternberg and their colleagues conducted a series of studies based on the triarchic theory of intelligence (2002, p. 204). According to this theory, all individuals have analytical, creative and practical intellectual strengths which vary from one individual to another. In their study, certain students were given instruction that went well with their ability profile, whereas other students were mismatched in terms of their ability and the form of instruction they received. In general those who received the triarchic instruction not only outperformed other groups on analytic, creative and practical, performance measures but also on traditional memory–based measures of
learning. The triarchic teaching approach possibly allows students to capitalise on their intellectual strengths to learn as well as provide them with multiple ways to encode information (through analytic, creative and practical activities) that reinforces memorisation of the material.

Another noticeable point here is that individualised education cannot be carried out without considering cultural differences. It is because, firstly, creative processes draw on cultural contexts in which they take place, and, secondly, culture is the outcome of learners' creativity in all of its forms (NACCCE, 1999, p. 112). Many scholars argue that understanding the cultural differences would enable teachers to make more meaningful connections to students' communities and to employ students' experiences within classrooms (Wilson & Peterson, 2006). Although it would be impossible for teachers to cater for all of the possible relevant differences among their students, the challenge for teachers is to continuously be aware of students' differences and to adapt their instructions accordingly (Aliakbari & Feili, 2012, p. 356; Carver et al., 1999, p. 38; Dreyer, 1998, p. 125; Iurea et al., 2011, p. 260; Novin, Arjomand & Jourdan, 2003, p. 30; Hess & Frantz, 2014, p. 44).

Within the constructivist perspective, the emphasis is on learner-centeredness and a learning environment, not a teaching environment. Learning and teaching have to incorporate various kinds of practices. Many studies suggest that practices to incorporate constructivist learning are observed through a combination of certain influential factors, which include (1) how to empower the students, (2) what teaching through a balanced curriculum entails, (3) the type of assessment which develops educational power, (4) the impact of teachers’ and students’ beliefs, (5) the emotional factors, (6) the importance of monitoring learners' learning habits, and (7) catering for differences in learning styles.

There may not be a simple formula for learners to orient them in a most effective learning process. It is because learning and teaching from a constructivist perspective focus on autonomy and ownership of learning by individuals. Learners have different
learning styles – characteristic, strengths and preference in the way they take in and process information (Felder, 1996). Some students are more visual, and others are analytic or some are more active and others are reflective. Given the importance of the autonomy of a learner in a constructivist classroom, the role of a teacher should change: to understand the classroom dynamics, to encourage their students to use their prior experiences to build up new experiences, and to recognize their physical and interpersonal environments in order to construct meaning from contexts.

Learners need to focus on making connections between facts and fostering new understanding in learners. In the process, students are to be encouraged to analyse, interpret, and predict information. Lecturers are asked to function in various capacities, since they take on different roles in various situations. One of the chief implications is the idea that lecturers are facilitators, coaches, guides and collaborators. As sports players cannot learn how to play just by listening to what their coach says, students also cannot learn by only listening to their lecturer. Practical and personal experiences develop a critical mind set and enable students to use their own knowledge and even to go beyond new information.

Lecturers, as coaches or as collaborators, must help students extend foundational skills, afford them the opportunities to practice, facilitate classroom discourse and keep an eye on structure (Bodilly, Keltner, Purnell, Reichardt & Schuyler, 1998, p. 30). They can do so by making use of learner-centered methods of instruction, such as classroom discussions, inquiry-based learning, problem-based learning and collaborative learning. In the course of learner-centered instruction, students may develop critical thinking, the ability to solve problems, cognitive flexibility and social negotiation. For example, when students present their own knowledge or newly acquired information in classroom discussions, they will learn how to present and discuss their ideas with others in intellectually productive ways. It will render their cognitive thinking more flexible.

Even though students are dynamic and active builders of their own knowledge, lecturers still need to choose an instructional strategy and create educational opportunities for
students. In order to be a good coach or guide, lecturers need to know an individual’s talents and styles. For lecturer-as-coach, having this information is essential to design or create an effective and efficient educational context, since the central task of lecturers is to enable all players to admit the value of individual differences. In other words, lecturers and students are aiming to constitute a community of learning.

Lecturers who believe that knowledge and information should be constructed, not just delivered, and that a group of learners can learn more when they work together instead of separately, should find ways to constitute a community of learners with a specific set of talents and styles so that they can effectively share their knowledge and experiences with one another under the guidance of the lecturer.

Hence, the improvement of student’s learning greatly depends on a lecturer’s ability to combine these influential factors (Good & Brophy, 2000). Baturo also suggests that good lecturers are not necessarily those who have academic knowledge, but those who can recognise and utilise powerful ideas when they see them (2004, p. 100). The support they need is the inclusion of these ideas in their daily teaching. Taking the learning into account as opposed to teaching environments, lecturers could be more disposed towards employing a teaching style which caters for differences between learning styles (Penfield, 1987, p. 29).

Nevertheless, catering for differences in learning styles cannot be interpreted just as matching of teaching and learning styles, as this is a controversial issue (Allinson & Hayes, 1996). It has been assumed for a long time that if lecturers could diagnose the learning style of their students, then it would be seemingly logical to match the teaching styles with learning styles to render the instruction more effective (Pinto, Geiger & Boyle, 1994). On the other hand, there are several studies that don’t support this assumption (Scott, 2010; Riener & Willingham, 2010; Dembo & Howard, 2007). Thus, it is clear that the jury is still out on whether matching learning styles and instructional styles is viable (Pinto et al., 1994, p. 118). Be that as it may, adapting teaching to cater for differences
in learning styles could be one of the best ways to probe what students know and how they learn best (Louange, 2007).

### 2.3 Style as a Central Construct for Individual Development

#### 2.3.1 Style in Literature

The origins of teaching and learning styles have been traced to different sources, but most notably, cognitive-developmental psychology, differential psychology, Gestalt psychology, psychoanalytic ego psychology and the experimental psychology have been credited with its inception (Zhang & Sternberg, 2006, p. 12). With regards to an account of the origin of style there are several opinions. The origin of style can be traced back to classical Greek literature (Martinsen, 1997, p. 136). Yet the construct of style literally started when James (1890) and Bartlett (1932) continued with research on individual differences in cognition (Rayner & Riding, 1997, p. 6). However, many studies (e.g., Grigorenko & Sternberg, 1995; Riding & Cheema, 1991; Riding & Sadler-Smith, 1997) agree that Allport (1937) first used ‘style’ as a theoretical construct in dealing with cognition.

The term ‘style’ has referred to patterns of behaviour that are consistent over long periods of time and across many areas of activity. It was regarded as individual reflection of how a person perceives, learns or thinks (Grigorenko & Sternberg, 1995, p.206). Alternatively the idea of style has always been related to individuality, relative stability and consistency (Rayner & Riding, 1997). In view of this relationship between style and individual differences, many researchers indicate that styles play an important role in many parts of our lives; social behaviours, well-being of mentality, the way of communication, learning or job performance. Since ‘style’ can be related practically in our lives, many kinds of styles were expanded in different perspectives: cognitive style, conceptual tempo, decision-making and problem-solving style, learning style, teaching style, mind style, perceptual style, intellectual style, thinking style, and so on.
Many studies regard the notion of cognitive style as being a bridge between cognition and personality. This idea was maintained for more than two decades. Sternberg and Grigorenko refer to the recent turn towards understanding the peculiarities of individual learner as the cognitive-styles movement (2001). As this movement developed, many alternative dimensions of styles also emerged, such as intuitive thinking, reflective-impulsive style, defensive styles, expressive styles, intellectual style or learning style and teaching style.

And yet, the number of studies dealing with styles waned in the late 1960's and early 1970s. Zhang and Sternberg mentioned three reasons for the decline (2006). It was firstly because style is not pure construct, indistinguishable from abilities and personality traits. The study of styles was easily immersed into abilities or personality traits, so it seemed a distinct area of research on styles no longer existed. The second reason was the result of the problems associated with conceptions and measurement of styles (Armstrong & Hird, 2009, p. 422; Riding & Sadler-Smith, 1997, p. 199). Many of these styles had largely evolved from theories generalized on single experiments with little subsequent empirical support. Lastly, there was a lack of common language and conceptual understanding to communicate either among researchers or with psychologists. The inability to build common ground led to the untimely end of style research.

Despite the challenges illustrated above, the notion of styles regained attention in the past three decades, out of efforts to rejuvenate the field of style. As a result of the rejuvenation of the field of style, three manifestations were mentioned: (1) the relationship of styles to ability and personality; (2) the three controversial issues concerning styles – style overlap, style malleability and style value; and, (3) the place of the styles literature within the larger contexts of psychological, educational, and business literatures (Zhang, Sternberg & Rayner, 2012).

In light of ‘style’ within educational contexts, in the 1970s the learning-centered approach began associating with educationists to meet individual differences in the
classroom. This approach had greater interest in the impact of individual differences upon instructional principles and methods (Rayner & Riding, 1997, p. 6).

2.3.2 From ‘Ability and Interest’ to ‘Style’

An early interest in style amongst cognitive psychologists stemmed from the failure of research into ability and intelligence to effectively "elucidate the processes generating individual differences" (Grigerenko & Sternberg, 1995, p. 207). Ability has been regarded an essential element for successful learning. Various studies on the resources and origins of human abilities have been conducted (Sternberg, 2003). The following three are conventional perspectives: Piaget’s developmental theory, the Psychometric approach, and Cognitive Psychology. Firstly, Piaget and Neo Piaget theorists provide developmental perspectives on how human abilities improve through the interaction of experience with the environment. Secondly, Psychometric theory explains human abilities as relative individual differences. Thirdly, cognitive psychologists posit the basic processes and factors related to learning, for instance the ability to memorize. Among the three traditional perspectives, the psychometric theory is the most influential in the field of education. Its prevalence is understandable in view of the overwhelming evidence that the conventional tests of intelligence yield. These tests predict a large variety of outcomes in schools. For instance, Intelligence quotient (IQ) tests are the most widely used in educational settings due to their efficacy in predicting behaviour.

However, the fact that the IQ test has the most supporters and published research over what is a protracted period of time suggests that it may fail to account for certain features of intelligence, such as creativity or emotional intelligence. It is especially problematic when psychometric perspective regards IQ test scores as reflections of learner’s genetic ability. Firstly, the psychometric perspective exaggerates the various inborn abilities individuals possess and ignores the continual development of humans through interaction with their environment (Lohman, 1993). Secondly, most IQ tests only measure achievement that individuals should have accomplished several years back,
even though it assumes a basic form of human intelligence at birth. In other words, it measures only a developed form of intelligence (Lohman, 2006; Sternberg, 2003). Sternberg and Kaufmann (1998 as cited in Kim, 2011) hinted that no tests can prove the acute limitation of learners’ abilities. In addition, because the psychometric approach regards ability as part of the inborn characteristic of a person, many educators miss the point. The reason being that developing ability is one of the most important purposes of education.

What alternative views of human abilities are available if the psychometric perspective cannot provide a proper explanation for successful learning? The desirable approach is the developmental perspective of learners’ abilities. In other words, ability needs to be seen as a constant developmental competence (Renzulli & Dai, 2001). From this developmental approach, the multiple intelligences theory of Howard Gardner (1983) and the triarchic theory of intelligence, developed by Sternberg (1985), provide a significant change of perspective in the study of intelligence and related abilities. These theorists draw attention to individual’s traits, which are a combination of their own potentials and strengths. Their purpose is not to decide whether people have good abilities or not, but to determine how individual potentialities and strengths can be used and developed. These perspectives provide an opportunity to focus on the individual styles, not abilities, which is an important contemporary issue in education.

In the light of this, cognitive styles appear to be independent of intelligence (Ridng, 1997, p. 33; Riding & Agrell 1997, p. 314) and it is regarded as one of the distinctions between style and ability. McKenna underlined four characteristics of the nature of cognitive style, as distinguished from ability; firstly, ability is more concerned with level of performance, while style focuses on the manner of performance (1990). Secondly, ability is unipolar while style bipolar. Thirdly, ability has values attached to it for instance one end of an ability dimension is valued while the other is not, whereas for a style dimension neither end is considered better than the other. Lastly, ability has a smaller range of application than style.
Both ability and style can have an effect on a given task. The basic difference between them is that performance on all tasks will improve as ability enhances. Whereas the effect of style on performance will be either positive or negative depending on the nature of the task; since certain styles will better suit certain tasks than others and vice versa. Style reflects qualitative rather than quantitative differences between individuals.

Since human ability cannot on its own provide a complete answer to how and why people differ in their performance, other factors have also to be considered. Interest would be one possible factor. Individual interest determines preferences to particular pieces of information, how someone responds to a new environment and how that person adapts to behave amenable. Interest has a strong influence on individuals' cognitive and affective functioning (Ainley, Hidi & Berndorff, 2002). The influence of interest on learning needs to be documented and described along with the nature and shifts in interest over time (Alexander, 1997, p. 435). Interest is defined as a relatively enduring predisposition to attend to certain objects and events and engage in certain activities (e.g., Crozier, 1997). This definition has three essential features: first, interests present a tendency to move or be drawn toward a certain cognitive direction; second, all interests have certain degrees of intensity, being indicated by behaviours in a purposeful activity or by affective reactions such as excitement and enjoyment; and third, interests are dynamic, that is, they occur in an event involving person-object or person-situation interactions and relations (Renzulli & Dai., 2001).

More pertinent questions could be: what makes a learner interested in a certain field or topic; what enhances a learner's interests; and how does a learner develop a new interest? Piaget (1997) may be the first psychologist who regarded interests as a critical construct for intellectual development. He assumed that there is an innate predisposition in children that allows them to organise their experiences and understanding of their surroundings. Since this elementary tendency starts to develop from a young age, it can be observed in a child's sense of control, power, and competence especially when the child overcomes challenges and successfully masters.
new tasks. Interests are indicative internal forces of motivation and the successful ability to control significant aspects of the environment.

However, positive perspectives on human development cannot answer these questions; why are some children more interested in a certain work than others; and why do some children show different patterns and different degrees of the same interest? For instance, some learners are interested in mathematics, while others just prepare for tests as they study it. Among those who are interested in mathematics some prefer studying algebra to geometry.

Theorists developed an interest in learning styles as a way to find a way to address the relationship between ability and interest. Renzulli & Dai stated that styles indicate “how” whereas interests refer to “what” (2001). This suggests that interests may be indicators of deeper individual preference that represent their styles.

In a nutshell, abilities deal with the question of whether one is capable of learning or performing specific cognitive tasks, while interests attend to the question of what topic or subject one likes most, and styles address the question of what are the characteristic ways of approaches to learning tasks. Defined as such, styles reflect more generalized and pervasive aspects of personal functioning than abilities and interests.

Ability-style associations reflect an intrapersonal dynamic in response to learning tasks, while interest-style links reflect intrapersonal dynamic in response to the characteristics of learning. Together, they highlight the importance of style constructs as an interface of cognitive ability and personality (Sternberg, 1988).
2.4 The Learning Style

2.4.1 The Theoretical Development of Learning Style

Everyone has their own way of learning. Learners with various learning traits operate according to their own learning process and interact with instructional environments. It generates varied learning needs, which have become a base for learning style theories and the widely supported significance of the concept of learning style (Claxton & Murrell, 1987; Kolb & Kolb, 2005). Among different types of styles, the learning style gained attention in education in the 1970s, partially in response to the explosion of style labels accompanied by the number of style measures, and partially due to the interest of scholars’ in applying the notion of styles to various specific disciplines, specifically in education (Zhang & Sternberg, 2006). Keefe (1987) states that the term ‘learning style’ was probably first used by Thelen (1954). Afterwards, Riessman (1964 as cited in Zhang, Sternberg & Rayner, 2012) argued for the concept of styles in learning, defining a learning style as a ‘more holistic or global dimension of learning operative at the phenomenal level’ (Riessman, 1964 as cited in Farooq & Regnier, 2001). Later, the term ‘learning style’ in the 1970s emerged as a more common term (Riding & Cheema, 1991).

In contrast to other styles, learning styles were presented by education-minded researchers who gave emphasis to styles as personal preferences involved in the learning process, the learning environment and the types of preferred instructional activities (Sternberg & Grigorenko, 2001). In the beginning of the 20th century theoretical and experimental studies were carried out in the USA and Western Europe. These contributed to the development of models set out for determining learning styles (Coffield et al., 2004b, p. 5).

There are two very different approaches to learning styles: the North American approach and the Australian/European approach. The former approach originated from cognitive psychology, as presented in the works of Friedman and Stritter (1976) and
Kolb (1976) (Zhang & Sternberg, 2006). The North American researchers have developed learning style concepts from their backgrounds in cognitive psychology and from the beginning emphasised psychometric considerations. The European and Australian researchers built up concepts based on their observations of learning behaviours. It is demonstrated by the work of Curry (1983), Biggs (1979) and Marton (1976) (Zhang et al., 2012). The differences in these two approaches, however, continues to make it difficult to resolve significant difficulties in learning styles, such as the confused definitions surrounding learning style concepts or the differences in scale or scope of behaviour claimed to be predicted by diverse models (Sims & Sims, 1995).

### 2.4.2 Learning Style as a Characteristic of Learners

Ability refers to whether people can learn or perform tasks on appropriate levels of challenges, and interest relates to whether a learner likes a theme or topic. Learning style, on the other hand, describes what a diagnostic method is in regards to access to tasks that will improve a learners' motivation to pursue what he or she studies. Compared to ability and interest, learning styles reflect the functional factors of an individual both in general and broad perspectives (Sternberg & Grigorenko, 2001). If, then, styles reflect personal functioning, especially used for explaining the learning quality and learners’ performance, it is necessary to recognise the difference among learning styles, cognitive styles, and learning strategies.

These terms are frequently used in theoretical and empirical studies. Cognitive style is described as an individual’s typical or steady mode of perceiving, thinking, and problem solving (Allport, 1937). Sadler-Smith defines cognitive style as “a distinctive and habitual manner of organisation and processing information” (1996, p. 32). This means cognitive style becomes "an individual's characteristic and consistent approach to organising and processing information" in the learning process" (Tennant, 1997, p. 89). Cognitive style is frequently included under the umbrella term 'learning style' (Sadler-Smith, 1996, p. 29) but it is much more pervasive, stable and deeply seated than learning style. While
cognitive styles appear to be fairly fixed characteristics for individual learners, learners develop learning strategies which enables them to make the most efficient use of the strengths and limitations of their particular cognitive style.

The “state-or-trait” debate possibly associates with cognitive style, learning style and learning strategy (Cassidy, 2004). While cognitive styles are viewed as fairly fixed characteristics of individuals (trait), it is possible to develop learning strategies to enable learners to make the most efficient use of their strengths and limitations (Riding & Agrell, 1997).

Cassidy stated that learning style can be regarded as both a structural trait and a processing state (2004). It means that learning style may have a structure, but that structure is, to some extent, responsive to the experiences and demands situational processes to allow for change. The ‘motherboard/software’ and ‘hard/soft’ wiring analogies have also been used to describe the interface of style (motherboard/hard wiring) and strategy (software/soft wiring). In this sense, cognitive or learning styles should be distinguished from cognitive or learning strategies – the latter evolves from the former. When a strategy is so contrived and overused that it becomes spontaneous and indiscriminate, the strategy turned into a style, that is, a stable, self-consistent disposition.

Learning style describes learning quality and function as both a structural trait and processing state. Teaching style depicts that interpersonal relationship with learners and responses to the needs of the classroom environment are critical in the learning process (Grasha, 1996). It is important to have an integrated perspective. For example, learning process at school cannot be considered without an interaction among learning styles, teaching styles and school environments.

McIlrath and Huitt developed the model of learning-teaching process at school (1995). In his model, school and state policies combine with lecturer and student characteristics to impact lecturer behaviour, while student characteristics and lecturer behaviour
influence student behaviour. And student classroom behaviour in turn influences lecturer classroom behaviour in an interactive pattern that eventually results in student achievement as measured by instruments influenced by state policies. He insisted that academic achievements will improve if classes are appropriate to cognitive behaviour and affective characteristics. In other words, learning styles and the quality of classroom situations determine the types and levels of learning achievement, learning speed, and affective accomplishments. The model McIlrath and Huit (1995) offered appears as follows (See Figure 5):

Figure 5 Model of the Teaching and Learning Process
(Adopted from McIlrath & Huit, 1995)

Learning style becomes one of the significant variables affecting learning process and outcomes, not as a vertical difference but as differences in behaviour. If learners are forced into a uniform learning style, regardless of the individual differences, it will make
their learning inefficient. Furthermore, it will result not only in losing their interest in schooling or learning, but also negatively influence their thinking about their environments. Researchers’ attention gradually moves to individual difference in the class for the selection of learning tasks as non-intellectual characteristics (Wan Hee Park, 1989). This leads in the end to learner-centered education. The basic assumption of learner-centeredness in teaching and learning is individualised needs and abilities. The Figure 6 represents the interlocking relationship between the teacher, the learner and the curriculum. The intersection set is the school and that plays a very pivotal role in ensuring effective teaching and learning.

From the perspective of learner-centered teaching, the effectiveness of lessons will be maximized when instructors use suitable teaching styles and methods to accommodate as many students as possible, considering individuals’ learning characters. As one of the core elements of individualisation, active learning has received considerable attention over the past several years. Presented or perceived as a radical change from traditional instruction, active learning has attracted strong advocates among educators and practitioners who are looking for alternatives to traditional teaching methods (Prince, 2004).

Renzulli proposed ‘three major components of instructional settings’ in this figural representation of active learning, which interact with one another to produce the intellectual or artistic equivalent of spontaneous combustion (See Figure 6) (1992). These components are the learner, teacher and the material to be learned (i.e. curriculum). ‘Active learning’ is to design the instructional programme which takes into account individual and developmental characteristics bearing on how students learn and what kinds of condition they are under. Learning style is one of the prominent characteristics of learners. Due to learners' various learning styles, different instructional methods for different kinds of students are recommended to be employed to achieve the educational goals, such as curriculum design, instructional methods, assessment methods; and student guidance (Curry, 1990). Many teaching strategies in promoting active learning are comparable to lecturers that focus on full understanding of
content and also they are superior to the development of learners’ skills in thinking and writing (Bonwell & Eison, 1991).

Figure 6  Figural Representation of Active Learning (Partially adopted from Renzulli & Dai, 2001)
2.4.3 The Classification of Learning Style

Approaches to utilizing learning styles have been conducted mainly by developing the learning style instruments or models. The diversification of learning style instruments and models were developed to meet realistic needs and objectives. There are various instruments which measure different dimensions and characteristics of learning styles.

Various discussions were initiated by Curry who developed ‘the onion model of learning style’ (See Figure 7) (1983). There are three layers in Curry’s onion model; ‘instructional preferences’, ‘information-processing style’ and ‘cognitive style’, which is analogous to the trait-state concepts.

![Curry's 'Onion Model of Learning Styles' (Curry, 1983)](image)

In conceptualising the way in which learning/cognitive style is measured; Curry utilises an onion metaphor to illustrate inner and outer layers of the construct. “Instructional Preference” refers to the individuals’ choice or environment in which to learn (1983). This layer interacts most directly with learning environments, learners and teacher expectations and other external features.
<table>
<thead>
<tr>
<th>Inventory</th>
<th>Curry (1987)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Instructional Preference</td>
</tr>
<tr>
<td>Witkin (1962) Field-dependence/independence</td>
<td></td>
</tr>
<tr>
<td>Kagan (1965) Impulsivity-reflexivity</td>
<td></td>
</tr>
<tr>
<td>Holzman &amp; Klein (1954) Leveller-sharpener</td>
<td></td>
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<tr>
<td>Pask (1972) Holist-serialist</td>
<td></td>
</tr>
<tr>
<td>Pavio (1971) Verbaliser-visualiser</td>
<td></td>
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<tr>
<td>Gregoc (1982) Style delineator</td>
<td></td>
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<tr>
<td>Kauffmann (1979) Assimilator-explorer</td>
<td></td>
</tr>
<tr>
<td>Kirton (1994) Adaption-innovation</td>
<td></td>
</tr>
<tr>
<td>Allinson &amp; Hayes (1996) Intuition-analysis</td>
<td></td>
</tr>
<tr>
<td>Kolb (1984) ELM</td>
<td></td>
</tr>
<tr>
<td>Honey &amp; Mumford (1992) LSQ</td>
<td></td>
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<tr>
<td>Vermunt (1994) LSI</td>
<td></td>
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<tr>
<td>Entwistle &amp; Tait (1995) Surface-deep</td>
<td></td>
</tr>
<tr>
<td>Biggs et al. (2001) SPQ</td>
<td></td>
</tr>
<tr>
<td>Schmeck et al. (1991)</td>
<td></td>
</tr>
<tr>
<td>Hunt, Butler, Noy, &amp; Rosser (1978) Conceptual level</td>
<td></td>
</tr>
<tr>
<td>Dunn, Dunn &amp; Price (1989) LSI</td>
<td></td>
</tr>
<tr>
<td>Reichmann &amp; Grasha (1974) Styles of learning interaction model</td>
<td></td>
</tr>
<tr>
<td>Ramirez &amp; Castenada (1974) Child rating interaction model</td>
<td></td>
</tr>
<tr>
<td>Reinert (1976) ELSIE</td>
<td></td>
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<tr>
<td>Hill (1976) Cognitive Style Interest Inventory</td>
<td></td>
</tr>
<tr>
<td>Letteri (1980) learner types</td>
<td></td>
</tr>
<tr>
<td>Keefe &amp; Monks (1986) Learning style profile</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 Taxonomy of Learning Style Models (Cassidy, 2004)
It describes the most observable and susceptible layers that are open to influence, making it the least stable level of measurement (Cassidy, 2004). “Information processing style” relates to the individuals’ intellectual approach to the processing of information. “Cognitive personality style” is defined as the individual's approach to adapting and assimilating information, but its adaptation does not interact directly with the environment, rather this is an underlying and relatively permanent dimension of personality.

There have been various discussions and classification with regards to learning style models Initiated by Curry (1983). Rayner and Riding (1997) took into consideration learning style within the three frameworks; cognitive-centered, personality-centered and learning-centered approaches. Cassidy (2004) classified 23 style inventories into 3 layers of Curry’s model according to the association with the measurement of each layer as showed in Table 1.

Cognitive-centered approaches proceed from the idea that styles could provide a bridge between the study of how people perceive, learn and think (cognition) and the study of personality. This approach identified styles based on individual difference in cognitive and perceptual functioning (Grigerenko & Sternberg, 1995), such as ‘field-dependence/field-independence’ (Witkin and his colleagues, 1962), the holist/analytic, verbaliser/imager dimension (Riding, 1991) or impulsivity/reflectivity (Kagan, 1966).

Learning-centered approaches are differentiated based on the impact of learning style in an educational context and the development of new learning-relevant constructs and concepts. Furthermore, Rayner and Riding (1997) framed learning-centered approaches around the distinction among process-based models (e.g., Kolb, Entwistle, Biggs), preference-based models (Price, Dunn, Riechman-Grasha) and cognitive skills-based models (Reinert, Letteri, Keefe) (Cano-Garcia & Hughes, 2000, p. 415).
Learning styles & preferences are largely constitutionally based including the four modalities: VAKT

- Learning styles reflect deep-seated features of the cognitive structure, including ‘patterns of ability’
- Learning styles are one component of a relatively stable personality type
- Learning styles are flexibly stable learning preferences

- Move on from learning styles to learning approaches, strategies, orientations & conceptions of learning

<table>
<thead>
<tr>
<th>Dunn &amp; Dunn</th>
<th>Gregorc</th>
<th>Bartlett</th>
<th>Gordon</th>
<th>Marks</th>
<th>Paivio</th>
<th>Richardson</th>
<th>Sheehan</th>
<th>Torrance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riding</td>
<td>Broverman</td>
<td>Cooper</td>
<td>Gardner et al.</td>
<td>Guilford</td>
<td>Holzman &amp;</td>
<td>Klein Hudson</td>
<td>Hunt</td>
<td>Kagan</td>
</tr>
<tr>
<td>Apter</td>
<td>Jackson</td>
<td>Myers-Briggs</td>
<td>Epstein &amp; Meler</td>
<td>Harrison-Branson</td>
<td>Miller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allinson &amp; Hayes</td>
<td>Herrmann</td>
<td>Honey &amp; Mumford</td>
<td>Kolb</td>
<td>Felder &amp; Silverman</td>
<td>Hermanussen, Wierstra, De Jong &amp; Thijszen</td>
<td>Kaufmann</td>
<td>Kirton</td>
<td>McCarthy</td>
</tr>
<tr>
<td>Entwistle</td>
<td>Sternberg</td>
<td>Vermunt</td>
<td>Biggs</td>
<td>Conti &amp; Kolody</td>
<td>Grasha &amp; Riechmann</td>
<td>Hill</td>
<td>Marton &amp; Saijo</td>
<td>McKenney &amp; Keen</td>
</tr>
</tbody>
</table>

**Figure 8** Families of Learning Styles (Coffield et al., 2004a)
Coffield and his colleagues (2004a) also develop ‘Families of learning styles’ (See figure 8). They organise different learning style models according to overarching ideas behind them, aiming to capture the extent to whether the learning style models are relatively fixed or more flexible to change.

2.4.4 The Learning Style of Cognitive Approach to Information

The Dimension of ‘Information Perception’

The first dimension of learning style is based on the level of ‘perception’, which relates to Jung's (1990) personality type theory (Cohen, 2008). ‘Perception’ refers to being aware of things, people, events, or ideas. It includes information gathering, the seeking of sensation or inspiration, and the selection of stimulus to attend to. (Baker, 2004, p. 123). The strength of this dimension has been assessed by using the Myers-Briggs Type Indicator (MBTI) on hundreds of thousands of people (Felder & Henriques, 1995, p. 22).

Out of the 4 dimensions of personality types (extroversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving), the sensing-intuition differences in the MBTI are the most basic, although the other three dimensions of personality types are also associated with learning style preferences (Lawrence, 1993). Geyer (2010) examined the broad nature of scales and patterns in each domain by using Isabel Myers’s rules for MBTI Form. It is shown in Table 2.

These poles in the ‘perception’ dimension are closely related to ‘Concrete - Abstract’ in Gregorc’s Styles Delineator (GSD, 1982) and ‘Concrete experience – Abstract conceptualization’ in Kolb’s Learning Style Inventory (LSI, 1976). These two models will be mentioned later since they have multifaceted dimension (Kozhevnikov, 2007).
<table>
<thead>
<tr>
<th></th>
<th>Sensing</th>
<th>Intuition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagination</td>
<td>Realistic, practical approach</td>
<td>New ideas; play of imagination</td>
</tr>
<tr>
<td>Concreteness</td>
<td>Dealing with real, tangible things, where results can be seen and measured.</td>
<td>Working with verbal or mathematical symbols at an abstract level; appreciate creativity even if results are not immediately visible.</td>
</tr>
<tr>
<td>Theorising</td>
<td>More at home in situations firmly grounded in facts and experience, which involve little or no theory.</td>
<td>Seeing how facts fit together and what they may mean, with only passing interest in the facts themselves.</td>
</tr>
<tr>
<td>Intellectuality</td>
<td>Action that leads to practical results. In education, applied fields which lead to directly useful accomplishments.</td>
<td>Intellectual interest. Enjoy learning, value university and postgraduate training.</td>
</tr>
</tbody>
</table>

**Table 2  Isable Myers’ Rules for MBTI from G Clusters (Geyer, 2010)**

Allinson and Hayes’ Cognitive Styles Index (CSI), and Herrmann’s Brain Dominance Instrument (HBDI) have something in common with the perception dimension. As the most fundamental dimension of cognitive style, the CSI was developed with two identifying factors; ‘Intuition’ and ‘Analysis’. ‘Intuition’, characteristics of right-brain orientation, refers to immediate judgment based on feeling and the adoption of a global perspective. On the other hand, ‘Analysis’, the characteristic of left-brain orientation, refers to judgment based on mental reasoning and a focus on detail.
<table>
<thead>
<tr>
<th>Quadrant A: upper left</th>
<th>Quadrant D: upper right</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learns by:</strong></td>
<td><strong>Learns by:</strong></td>
</tr>
<tr>
<td>Acquiring and quantifying facts</td>
<td>Taking initiative</td>
</tr>
<tr>
<td>Applying analysis and logic</td>
<td>Exploring hidden possibilities</td>
</tr>
<tr>
<td>Thinking through ideas</td>
<td>Relying on intuition</td>
</tr>
<tr>
<td>Building cases</td>
<td>Self-discovery</td>
</tr>
<tr>
<td>Forming theories</td>
<td>Constructing concepts</td>
</tr>
<tr>
<td>Synthesising content</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Learners respond to:</th>
<th>Learners respond to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formalised lecture</td>
<td>Spontaneity, Free flow</td>
</tr>
<tr>
<td>Data-based content</td>
<td>Experiential opportunities</td>
</tr>
<tr>
<td>Financial/technical case discussions</td>
<td>Experimentation</td>
</tr>
<tr>
<td>Textbooks and bibliographies</td>
<td>Playfulness</td>
</tr>
<tr>
<td>Programmed learning</td>
<td>Future-oriented case discussions</td>
</tr>
<tr>
<td>Behaviour modification</td>
<td>Visual displays, Individuality</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Being involved</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quadrant B: lower left</th>
<th>Quadrant C: lower right</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learns by:</strong></td>
<td><strong>Learns by:</strong></td>
</tr>
<tr>
<td>Organising and structuring content</td>
<td>Listening and sharing ideas</td>
</tr>
<tr>
<td>Sequencing content</td>
<td>Integrating experiences with self</td>
</tr>
<tr>
<td>Evaluating and testing theories</td>
<td>Moving and feeling</td>
</tr>
<tr>
<td>Acquiring skills through practice</td>
<td>Harmonising with the content</td>
</tr>
<tr>
<td>Implementing course content</td>
<td>Emotional involvement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Learners respond to:</th>
<th>Learners respond to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorough planning</td>
<td>Experiential opportunities</td>
</tr>
<tr>
<td>Sequential order</td>
<td>Sensory movement</td>
</tr>
<tr>
<td>Organisational and administrative case discussions</td>
<td>Music</td>
</tr>
<tr>
<td>Textbooks</td>
<td>People-oriented case discussions</td>
</tr>
<tr>
<td>Behaviour modification</td>
<td>Group interaction</td>
</tr>
</tbody>
</table>

Table 3  Whole Brain’s Learning and Design Considerations (Herrmann, 1989 as cited in Coffield et al., 2004a)
The Herrmann’s Brain Dominance Instrument (HBDI) provided a four-category classification of mental preferences of learning styles (See Table 3) without a biological base. The constructs in this four-quadrant theory are formed on the basis of observations of people in many important life situations; for example at work, at home, and while playing. The constructs are related to actions and decisions in situations rather than genetic inheritance (Bunderson, 1989, p. 342).

**The Dimension of ‘Information Input’**

The dimension of information input has two poles; visual – verbal. It is considered a major cognitive style (Jonassen & Grabowski, 2012) and is closely related to ‘split-brain research’. The basic premise of split-brain research, or hemispheric dominance, is that an individual relies more on one mode or cerebral hemisphere than on the other. In other words, the left-hemisphere dominant deals with verbal or analytic information whereas the right-hemisphere dominant handles holistic or spatial information (Raj, Dharmangadan & Subramony, 2007, p. 275).

Barlett (1932), Paivio (1971) and Richardson (1977) suggested that individuals can be reliably categorised as visualisers or as verbalisers. According to this view, visualisers (also called imagers) depend chiefly on imagery when attempting to perform cognitive tasks, whereas visualisers rely primarily on verbal-analytical strategies (Kozhevnikov, Kosslyn & Shephard, 2005).

Paivio (1971) was the first to design an individual differences questionnaire to evaluate the extent to which different individual habitually use imagery as opposed to verbal thinking. This questionnaire asked participants to indicate whether or not a list of statements, such as “I often use mental pictures to solve the problems”, described their habitual method of thinking (Kozhevnikov et al., 2005). The participants were classified as visualisers or as visualisers by testing their ability to produce information. Those who responded quickly are ‘visualisers’ and those who responded slowly are ‘visualisers’.
The fact that people have a preference for using visual or verbal information has a significant implication in learning (Clark & Paivio, 1991).

Ever since the research on the visualise-visualise dimension began to appear in educational literature in 1970s (Kozhevnikov et al., 2005), many studies proved Paivio’s ‘Dual Code Theory’ contributed widely to the educational field; and that it affected reading skills, written composition, remedial literacy and mathematics. For example, beginning readers learn to read concrete words much faster by sight when the words are accompanied by referent pictures than when paired only with their pronunciation. The dual coding process required by this dimension has been used in teaching mathematics as well. Children first learn names of numerals and then their meanings by associating them with their pictures.

Clark and Campbell developed a general theory of number processing using dual coding mechanisms (1991, p. 204). This integrated, associative view of number processing is supported by individual differences in number processing and format-specific phenomena in calculation. In reviewing researches on the visualiser–visualiser dimension, this dimension is referred to in various ways – some consider it as a cognitive style (Sternberg & Grigorenko, 2001), some learning preference (Plass, Chun, Mayer, & Leutner, 1998), verbal and spatial ability (Kirby, Moore & Shofield, 1988, p. 169) while other see it as multifaceted (for cognitive ability, cognitive style, and learning preference) (Mayer & Massa, 2003, p. 833).

The Dimension of ‘Information Understanding’

With regards to ‘information ordering and understanding’, theorists are yet to agree on what to call the pole of this dimension: Pask refers to ‘serialists’ and ‘holists’ (1976); Tharp uses the terms ‘linear’ and ‘holists’ (1989); Riding and Cheema prefer ‘analytics’ and ‘holists’ (1991); while Felder and Silverman refers to ‘global – sequential’ under the question ‘how does people progress toward understanding’ (1988). The holist-analytical dimension describes the habitual way in which an individual organises and processes
information. Holists retain a global or overall view of information, while analytics process and organise information into its component parts (Sadler-Smith & Riding, 1999). It reflects an individual tendency to respond to a learning task either with a holistic strategy (hypothesis-led) or a step-by-step (date-led) process (Zhang & Sternberg, 2000).

<table>
<thead>
<tr>
<th>Field-Dependent</th>
<th>Field-Independent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceives globally</td>
<td>Perceives analytically</td>
</tr>
<tr>
<td>Experiences in a global fashion, adheres to structures as given</td>
<td>Experiences in an articulate fashion, imposes structures of restrictions</td>
</tr>
<tr>
<td>Makes broad general distinctions among concepts, sees relationships</td>
<td>Makes specific concept distinctions, little overlap</td>
</tr>
<tr>
<td>Social orientation</td>
<td>Impersonal orientation</td>
</tr>
<tr>
<td>Learns material with social content best</td>
<td>Learns social material only as an intentional task</td>
</tr>
<tr>
<td>Attends best to material relevant to own experience</td>
<td>Interested in new concepts for their own sake</td>
</tr>
<tr>
<td>Requires externally defined goals and reinforcements</td>
<td>Has self-defined goals and reinforcements</td>
</tr>
<tr>
<td>Needs organisation provided</td>
<td>Can self-structure situations</td>
</tr>
<tr>
<td>More affected by criticism</td>
<td>Less affected by criticism</td>
</tr>
<tr>
<td>Uses spectator approach for concept attainment</td>
<td>Uses hypothesis-testing approach attain concepts</td>
</tr>
</tbody>
</table>

Table 4  The Difference between ‘Field-Dependent’ and ‘Field-Independent’ Characteristics (Garger & Guild, 1987)

The theoretical origin for this dimension is linked to Witkin’s work (1962) on ‘Field-Dependence [FD] – Field-Independence [FI]’. The distinction between FD – FI is similar to the distinction between the holistic (global) – analytical (sequential) dimension.
The construct of FD-FI dimension is one of the most significant factors contributing towards educational problems (Ausburn & Ausburn, 1978). It constitutes a crucial aspect of individual differences among learners with regards to the way they acquire and process information (Chinien & Boutin, 1993 as cited in Cao, 2006).

Witkin proposes that people could be classified according to the degree to which they are dependent on the structure of the prevailing visual field (1976). For example, when people are on an airplane, the more field independent person can perceive whether the plane is level with the ground without looking down at the ground. While the more field dependent person needs to look out the window to figure out the plane’s orientation relative to the ground. Garger & Guild have summarized the characteristics of field independence and field dependence as a learning style (See Table 4) (1987).

Global style learners tend to take a holist approach to learning, which entails relationships among several topics, and focusing on constructing a broad conceptual overview. Sequential style learners, by contrast are inclined to use a largely local learning approach, which entails analysing one thing at a time, and later concentrating on separate topics and the logical sequences between them. Given that sequential learners grasp the overall picture relatively late in the learning process, they work on either the theoretical or the real world topics. They put the theory and application together only when it is utterly necessary to attain understanding. Global learners, by contrast, shifted frequently between theory and application from the beginning. The global learners are likely to look ahead in the hierarchy of topics (Bajraktarevic, Hall & Fullick, 2003, p. 2); Cha, Kim, Park, Yoon, Jung, & Lee, 2006, p. 514; Tanner & Allen, 2004, p. 200). A detailed comparison of the differences between global learner and sequential learner can be shown in Table 5.
Global learner | Sequential learner
---|---
Take a holist approach and create conceptual links between objects on early stage. | Take an analytical approach, examining individual topics before forming conceptual links.
Able to move between theory and real world examples from the beginning. | Analyses theory or real world examples separately, only joining together if necessary.
Broad focus; likes to have more than one thing on the go at the same time. | Narrow focus; prefers to focus on completing one task before moving on to the next.
Internally directed. | Externally directed.

Table 5 The Difference between ‘Global’ and ‘Sequential’ Learner’s Characteristics (Pask, 1979 as cited in Clewley, Chen & Liu, 2011)

More specifically, global learners develop a general understanding of the scope and structure of learning tasks at hand and gradually shift attention to details that fill in the structure, while the sequential learners undertake individual details first, connect the separate topics, and finally shape the overall picture (Ford, 2000).

The Dimension of ‘Information Processing’

Kagan, Rosman, Day, Albert, & Phillips proposed two poles in respect to a ‘processing information’ dimension; ‘active-reflective’, (impulsivity-Reflexivity) style (1964 as cited in Rozencwajg & Corroyer 2005). They developed the Matching Familiar Figures Test (MFFT), which requires familiar line drawing of objects to be matched against several possibilities (Cassidy, 2004). From a more cognitive perspective, the Impulsivity-Reflexivity style is defined as one kind of the cognitive construct that combines individuals’ decision making time and the number of errors in uncertainty problems. It is because people differ in the way they collect, arrange, and process information to solve problems (Rozencwajg & Corroyer, 2005). Impulsivity to problem solving is related to
short latencies and a great number of incorrect answers, opposed to the type of reflexivity which presents long latencies and few errors. Some are careful and commit fewer errors (reflexive), while others are less cautious and make numerous errors (impulsive) (Kagan, Lapidus & Moore, 1978 as cited in Buela-Casal, Carretero-Dios, De los Santos-Roig, & Bermúdez, 2003).

Kolb defined learning in his experiential learning theory as the process whereby knowledge is created through the transformation of experience (1984). In other words, knowledge learners obtain results from the combination of grasping and transforming experience. These multifaceted mental processes by which perceived information is converted, can be categorised into two categories: active experimentation and reflective observation (Kolb, 2005). Active experimentation (AE) is related to the active approach to learning which relies heavily on experimentation while reflective observation (RO) is connected to a tentative and impartial approach to learning. ‘Active’ suggests that students do something in class beyond simply listening and watching. They prefer discussing, questioning, arguing or brainstorming (Kolb & Kolb, 2005).

The consequence is that they don’t learn much in situations that require them to be passive and learn best when they can engage in collaborative learning projects. On the other hand, reflective learners rely on careful observation of others or on their own experience. They do not learn much in situations that provide no opportunity to think about the information and work better by themselves or with at most one other person (Felder & Silverman, 1988).

Simply speaking, those who make quick responses after briefly looking into the alternatives are labeled “active learners,” while individuals who examine each alternative before making a final decision are labeled “reflective learners” (Buela-Casal et al., 2003).

Honey and Mumford named active learners as ‘activist’ and defined those who learn by doing and have an open-minded approach to learning, fully involving themselves
without bias in new experiences. They argued that the active learners tend to act first and consider the consequences afterwards. Active learners used to tackle problems by brainstorming. As soon as the excitement from one activity has died down they start to look for the next. They tend to thrive on the challenge of new experiences but are bored with implementation and longer term consolidation.

Another learning style type, ‘Reflector’ in Honey and Mumford was defined as those who learn by observing and thinking about what happened. (http://www.le.ac.uk/users/rjm1/etutor/resources/learningtheories/honeymumford.html). Reflectors avoid leaping in and prefer to watch from the sidelines, standing back and viewing experiences from various perspectives, collecting data and considering thoroughly before coming to an appropriate conclusion. (http://www.le.ac.uk/users/rjm1/etutor/resources/learningtheories/honeymumford.html).

With respect to the way of applying this construct in general, it can be hardly determined which style is better. The difference between active and reflective reflects the preferable strategy of processing information (Zelniker, Jeffrey, Ault & parsons, 1972). Rather, this dimension is associated with the personality types. As several researches indicated, the ‘active-reflective’ is correlated to Jung’s ‘extraversion-introversion’ (Kolb & Kolb, 2005).

**The Multifaceted Dimension**

Gregorc (1979) claimed that individuals have an inborn inclination for learning when they learn and act upon their environments. He presented four distinctive and observable behaviours based on ‘perception’ along with ‘ordering’. ‘Perception’ signifies ‘the means by which learners grasp information’ and ‘ordering’ means ‘the ways in which learners arrange, systematize, reference and dispose of information’ (Gregorc 1982). As Figure 9 shows ‘Perception’ has two poles, ‘concrete’ or ‘abstract’ and ‘ordering’ consists of ‘sequential’ or ‘random’.
The dimensions in Gregorc's Mind Style Model bear a strong resemblance to the Piagetian concepts of 'accommodation' and 'assimilation', which Kolb also adopted and labelled 'prehension' and 'transformation' (Coffield et al., 2004a). A combination of these behaviours is indicative of individual style (Cassidy, 2004). The concrete sequential learning preference (CS) is characterised by the tendency to derive information from direct, hands-on experience, using the five senses. For instance, a plaster model handled by the teacher in a science class would be insufficient for these learners. CS learners prefer step-by-step processing when confronted with a learning situation since they like clearly planned presentations and a quiet atmosphere of learning.

Concrete random learners (CR), on the other hand, are differentiated by an experimental attitude and accompanying behavior. CR learners quickly get the general
idea and demonstrate the ability to make leaps in exploring unstructured problem-solving experiences. Concrete random learners prefer the trial-and-error approach to acquire information. They are not good at working independently without a teacher’s intervention.

<table>
<thead>
<tr>
<th>Types of learner</th>
<th>Descriptive characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>The concrete sequential (CS) learner</td>
<td>Ordered, perfection-oriented, practical and thorough</td>
</tr>
<tr>
<td>The abstract sequential (AS) learner</td>
<td>Logical, analytical, rational and evaluative</td>
</tr>
<tr>
<td>The abstract random (AR) learner</td>
<td>Sensitive, colourful, emotional and spontaneous</td>
</tr>
<tr>
<td>The concrete random (CR) learner</td>
<td>Intuitive, independent, impulsive and original</td>
</tr>
</tbody>
</table>

**Table 6  The Characteristics of Four Types of Learner (Coffield et al., 2004a)**

Abstract sequential (AS) are distinguished by excellent decoding abilities with written, verbal, and visual symbols. AS learners have a wealth of conceptual "pictures" in their minds against which they match what they read, hear, or see in graphic and pictorial form. These learners prefer a presentation with rational and sequential substances which helps them to extract main ideas from the presentation.

Abstract random learners (AR) are characterised by their attention to human behavior and a capacity to sense and interpret "vibrations." Since abstract random learners prefer to receive information in an unstructured manner, they like group discussions or activities that involve multi-sensory experiences (Gregorc, 1979). The characteristics of the four types of learner are described in Table 6. Figure 10 is a representation of the Cognitive Style analysis (CSA) made up of bipolar independent dimensions. viz. cognitive organisation (holist-analytic) and mental representation (verbal-imagery) (Riding & Rayner, 1998).
Gregorc regarded learning styles as inborn inclinations, assuming that styles are fixed or at least are very difficult to change. A number of theorists who provide relatively flexible accounts of learning styles refer to genetic and constitutional factors. Unlike Gregorc’s Styles Delineator (GSD) (Gregorc, 1979), ‘styles’ in Riding’s Cognitive Styles Analysis (CSA) (Sadler-Smith et al., 1999) are more like generalised habits of thought with the enduring structural basis for such a habit. Learning style in the CSA reflects deep-seated features of the cognitive control and process. Cognitive organisation derives from the work of Witkin (1962) on field-independence and field-dependence and mental representation is connected to Paivio’s ‘Double Cod Theory’ (1971).

![Figure 10 The Two Dimensions of Cognitive Style (Sadler-Smith & Riding, 1999)](image)

The holist-analytic’ dimension refers to a habitual way of processing and organising information, while the ‘verbal-imagery’ dimension describes a habitual way of representing information (textual/verbal or diagrammatic/pictorial modes) in memory while thinking. These two dimensions of cognitive style affect learning performance in two ways (Sadler-Smith & Riding, 1999): (1) the holist-Analytic dimension interacts with the structure of the contents of instruction (e.g., simultaneous vs. sequential; wholes vs.
parts) and (2) the Verbal-Imagery dimension interacts with the mode of the presentation of information (e.g., textual vs. pictorial) (Riding & Agrell, 1997).

The holist-analytical dimension may affect preferences for different types of instructional methods (e.g., role play vs. distance learning) and instructional media (e.g., text vs. video). Analytics takes a structured approach to learning and prefers clearly organised information. They may impose order on information, events and experiences if they are not inherently structured (Riding, 1997). Holists, on the other hand, feel the need to impose structure on some unstructured situations or experiences. The holist-analytical dimension affects social behavior as well (Riding, 1991). Holists tend to be dependent and gregarious while analytics tend to be isolated and self-reliant. The Verbal-Imager dimension may also affect preferences of presentation; verbalisers prefer textual modes and imagers are more comfortable with pictorial modes (Sadler-Smith & Riding, 1999).

The next multifaceted learning style instrument is Myers-Briggs Type Indicator (MBTI). The MBTI was influenced by the work of Jung (1968) and focused on learning style as one part of the observable expression of a relatively stable personality type. The significant characteristic of the MBTI is to operate at the interface of intelligence and personality (Grigorenko & Sternberg, 1995) while debates continue about the appropriate descriptors for personality traits and how many factors underpin individual differences. The MBTI along with Apter’s Motivational Style Profile (MSP) and Jackson’s Learning Styles Profiler (LSP) is concerned with constructing instruments that embed learning styles within an understanding of the personality traits that shape all aspects of an individual’s interaction with the world (Coffield et al., 2004). Figure 11 shows the four

![Figure 11 MBTI four preferences](image-url)
bipolar discontinuous scales of the MBTI. There are 16 MBTI personality types based on these scales.

Although there is inconclusive evidence to support the MBTI as a valid measurement of style, or as an aid to pedagogy, few can deny the influence of the MBTI on various dimensions of learning style. Many researchers examined the relationship between the MBTI and other inventories (Capraro & Capraro, 2002). One of the theorists who are greatly influenced by the MBTI is Kolb (1974, 1976, 1984), who developed a model of learning styles based on theories of experiential learning (Kolb, Boyatzis & Mainemelis, 2001). Kolb’s Learning Style Inventory (LSI) has two dimensions (‘Concrete Experience / Abstract Conceptualisation’ and ‘Active Experimentation / Reflective Observation’), which are correlated with the MBTI (‘Feeling/Thinking’ and ‘Extraversion/Introversion’) (Kolb et al., 2001). His proposed “cycle of learning” involves four adaptive learning modes: two opposing modes of grasping experience, concrete experience (CE) and abstract conceptualization (AC); and two opposing modes of transforming experience, reflective observation (RO) and active experimentation (AE) (Kozhevnikov, 2007).

In Kolb’s Learning Style Inventory there are 4 types of learning style; diverging, assimilating, converging and accommodating learning style (See Figure 12). The dominant learning abilities in the ‘Diverging’ learning style are ‘Concrete Experience’ (CE) and ‘Reflective Observation’ (RO). People with this learning style are best at viewing concrete situations from many different points of view. Since they like to have broad cultural interests and to gather information, ‘Diverging’ learners prefer to work in groups and receive personalised feedback.

The ‘Assimilating’ style’s main learning abilities are Abstract Conceptualization (AC) and Reflective Observation (RO). People with this learning style are best at understanding a wide range of information and putting this into logical form. Rather than practical values, logical soundness is more important to them. For this reason ‘Assimilating’ learning style prefers readings, thinking through problems, and exploring analytical models.
The leading learning abilities of the ‘Converging’ style are Abstract Conceptualization (AC) and Active Experimentation (AE). People with this learning style are good at finding practical uses for ideas and theories. Since they have ability to find solutions and make decisions, they prefer to deal with technical tasks and problems rather than with social or interpersonal issues. In formal learning situations, ‘Converging’ learning style enjoys experiments with new ideas, simulations, laboratory assignments, and practical applications. The ‘Accommodating’ styles dominant learning abilities are Concrete Experience (CE) and Activity Experimentation (AE). Unlike the ‘Converging’ learning style, people with ‘Accommodating’ learning style depend heavily on people for information than on their own technical analysis. They like to carry out plans and involve themselves in new and challenging experiences (Kolb et al., 2001).

There are similarities among Gregorc’s sequential–random processing, Kolb’s convergent–divergent, and the ‘thinking–feeling’ in the MBTI as well as between
Gregorc’s and Kolb’s concrete–abstract dimensions (See Table 7). Several scholars noticed a close similarity between Kolb’s and Gregorc’s characterisations of learning styles and the MBTI personality styles (Garner, 1993 as cited in Salter, Evans, & Forney, 2006).

<table>
<thead>
<tr>
<th>Level</th>
<th>MBTI</th>
<th>Gregorc</th>
<th>Kolb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception</td>
<td>Sensing-Intuitive</td>
<td>Concrete-Abstract</td>
<td>Concrete-Abstract</td>
</tr>
<tr>
<td>Complex cognitive activities</td>
<td>Thinking-Feeling</td>
<td>Sequential-Random</td>
<td>Convergent-Divergent</td>
</tr>
</tbody>
</table>

**Table 7** The Comparison Among MBTI, Gregorc & Kolb Learning Style

They introduce two bipolar models of learning style, designating styles that operate in both the ‘perception’ and ‘complex cognitive activities’ (decision making, judgment, and problem solving).

### 2.5 The Teaching Style

The purpose of teaching is to enhance learning. For the enrichment of learning it is important to teach learners how to utilize methods and strategies that caters for a diversity of learning styles (Seaman & Fellenz, 1990). Every educator needs to understand that all learners have different preferences for, and styles of, learning. In this regard information about learning styles only present half of the picture, since it lacks understanding of teaching styles.

In the classroom, teachers engage themselves in a teaching-learning transaction that is defined by a set of values, such as the personalities of learners and a teacher, the contextual setting and the prevailing political climate (Brookfield, 1986, vii). The teaching-learning transaction affects a teacher’s beliefs, their perceived roles and the
purpose of the curriculum (Darkenwald & Merriam, 1982). The function of teacher values, beliefs, knowledge, roles and their preferred pedagogies are operationalised in the classroom by an individual’s teaching style (Conti, 2007). This means that awareness of one’s own teaching style can make a difference in how teachers manage their classroom, how they deal with learners and how well their students do in their learning (Conti, 1989).

2.5.1 The Notion of Teaching Style

Teaching style is connected with what each educator holds in high-esteem (attitudes, values, belief, skills and personality) and involves matching his or her behaviour with this teaching philosophy (Heimlich & Norland, 2002). There is, for this reason, no single theory that accounts for the complexity of the learning environment. There is also no single agreed upon way of defining teaching style. Grasha (1996) understood styles as a set of personal characteristics. Various approaches to identifying the elements of teaching style have been developed, which have implications for the practices of teaching. Many different aspects were drawn on and each of these perspectives adds a differential insight to the notion of style.

Grasha formulates the elements of teaching style as follows (1996, p. 38):

a) The teachers’ ability to provide intellectual excitement and to develop interpersonal relationship with learners;

b) Successful combinations of personal characteristics and instructional practices;

c) The organisation of information and the supply of order and structure the learners need to learn;

d) The specific instructional process associated to the effort towards promoting active learning;

e) The roles employed in response to the needs of the classroom environment;
f) The degree of interaction between an educator and learners reflecting the stage of growth leading from dominating interactions to sharing and discussing information (e.g., teacher-centered or learner-centered); and

g) The particular needs, attitudes, values and beliefs reflected within the learning-teaching metaphors as a conceptualization of principles guiding the actions of teachers.

Teaching style incorporates the full implementation of educators’ philosophy, beliefs, values, and behaviors toward common features of the teaching-learning transaction (Javis 2004). They have to continue to study themselves and then develop this insight to their teaching. The first step is ‘self-reflection’ to gain a new perspective on the teaching style; asking themselves ‘who I am as a teacher and what I want to become?’ and considering possible changes. Self-reflection aims at learning from experiences to make themselves better teachers. This process involves obtaining insight into underlying attitudes, values and assumptions about teaching and learning. It may entail challenging long-held beliefs about themselves, their learners, and the whole processes of teaching and learning.

According to De Bem, there are three characteristics of people who are successful in making changes in their lives: learning from their mistakes, chastising themselves for slow progress or relapses to older ways, and falling back into the contemplation stage to think over and to decide how to try again in the future (2013). The willingness to change should also be brought to analysis in a process of self-reflection, specific aims to pursue, or personal qualities to develop.

### 2.5.2 The Conceptual Base of Teaching Style

The teaching style is embedded in a conceptual base that includes principles of teaching and learning. Both the content and the selection of particular teaching methods is based on scholarly research and inquiry subsumed by a philosophical, theoretical,
and empirical basis (De Bem, 2013). These will give instructional processes a consistent theoretical structure. In effect, the intellectual context will guide and direct the selection of goals to pursue, the teaching methods to employ and the desired outcomes to work towards (Grash, 1996).

The following are the components of a conceptual basis of teaching style (Grasha, 1996; De Bem, 2013):

- Firstly, individual assumptions and definitions about teaching and learning: they play an important role in how teachers design and implement various classroom processes. Regardless of teachers’ personal assumptions, they may lead educators to explore alternate ways of teaching or broaden perspectives of what is possible. On the other hand, they can lead to rigid ways of teaching.

- Secondly, there are formal principles of teaching and learning: theories of learning, models of teaching style and learning style, and views of human nature. Even though it appears from various forms of quantitative and qualitative research on teaching-learning processes, formal principles of teaching and learning include every theory, model or perspective. Yet, the majority of people teaching in higher education ignore these sources, as Grasha has pointed out (1996).

- Lastly, guiding metaphors for teaching, i.e.: analogies, smiles, or allegories, summarize the personal teaching-learning process model. Guiding metaphors are more than figures of speech. It reflects a teacher’s beliefs, attitudes and values that direct action. This personal model intervenes in all decisions about how and what to teach.
2.5.3 The Models of Teaching Style

A number of dimensions for measuring teaching styles have been developed. There are many categorisations of teaching styles with various terminologies from different fields (Alhussain, 2012), these include: open –Traditional (Solomon & Kendall, 1979); Formal-Informal (Bennett, Jordan, Long & Wade, 1976; ‘Expert, Formal authority, Personal model, Facilitator, and Delegator (Grasha, 1996); Intellectual Excitement – Interpersonal Rapport (Lowman, 1996); ‘Assertive, Suggestive, Collaborative and Facilitative (Benzie, 1998); content-centered and people-centered; proactive and reactive; teacher-centered and learner-centered; guided, exposition, and inquiry; didactic, Socratic, and facilitative facilitator and path gnomonic; reproducing and productive; and holistic and analytical (Alhussain, 2012). Another important teaching style model is reflected in the Teaching Perspective Inventory (TPI) developed by Pratt and Collins (2000), which evaluates several styles: transmission, apprenticeship, developmental, nurturing, and social reform. Research has also identified which areas influence an individual’s teaching style: beliefs, cultural background, teaching experiences, (Heimlich, 1990), the nature of the subject area (Evans, 2004; Lawrence, 1993), government curriculum initiatives (Hargreaves, 2003), and job satisfaction (Opdenakker & Van Damme, 2006; Alhussain, 2012).

2.5.3.1 Formal - Informal Teaching Style

Bennet and Jordan attempted to provide a typology based on the self-reported teaching strategies of primary school lecturers (1975). Their tasks were: (1) to provide a more adequate theoretical and experiential conceptualisation of the elements constituting teaching styles; (2) to design questionnaires which elicit objective information on a wide range of teaching practices; and (3) to create on the basis of this information, a typology of teaching styles by using cluster analysis.
Bennet and Jordan described 12 teaching styles along with some psychometric information (Type 1 is highly informal and type 12 is highly formal) as showed in Figure 13 (1975). They aggregated seven of the 12 types into three categories: informal, mixed and formal (Bennet, 1976).

![Figure 13 Twelve Types of Teaching Styles (Bennet & Jordan)](image1)

This means that lecturers in type 1 (highly informal) prefer the integration of subject matter while allowing students to choose whether to work individually or in groups. Most lecturers in type 1 give students the choice of where to sit in class. On the other hand, the lecturers in type 12 (highly formal) do not use an integrated approach and allow students to choose where they sit in class. These lecturers are above average on the use of all assessment procedures (Bennet & Jordan, 1975).

![Figure 14 B-P-E Model (Bennet, 1976)](image2)

Bennett (1976) stated that there is no guaranteed way of preventing the traditionalist from concluding that formal teaching is better in general. Yet the oversimplified interpretation can be avoided by reporting references to the persons to whom it applies and its purpose (e.g., formal approaches were found to be linked with better academic skill acquisition in grade 4 students). Another solution is to use the general form of
Behavior-Person-Environment linkages (Hunt & Sullivan, 1974), where the outcome (B) of teaching methods (E) is considered in relation to specific pupils (P) (See Figure 14).

2.5.3.2 Intellectual Excitement – Interpersonal rapport

Lowman introduced the two-dimensional model of teaching style in his book titled *Mastering the Techniques of Teaching* (1984). It characterises the range of teaching styles found in college classrooms. He describes the effectiveness of teaching and learning in using the following equation:

\[ Q(I) = (IE + IR) \]

The Quality \( Q \) of Instruction \( I \) is regarded as the summation of the two skills of ‘evoking Intellectual Excitement \( IE \)’ and ‘creating Interpersonal Rapport \( IR \)’ in students (Lowman, 1995). In using this equation, he developed a ‘two dimensional model of effective college teaching’ (See Table 8) Intellectual Excitement focuses on the content to be learned – the clarity of communication, expertise, organisation, technical expertise and engaging presentation. ‘Interpersonal Rapport’ contains interest in students as individuals, interest in students’ learning, and receptive to students’ preferences about assignments and policies.

<table>
<thead>
<tr>
<th>Intellectual Excitement</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
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<tbody>
<tr>
<td>High</td>
<td>Intellectual Authority</td>
<td>Exemplary Lecturer</td>
<td>Complete Exemplary</td>
</tr>
<tr>
<td>Moderate</td>
<td>Adequate</td>
<td>Competent</td>
<td>Exemplary</td>
</tr>
<tr>
<td>Low</td>
<td>Inadequate</td>
<td>Marginal</td>
<td>Socratic</td>
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*Table 8  Lowman’s Two Dimensional Model of Effective College Teaching (Larson, 2007)*
Lawman stated that the process of teaching is not the simple act of conveying words that describe some subject (1996). Rather, it is the complex act of transferring understanding from one person directly to another. This means that an outstanding lecturer is one who has high ‘intellectual excitement’ and high ‘positive rapport’. Excellence in both can guarantee effective teaching with every student and in any kind of class.

Students in a low ‘IR’ classroom are motivated by fear. Usually the atmosphere of a classroom is highly controlled, cold and uneasy. An instructor demonstrating low ‘IE’ is described as a dazed, unenthusiastic, and vague lecturer. Students in this classroom are frustrated, confused and uncertain. Instructors with high ‘IR’ work with students individually and acknowledge their feelings. They are concerned with how well students understand the content of their subject. Students are encouraged to ask questions in class. They are motivated to do their best, because they believe that the lecturer has confidence in their abilities.

In a high ‘IE’ classroom, the content is well-organised. It is presented in clear language, in an engaging way, and relationships between topics are emphasised. When lecturers who have a high ‘IE’, students know exactly where the lecture is going. They see connections between topics and experience a sense of excitement about the content. Based on the two-dimensional model of teaching, a highly proficient lecturer has two skills: (1) the ability to present information in a well-organised and interesting manner; and (2) the aptitude to communicate and motivate students to work hard to meet academic challenges. In his conclusion Lowman (1996) pointed out one important question; ‘What impact do these qualities of an exemplary lecturer have on what students learn?’

He explains that what students learn is mostly influenced by:

- The amount of academic ability students have; and
- How inspired they are to use the ability of students in a given class
In other words, students who are more knowledgeable and motivated and who work harder will learn more effectively. The contribution made by lecturers is the next step. The combined product of their teaching ability and how motivated they are would do the best possible job in a given course. The way a course is organised plays tertiary role in influencing how much students learn. For instance, enriching a course with technologies or using cooperative teaching techniques is likely to influence what students learn (Johnson and Johnson, 1987). Yet the contribution of course characteristics will always be smaller than what is produced by the qualities of the students and lecturers (Lowman, 1996).

2.5.3.3 Assertive – Suggestive - Collaborative – Facilitative

Benzie examines teaching styles by focusing on how they impact the learning process. He believed that teaching styles help determine how much information is retained and understood by students (1998). Benzie developed the model below (See Table 9) as a resource for tutoring medical students, but it can be possibly utilised in any context.

The assertive style of teaching requires clear, instructor-determined expectations with regards to all aspects of the teaching and learning process. It enables an instructor to use class time more productively for teaching and provides supportive control. Yet students in the assertive class, easily become passively quite. The supportive style of teaching helps instructors motivate students to get involved in the learning process and to reflect on what they are learning. This approach encourages acquiring learning skills, self-management skills and responsible learners. The collaborative style focuses on the developmental needs of many students by drawing on students’ ideas and personal experiences. Students are asked and encouraged to think with differential diagnoses of problems. This approach is helpful in teaching problem-solving skills (Dasari, 2006). The facilitative style allows for more student self-understanding. It correlates with the humanistic approach to learning and represents a shift to one of empowering the
students to learn theory and skills. Students are supported to engage in intellectual analysis and describe experiences (Gregory, 2002).

<table>
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<tr>
<th>Four Basic Teaching styles</th>
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<td>Assertive</td>
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<tr>
<td>Suggestive</td>
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<tr>
<td>Collaborative</td>
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<td>Facilitative</td>
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<tr>
<th></th>
<th>Gives direction</th>
<th>Suggests alternatives</th>
<th>Elicits students' idea</th>
<th>Elicits students feelings</th>
<th>Offers opinions</th>
<th>Explores student ideas</th>
<th>Offers feelings</th>
<th>Relates personal experiences</th>
<th>Invites personal experiences</th>
<th>Encourages / uses silence</th>
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<td>Assertive</td>
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<td>Suggestive</td>
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<td>Collaborative</td>
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<tr>
<td>Facilitative</td>
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</table>

Teacher-centered          Student-centered

Table 9  Four Basic Teaching Style (Benzie, 1998)

2.5.3.4 Didactic – Socratic – Facilitative – Experiential

Jarvis (2004) combine the authoritarian didacticism approach with the democratic facilitator’s approach and developed a classification of 4 levels; didactic, Socratic, facilitative and experiential. A didactic approach can be very effective when students are encouraged to ask questions, analyse the course content and initiate the learning process. Figuring out the answers without the help of a lecturer demonstrates respect for the students’ knowledge and experience as well as facilitating independent learning (Jarvis, 2004).

However, the didactic approach to teaching primarily involves lecturing and is essentially teacher-centered (Entwistle, 1997). It entails various constraints; rote
learning, learning through taking notes, potential boredom and the limitation of student participation and reflection. The Socratic method of teaching places emphasis on learner-centeredness unlike didacticism, which is conventionally teacher-centered. Lecturers offer the initial theoretical frameworks and introduce the associated discrepancies in an attempt to raise awareness in students, initiate reflection and ponder the main theme. In this process, students become independent learners and critical thinkers.

Jarvis mentioned the effectiveness of Socratic teaching to adults, which includes: (1) utilizing both the learner’s store of knowledge and their experience of life, (2) helping the learners create rather than reproduce knowledge; and (3) actively engaging the learners in the learning process (2004). The facilitative lecturer serves as a coach. He or she shares information first and then allows the learners to practice what they have learned in discussion and questions. In being questioned students are motivated to understand how they can use what they have learned. This facilitative approach to teaching clarifies previous learning and improves learners ability to ‘make sense’ of experiences in relation to real world events (Gregory, 2002). The experiential approach to teaching is not just related to ‘field work’ or ‘praxis’ but is much closer to real life situations. When considering pragmatic knowledge, students are more self-directive learners and they can develop their ability and increase their motivation by contributing to the learning process.

2.6 The Learning and Teaching Style with Other Variables

In educational context, there are various variables to contribute towards educational achievement: competencies (prior knowledge, skills and strategies, self-regulation) or encoding strategies (learning styles, expectancies and subject values (Mischel, 1981). Lecturers who endeavour to promote their students’ learning should consider the implications of these factors.
In literature during the last decade or so, interest in teaching style and learning style has grown. This has led to a firm conviction of their influence on instructional practice (Woods, 1995 as cited in Louange, 2007). The important role of individual differences is proved by considerable attention and numerous studies on learning and teaching style. However, there is a long-standing debate on whether or not the match between teaching/learning styles is beneficial on academic outcomes. Zhang asserts that the literature on lecturer/student style match/mismatch contains somewhat ambiguous findings. Some argue the benefits of a match, whereas others contend that the effect of matching is insignificant (2006, p. 396).

With regards to match/mismatch, there is a controversy as mentioned earlier. Matching instructors' preferred teaching style to students' preferred learning styles will produce higher academic success (Clark & Latshaw, 2012; Court & Molesworth, 2003; Iurea et al., 2011; Peacock, 2001; Visser, McChlery & Vreken, 2006). On the other hand, other researchers assert that there is no significant relationship between style match and academic success (Brown, 2010; Karakava, Ainscough & Chopoorian, 2001; Tucker et al., 2003).

One of the reasons of controversy might be that learning and teaching style is contingent on the learning context. The importance of the interaction between learning and teaching style may be content-specific: whether the classes are more traditional or not, how much a lecturer rely on structuring the class in accordance with his/her own learning style or how much assessments (homework and exams) is related to lectures (Clark & Latshaw, 2012). Spoon and Shell (1998) also mention learning style may differ according to age and situational variables – the nature of the curriculum, subject being studied, type of class or the learners’ purpose for attending classes.

Another reason might be that learning and teaching styles are closely linked to affective variables – students’ effort in learning and a lecturer’s attitude toward teaching. Busato and his colleges studied the relationship of intellectual ability, achievement motivation,
personality and learning style with student performance. They denote that these factors overlap on academic success (Busato, Prins, Elshout & Hamaker, 2000, p. 1058).

A lecturer’s effort is also one of contribution. If a lecturer concentrate on developing students’ aptitudes, and motivating them, the lecturers’ effort will be more effective (Clark & Latshaw, 2012). Teaching strategies which consider different learning styles will lead to a development in differentiated instructional approaches for these learners. And it might have a positive impact on student performance (Tulbure, 2011). Also the preferred learning style of learners in the past may not be the current preferred learning style anymore. Lecturers need to examine their belief and engage in an ongoing process of diagnosis, with self and with learners through observation, questioning, obtaining evaluative feedback, and critical reflection (Gilakjani, 2012, p. 56).

Instead of catering for individual’s learning style, understanding differences in learning styles and considering relevant teaching styles would be a more appropriate perspective to empower learners. Felder predicts that if lecturers teach exclusively in a way that favours their students’ less preferred learning style modes, the students’ discomfort may increase and interfere with their learning (1993). If students learn only in a manner that favours his/her preferred learning style mode, they will lose an opportunity to develop mental dexterity.

There are certain patterns that emerge when learning styles are investigated through group categorisation, such as academic discipline and gender. Learners from different discipline are found to have different learning styles. There is a difference between learners from humanities-based majors and those with mathematically-based majors (Mathews, 1994); between learners majoring in psychology and special education and those majoring in social work and criminal justice (Gadzella & Masten, 1998); and between psychology majors and biology majors (Clump & Skogsberg, 2003).

With regards to the relationship between learning style and academic discipline, Kolb and Kolb (2005) indicate that various disciplines are localised in different learning style
modality. Although early educational experiences makes individual learning style generalised, an increasing process of specialization starts to shape in high school. This specialisation in the realm of social knowledge affects an orientation of learners toward learning and ends in meticulous relations between learning styles and an educational specialty or discipline. Given that learning and teaching style is contingent on the learning context, they are diverse and sensitive to disciplines. Students perceive that different disciplines require different learning strategies, and they are able to adapt or meet the requirements of the learning task (Jones, Reichard & Mokhtari, 2003, p. 373).

Researchers have continuously found that there are significant differences in learning styles between males and females (Baneshi, Tezerjani & Mokhtarpour, 2014; Keri, 2002; Miller, Finley, & McKinley, 1990; Philbin, Meier, Huffman & Boverie, 1995). For instance, males are more kinesthetic, tactual, visual, and require more mobility than females. Females conform much easier to what parents and lecturer say than males (Miller et al., 1990). Keri (2002) found that females demonstrated stronger preferences than males for the ‘Social/Conceptual’ learning styles, and learned best through hands-on experience. Males, on the other hand prefer ‘Abstract/Reflective’ learning styles more than females, and seemed to learn best if they were thinking and watching.

According to studies conducted by Amir, Jelas and Rahman (2011) and Amir and Jelas (2010), female students prefer collaborative learning and welcome lecturers who provide notes and learning materials. They benefit more from a well structured lecturer, guidance and concrete hands-on experiences. This finding is related to personality. Regardless of their field of study, female students are more agreeable and more conscientious than male students. Carson, Butcher and Mineka state that female students are much more likely to seek professional help (Rubinstein, 2005).

In terms of mathematics education, potential gender difference has given attention with regards to the way individuals acquire and process information (Arnup, Murrihy, Roodenburg & McLean, 2013). Gender differences in mathematics are a somewhat controversial research area: some researchers suggest that males often outperform
females, especially in high school and university populations (e.g., Halpern et al., 2007; Leder, Forgasz, & Taylor, 2006) and others argue that females more often outperform their male classmates. The gender difference could be explained with cognitive ability (high spatial ability / low spatial ability), cognitive style (visual mode of thinking / verbal mode of thinking) or learning style (preference of instruction involving picture / involving words). (Arnup et al., 2013; Mayer & Massa, 2003).

The result from Matthews shows that female students are more independent in their learning than male students (1994). Additional research confirms that females tend to prefer accommodating or diverging learning, which focuses on concrete methods of knowledge acquisition. On the other hand, males prefer traditional and analytical learning, which focuses on the use of abstraction (Matthews, 1996). Orhun states that female students prefer learning by doing and male students tend to be risk-takers (2007).

Many studies are linked to the notion that a learner’s attitude affects his/her performance, and interest in mathematics (Bramlett & Herron, 2009, p. 43). A relationship between attitudes toward mathematics and mathematics achievement has been found in various ways (Aiken, 1976; Ma & Kishor, 1997 as cited in Middleton, Ricks, Wright, & Grant, 2013). How learners feel, think, and act, within and toward mathematics (attitude) affects achievement outcomes and later their participation in the learning of mathematics (Yates, 2002, p. 4). It happens because learning style has a close relationship with anxiety, self-efficacy and attitude towards mathematics (Peker & Mirasyedioğlu, 2008). The instructional environment created by learning styles and teaching styles also interacts with these variables. Many studies prove that there is a positive relationship between learning style and achievement in mathematics (e.g., Alberg, Cook, Fiore, Friend & Sano, 1992).

Regardless of the current controversy surrounding learning and teaching styles and their impact on academic achievement and despite the ongoing scepticism regarding
teaching styles’ impact on learning style, research in this area gains momentum, (Felder, 1993; Park, 2001).

At tertiary level, instead of utilising teaching styles to match learning styles, problem-based learning is recommended. (Duch, Groh & Allen, 2001). Problem-based learning takes students’ individual differences into account and lecturers are advised to prepare meaningful learning situations so that each student would participate actively in problem solving. Inquiry-based learning is also recommended, especially in undergraduate mathematics education. Inquiry-based learning engage learners in learning new mathematics by exploring mathematical problems, proposing and testing conjectures, developing proofs or solutions, and explaining their ideas” (Laursen, Hassi, Kogan & Hunter, & Weston, 2011, p. 73).

Although it would be impossible for lecturers to cater for all of the possible relevant differences among their students, lecturers are asked to continuously be aware of the learning styles of their learners and to adapt their instructions accordingly. Identifying learning preferences manifested by students in various educational contexts, lecturers need to revise and modify instructional strategies and methods which should reflect students’ learning styles. By using an instructional framework based on learning and teaching style, lecturers will also benefit from the knowledge and creativity of learners (Iurea et al., 2011, p. 260).

Another aspect is learners’ responsibility. Since learners know their learning preferences and their own needs, they should make an effort to meet those needs in the classroom. Brown (2003) points out that matching teaching and learning styles is not effective for adult learners. Rather he emphasises ‘all-around’ learners. Since learning is an ongoing process and it occurs over the span of lifetime through a variety of instructors with a variety of teaching styles, learners need to be able to adjust their learning styles to different instructional approaches.
There are two sorts of learning effectiveness: “learners can do better at selecting learning opportunities to suit their style or they can set out to work to become better all-around learners by investing extra effort in underdeveloped or underutilized styles. (Delahoussaye 2002, p. 31). In the latter way learners can reach their potential for achievement in school and as professionals by developing mental dexterity (Felder, 1996). Hayes and Allinson (1997, p. 3) also note that learners who are exposed in learning activities that are mismatched with their preferred learning style will develop the required learning competencies. It is necessary to cope with situations involving a range of different learning requirements. For the ‘teaching around the cycle’ and for ‘all-around learners, lecturers are advised to focus on helping students build their multidisciplinary skills in both their preferred and less preferred modes of learning (Goodnough, 2001; Brown, 2003; Gilakjani, 2012).

2.7 Conclusion

From the perspective of social constructivism, it may be argued that both success and failure in learning and teaching mathematics are the collaborative social accomplishments of learners and a lecturer (McDermott & Gospodinoff, 1981; Au, 1998). In a sense, the integrated elaboration of the individual process of constructing knowledge and the process of social interaction between a lecturer and learners or among learners is significant (Cobb et al., 1992, p. 28; Bauersfeld, 1992, p. 467).

A mathematics classroom should be more of a learning and less of a teaching environment. Learners need to be able to understand and apply mathematical concepts and procedure by using their prior knowledge and recognising their physical and interpersonal environments, instead of just sitting and gaining knowledge. Grasha defines (1996) learning style as learners’ role in interaction with peers, lecturers and course content’. In this regards, learning style should be given consideration for effective learning and an active and productive classroom environment; which is important for both a lecturer and learners.
The role of a lecturer as a facilitator is emphasised. He or she needs to help learners extend fundamental skills, afford them the opportunities to practice, facilitate classroom discourse and constantly check instructional structure (Bodilly et al., 1998, p. 30; Visser et al., 2006). In the course of learner-centered instruction students may develop critical thinking, the ability to solve problems, cognitive flexibility and social negotiation. Taking learning into account as opposed to teaching, lecturers could be more disposed towards employing a teaching style which caters for differences between learning styles (Penfied, 1987, p. 29).

However catering for differences in learning styles is a controversial issue (Allinson & Hayes, 1996). There are positive results regarding style/match that it would be seemingly logical to match the teaching styles with learning styles to render the instruction more effective (Pinto et al., 1994). On the other hand, there are several studies that don’t support this assumption (Scott, 2010; Riener & Willingham, 2010; Dembo & Howard, 2007).

There might be several reasons:

- The contingent characteristics of learning and teaching style (Clark & Latshaw, 2012):
  Learning and teaching style may be content-specific and it may differ according to situational variables (the nature of the curriculum, subject being studied, type of class or the learners’ purpose for attending classes) (Spoon & Schell, 1998).

- The amalgamation of certain influential factors (Busato et al., 2000; Chamorro-Premuzic & Furnham, 2003; Duff, Boyle, Dunleavy & Ferguson, 2004): the relationship of intellectual ability, achievement motivation, personality, belief or attitude.
Lecturers’ attitude and effort (Clark & Latshaw, 2012; Tulbure, 2011; Gilakjani, 2012): considerate teaching strategies and differentiated instructional approaches through observation of his or her learners’ learning style, or examination on their own belief.

Regardless of the current controversy surrounding learning and teaching styles and their impact on academic achievement and despite the ongoing scepticism regarding teaching styles’ impact on learning style, research in this area is gathering momentum (Felder, 1993; Park, 2001). It happens because adapting teaching to cater for differences in learning styles could be one of the best ways to probe what students know and how they learn best (Louange, 2007). At tertiary level, there is a reform to enhance learning by making use of learning and teaching style. Instead of utilising teaching styles to match learning styles, problem-based learning (Duch, Groh & Allen, 2001) and inquiry-based learning are recommended, especially in undergraduate mathematics education (Hassi, Kogan & Laursen, 2011, p. 73).

Learners can do better at selecting learning opportunities to suit their style or they can set out to work to become better all-around learners by investing extra effort in underdeveloped or underutilized styles. (Delahoussaye 2002, p. 31). Learners need to be empowered with multidisciplinary skills. When learners take in and process information, they need to be observant, methodical and careful (‘Sensing’ learning style) and at the same time learners should be innovative and inclined to go beyond fact to interpretation and theory (‘Intuitive’ learning style). Similarly, learners must develop both visual verbal mode of learning and have sequential and global understanding of information. Through this teaching around the cycle, learners can reach their potential for achievement in school and as professionals by developing mental dexterity (Felder, 1996). In a sense lecturers are advised to teach in both their preferred and less preferred modes of learning (Goodnough, 2001; Brown, 2003; Gilakjani, 2012).
CHAPTER 3
RESEARCH METHODOLOGY

3.1 Introduction

This chapter introduces the philosophical assumptions and the design strategies corroborating this research study. While clarifying the various stages and processes involved in the study, it also discusses the research methodologies as well as data collection and analysis methods employed. It is recommended that a general framework be adopted to present all facets of the study which comes from the philosophical ideas behind data collection and analysis procedures. The research design for this study is a mixed method design that is analysed through quantitative and qualitative methods.

3.2 A Research design and Approach

A research design is ‘concerned with the research methodology, approach and the subsequent analysis of the data’ (Robert-Hulmes 2014, p.20). The research design connects the research questions to the data being collected. Learning and teaching is of equally complex in nature, as human phenomena are complex. Such complexity cannot be investigated from a single research perspective or approach. When researchers began to realise that quantitative methods were inadequate to answer questions about human phenomena, qualitative research started taking off. Many authors highlight the differences between the two approaches for gaining a better understanding of the methods so that they can be used appropriately.

Leedy and Ormrod depict a clear distinction between qualitative and quantitative approaches (2001, p. 102). This description is delineated in terms of purpose, process, data collection, data analysis and reporting of findings.
The purpose of quantitative research is to seek explanations and findings that can be generalised to other situations and can contribute to theory. The intent is to establish, validate or confirm causal relationships. The purpose of qualitative research is to seek a better understanding of complex relationships. This type of research is exploratory in nature and builds theory from the ground up through observations. Quantitative research is a structured process wherein concepts, variables, hypotheses and methods of measurement are determined before the study and remain the same throughout. The choice of methods allows for objective measurement of variables of interest and unbiased conclusions. The qualitative research process is more “holistic and emergent” (Leedy & Ormrod, 2001, p. 102). The specific focus of the research, the measurement instruments and interpretation may be developed or possibly changed as the research unfolds. Researchers immerse themselves in the situation and interact with participants in order to gain an understanding from their point of view. Themes (variables) emerge from the data; and rich, context-bound information, patterns and theories are interpreted in order to explain the phenomenon being studied.

In quantitative research, the variables are determined beforehand and specific methods of measuring each variable are developed. Data is collected from a randomly chosen population or a large sample representing the population. Data is collected in a form that is easily converted to numerical indices. Emphasis is placed on the reliability and validity of the instruments used. Qualitative researchers operate under the assumption that “reality is not easily divided into discrete, measurable variables”. Sampling involves the selection of a few participants who can shed light on the phenomenon in question, since the purpose is not to make generalisations. Data is collected through observations and interviews as the researcher immerses himself or herself in the setting. Hence in qualitative research the researcher is often described as being the research.

Quantitative researchers begin with a hypothesis or theory and then relying heavily on deductive reasoning to draw logical conclusions. Qualitative researchers rely more heavily on inductive reasoning. After specific observations are made, the researcher draws conclusions about larger and more general phenomena. However, most
researchers in reality use both types of reasoning in a continual repeating form. With regards to reporting findings, in quantitative research, the data is reduced to numbers that can be presented as statistical tests. The data is interpreted based on the average of the group’s performance, rather than focusing on individual scores. Reporting assumes a formal, scientific style using the passive voice and impersonal language. Qualitative researchers describe the complexity of the phenomenon being studied by constructing interpretive narratives from the data. A more personal writing style is used and the participant’s own language and perspectives are more often included in reports on findings (Leedy & Ormrod, 2001, p. 102).

The perspective of research is grounded in his or her assumptions about social science and the social world. This includes researchers’ assumptions about knowledge; about what is acceptable as evidence; the nature of human action; and assumptions about what characterises social structures and processes (Rossman & Rallis, 2012, p. 34). They go on to say that philosophers and sociologists have used the concept of “paradigm” to describe the complexity of thought that guides definitions of science.

3.3 Research Paradigm

Thomas Kuhn is considered as the progenitor of the concept of paradigm in relation to the study of history and science philosophy. In its broadest sense, Kuhn used the term paradigm as “worldviews or all-encompassing ways of experiencing and thinking about the world, including beliefs about morals, values and aesthetics” (Klenke, 2008, p. 13). Paradigm is also termed as the net that contains the researchers’ epistemological, ontological and methodological premises (Denzin & Lincoln, 2011, p. 13). Every research is guided by a set of beliefs about the world and how it is to be understood and studied. In a sense they are interpretive. Each paradigm makes particular demands on the researcher, in terms of approach and methodology, the questions that are asked and the way in which they are interpreted (Denzin & Lincoln, 2011, p. 13).
An Individual paradigm can be determined by responding to three fundamental and interrelated questions (Guba & Lincoln, 1994, p. 108): the ontological question, the epistemological question and the methodological question. The ontological question deals with the form and nature of reality and what can be known about it. The epistemological question probes the nature of the relationship between the knower and what is to be known. The methodological question deals with the methods that the inquirer undertakes to find out what he or she believes can be known. And lastly the axiological (interrelated) question deals with the role of values and bias in research.

Guba and Lincoln offer an example of an assumption of the real world according to these questions (1994). If one assumes that there is a “real world”, then only questions pertaining to what really exists and how things really work are relevant. Other questions, for example, questions pertaining to moral or aesthetic matters, are not considered as legitimate scientific inquiry (the ontological question). If one assumes a realist ontological position, then the knower inadvertently assumes an objectivist posture. This implies that there is a “real” world to be discovered (the epistemological question). If an “objective” inquirer attempts to discover a “real” reality then he or she has to control possible variables (the methodological question).

This study is founded on the assumption that multiple realities exist (Creswell, 2013, p. 20; Denzin & Lincoln, 2011, p. 13; Klenke, 2008, p. 16). The study reported on these multiple realities by way of obtaining the opinions and describing the various perspective from the participants, based on the researcher’s own contextual interpretation (Klenke, 2008; Leedy & Ormrod, 2001) using multiple forms of evidence (Denzin & Lincoln, 2011).

### 3.4 Mixed Methods Design

The purpose of this study is to provide university students and lecturers with different views of learning and teaching by exploring the learning and teaching styles evident in university mathematics instruction. Identifying the different learning and teaching styles
are sure to contribute towards a more balanced approach to instruction. For the purpose of this study, a sequential explanatory mixed methods design has been selected to obtain the richest data on multiple planes.

This chapter presents the research design that was selected for this study. A rationale is provided for the choice to use mixed methods, along with a description of the sequential mixed methods (MM) design, which has been used to address the research questions asked in this study.

Creswell and Clark define the MM design as (2007, p. 5):

A research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collecting, analysing, and integrating both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone.

The MM research approach requires collecting, analysing, and integrating both quantitative and qualitative methods. It yields a comprehensive view of the issues with the products of pragmatic and transformative data that neither quantitative nor qualitative alone can offer (Teddlie & Tashakkori, 2009).

There are three areas where the MM research is superior to the purely paradigmatic approaches to data collection and analysis (Teddlie & Tashakkori, 2009, p. 33):

- MM research can simultaneously address a range of confirmatory and exploratory questions with both the qualitative and the quantitative approaches.
- MM research provides better (stronger) inferences.
- MM research provides the opportunity for a greater assortment of divergent views.

As a result, this mixed approach is likely to produce high quality, complex meta-inferences, which are reflected in the integration of the quantitative and qualitative phases of the design (Ivankova & Kawamura, 2010). The rationale for mixing both kinds of data within one study is that neither quantitative nor qualitative methods provide a broader perspective, to capture the movements and details of a certain situation (Ivankova, Creswell & Stick, 2006). To answer the research questions of this study, the quantitative data alone will not be sufficient. As a result, qualitative data was gathered to explain in greater detail what really happens in the mathematics classroom at university in the nexus of learning styles and teaching styles.

There are approximately forty mixed-methods research designs according to literature (Tashakkori & Teddlie 2003 as cited in Ivankova et al., 2006). Teddlie and Tashakkori explain that there are six mixed method designs that are used most often; Parallel Mixed Designs, Sequential Mixed Designs, Iterative Sequential Mixed Design, Conversion Mixed Designs, Multilevel Mixed Designs, and Fully Integrated Mixed Designs (2009). Out of many mixed methods designs, the sequential explanatory mixed methods design is very popular among researchers (Creswell, Clark, Gutmann & Hanson., 2003).

The basic purpose of the sequential explanatory design is to use qualitative data to explain or build on the initial quantitative results (Creswell et al., 2003). The advantages and disadvantages of this mixed-methods design have been debated broadly in literature (Ivankova et al., 2006). In short, its strengths include straightforwardness to implementation and opportunities for the exploration of the quantitative results in more detail. It also provides a clear delineation of contributions of internal and external factors for readers. The limitations of this design are the practicability of resources to collect and analyse both types of data and length of time required to complete the data collection and analysis process. The interrelation of quantitative and qualitative data in
this model allows for the examination of the overlapping parts of each phase. This process leads to the different findings that are related to the same problem (Creswell & Clark, 2007)

To identify the dominant learning styles exhibited by mathematics students at an urban university in South Africa, the statistical data and their subsequent analysis were used. This provided a general understanding of the research problems. Thereafter, qualitative data and their analysis filter the quantitative data and provide details on the different views of learning and teaching on what constitutes a balanced instructional approach.

This study employs, from pragmatic reasons, a sequential explanatory mixed method design to obtain rich data on multiple planes.

The research questions of this study are divided into the various data collections phases as follows:

Phase one — quantitative research question
   1. What are the dominant learning styles and teaching styles exhibited in mathematics classes at an urban university in South Africa?

Phase two — qualitative research question
   2. What are the suitable teaching styles that effectively address these learning styles?

Phase three — mixed-methods integration
   1. What can be done to reach out to students whose learning styles are not addressed by the common instructional approaches in mathematics classes in South Africa?
<table>
<thead>
<tr>
<th>PHASE</th>
<th>PROCEDURE</th>
<th>PRODUCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>• Identity and adapt Instruments</td>
<td>• Revised assessment</td>
</tr>
<tr>
<td>QUAN data</td>
<td>• Cross-Sectional Survey (N = 277 / 251)</td>
<td>• Signed authorisation forms</td>
</tr>
<tr>
<td>Collection</td>
<td></td>
<td>• Numeric Data</td>
</tr>
<tr>
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<td>• Data Screening</td>
<td>• Clean database</td>
</tr>
<tr>
<td></td>
<td>• SPSS V. 22</td>
<td>• Descriptive Statistics, Missing data, Outliers</td>
</tr>
<tr>
<td></td>
<td>• Descriptive statistics &amp; Data visualisation</td>
<td>• Frequency, Valid percent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Median Split Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUAN data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June -</td>
<td>• Development of interview Protocol from QUAN results</td>
<td>• Interview protocol</td>
</tr>
<tr>
<td>July</td>
<td>• Purposefully select the participant from QUAN phase</td>
<td>• Participants (N=15 / 7)</td>
</tr>
<tr>
<td>Collection</td>
<td>• Segmented by varied degree in each style</td>
<td>• Open-ended interviews</td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Transcripts of open-ended interviews</td>
<td>• Transcripts of open-ended interviews</td>
</tr>
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<td></td>
<td>• Audio-recording</td>
<td>• Audio-recording</td>
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<td>Phase II</td>
<td>• Open-ended interviews</td>
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<td>Qual. data</td>
<td>(N = 15 / 7)</td>
<td></td>
</tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Transcribe open-ended interviews</td>
<td></td>
</tr>
<tr>
<td>Qual. data</td>
<td>• Coding of themes</td>
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</tr>
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<td>Analysis</td>
<td>• Theme analysis</td>
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</tr>
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<td>• Develop intervention based on meta inferences</td>
<td>• Intervention</td>
</tr>
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<td></td>
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<td></td>
<td>• Participants</td>
<td>• Participants</td>
</tr>
<tr>
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<td></td>
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<tr>
<td>Nov - Dec</td>
<td>• Code</td>
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</tr>
<tr>
<td>2014</td>
<td>• Themes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Similarities / differences</td>
<td></td>
</tr>
<tr>
<td></td>
<td>In categories &amp; themes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Thematic matrix</td>
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</tbody>
</table>

**Figure 15** Visual model of this sequential explanatory mixed methods design
It is necessary in any mixed-methods study to deal with issues of priority, implementation, and integration of the quantitative and qualitative approaches (Ivankova et al., 2006, p. 10). ‘Priority’ refers to which approach, quantitative or qualitative (or both) enjoys more emphasis. The researchers’ interest, the orientation of the study, and the audience of the study can possibly influence where ‘priority’ lies (Creswell & Clark, 2007). In this study, priority is placed upon the quantitative data because the results of the quantitative phase directed the qualitative phase of the study. Qualitative data are related to the quantitative results and are used to explain the statistical findings of the quantitative phase.

‘Implementation’ determines whether data collection and analysis of both quantitative and qualitative data sets will follow in sequence (Green, Caracelli & Graham, 1989). In this study, quantitative data was collected first to identify the dominant learning styles of students and teaching styles of mathematics lecturers. Due to the broad scope of the present study, the quantitative phase utilizes instruments designed to capture information on teaching and learning styles. This is likely to be more comprehensive than the qualitative data gathering phase.

After the statistical data was analysed, an interview protocol was developed from the findings that emerged in the quantitative analysis and a priori by the researcher. Participants were selected from the quantitative phase using a maximum variation sampling strategy, based on their responses to the survey questions. Qualitative data collection and analysis are meant to be complementary to the largely in-depth understanding of quantitative phase.

‘Integration’ refers to the stage in which high-quality meta-inferences are made via the combination of the quantitative and qualitative phases of the study (Onwuegbuzie & Johnson, 2006, p. 53). In this study, the quantitative and qualitative phases are integrated in the intermediate stage when the quantitative inferences inform and guide the development of the questions for the qualitative phase. In addition, the participants for the qualitative phase were selected from the sample of the quantitative phase. To
end with, the results generated in the quantitative and qualitative phases of this study are for the creation/generation of meta-inferences.

The findings from the quantitative and qualitative phases along with existing literature were utilized to develop implications for a balanced instruction. The visual model of the mixed methods sequential design procedures in this study is presented in Figure 15.

3.5 Legitimation

The term “validity” in quantitative research is explained as the “interpretations, inferences and actions that we make on the basis of numerical data” (John & Christensen, 2008, p. 150). On the other hand “validity” in qualitative research relates to the context, situation, person, and language or world view (Creswell 2013). Since mixed research involves combining complementary strengths and minimizing the weaknesses of quantitative and qualitative research (Creswell, 2013), the term “legitimation” was proposed by Onwuegbuzie and Johnson (2006). They developed the legitimation model and it consists of nine types of legitimation: sample integration, inside-outside, weakness minimization, sequential, conversion, paradigmatic, commensurability, multiple validities, and political legitimation (Onwuegbuzie & Johnson, 2006, p. 53).

To ensure the quality of the inferences, this study incorporates three types of legitimation: (1) Sequential legitimation, (2) Inside – outside legitimation, (3) Multiple validities’ legitimation. Sequential legitimation refers to the minimization of potential problems wherein the meta-inferences can be affected by reversing the sequence of the quantitative and qualitative phases (Onwuegbuzie & Johnson, 2006, p. 57). This study is conceptualized to include two phases in a sequential mixed methods design. Quantitative data is collected to identify what the dominant exhibited learning and teaching styles at university are. This informs the qualitative phase which in turn is
designed to better understand the relationships between teaching and learning styles. Findings from the quantitative and qualitative phases are used to produce the meta-inferences to address the effective and efficient instructional approach.

Inside-outside legitimation refers to the extent to which the researcher accurately presents the insider’s and observer’s view within the description or explanation (Onwuegbuzie & Johnson, 2006, p. 57). The view of the outsider is represented by the quantitative data, whereas the view of insider is represented within the qualitative data. Inside-outside legitimation validates conclusions and minimizes bias in interpretation and integrates quantitative and qualitative data. In this study the researcher used peer reviewers both in the quantitative phase and the qualitative phase. Peer reviews are helpful to evaluate how the relationships among the variables were conceptualized and interpreted in the quantitative phase and to minimize the threat of bias by reviewing the interpretations.

Multiple validities legitimation refers to the extent to which addressing legitimation of the quantitative and qualitative components of the study result from the use of quantitative, qualitative, and mixed validity types, yielding high quality meta-inferences (Onwuegbuzie & Johnson, 2006, p. 57). For this study, in the quantitative phase, students and lecturers will be asked to complete surveys in a group setting with adequate space to distribute this survey.

In the qualitative phase, minimal bias is essential for producing accurate results by using multiple ways of collecting data, disclosure of researcher’s beliefs and biases, and peer reviewers. During integration of quantitative and qualitative data, meta-inferences were drawn relevant to the population of interest.
3.6 Quantitative Phase

The goal of the quantitative phase is to identify the dominant learning and teaching styles exhibited at an urban South African university. Through survey research, the researcher is able to provide “a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population” (Creswell, 2013: p. 249). There are two major types of surveys: cross-sectional and longitudinal.

A cross-sectional survey is a type of observational study that involves the analysis of data collected from a population, or a representative subset, at one specific point in time. In other words, it is surveys completed by a single respondent at a single point in time. On the other hand, a longitudinal survey entails the correlation of repeated observations of the same variables over long periods of time (often many decades). Longitudinal data can be obtained for any measure or subject employed in a cross-sectional survey.

This study uses a cross-sectional survey since it occurs at one point in time to identify the prominent mathematical learning styles and teaching styles exhibited at the university where this study was conducted.

3.6.1 Subjects

There are multiple participants in this study. The use of multiple participants could increase the strength of inference (Lester, 1999). The first group of participants is students who registered for mathematics modules and who attended classes during 2014 at the University of Johannesburg. The second group of participants includes 21 lecturers who were teaching mathematics at the university.

Sampling is used as a process of selecting participants from the target population with the purpose of generalising from the sample (the smaller group) to the population (the larger group) (Gliner, Morgan & Leech, 2000). In survey research, 100 samples are
required for each major sub-group in the population and between 20 to 50 samples for each minor sub-group (Delice, 2010). Many researchers agreed that the size of between 30 and 500 is the necessary sample size if parametric tests are to be used (Delice, 2010). The researcher tried to maximize the response rates from students, as well as to seek representation from each faculty.

<table>
<thead>
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<td>Total</td>
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</table>

Table 10 Descriptive Aspects of the Participants of GRSLSS

During the first stage (Quantitative phase), 302 students at the University of Johannesburg completed ‘Felder – Silverman learning style inventory’ and 276 students at the University of Johannesburg completed ‘Grasha - Riechmannnn student learning style inventory’. Both questionnaires were randomly distributed at mathematics classes.
with the permissions of the lecturers who agreed to participate this study. Simple random sampling “involves a selection process that gives every possible sample of a particular size the same chance of selection (Blaikie, 2003, p. 168) and the samples may possibly be representatives of the population (Silverman, 2006, p. 37). 21 lecturers completed the ‘Grasha teaching style survey’. Some key descriptive aspects of samples are provided in Table 10, 11 and 12.

<table>
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Table 11 Descriptive Aspects of the Participants of ILS
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</tr>
</tbody>
</table>

Table 12 Descriptive aspects of the participants of GTSI

3.6.2 Instruments

The instruments are relevant to the research questions. To answer the first research question, “What are the dominant learning styles and teaching styles exhibited in mathematics classes at an urban university in South Africa?”, three inventories were chosen. Two learning style inventories (Felder – Silverman inventory and Grasha - Riechmann Student Learning Style Scales) and Grasha’s teaching style inventories.

The reason why the two learning style inventories were selected is because it is necessary not only to examine students’ learning styles related to cognitive characteristics but also to consider the individual’s preferred choice of learning environment and level of interaction with environmental factors (Cassidy, 2004, p. 423).
By taking into account that enhanced learning relies on whether a learner is active, highly motivated and in possession of the right strategic knowledge (Amir et al., 2011, p. 22), understanding both the inner and outer learning process is significant.

To find out ‘Flexibly stable’ learning styles of UJ students, the ‘Felder - Silverman Index of Learning Style (ILS)’ was used. This inventory is classified into the category of cognitive characteristics related learning style (Kim, 2011). On the other hand, to get know ‘Social Interaction learning style’, Grasha -Riechmann Student Learning Style Scales (GRSLSS) was used. This scale is characterised under the instructional preference and social interaction (Cassidy, 2004, p. 422). Both inventories were developed for college students as the target population. Many researchers made use of these instruments to examine the learning styles of college students (Lang, Stinson, Kavanagh, Liu & Basile, 1999; provitera & Esendal, 2011; Ültanir, Ültanir & Temel, 2012; Graf, Viola, Leo, & Kinshuk, 2007).

With regards to teaching style, the ‘Grasha Teaching Styles Inventory’ was used. This inventory firstly emphasises assisted learning strategies and personal applications of course content (Filonova, 2008, p. 4), secondly it enables lecturers to identify their own strengths and weakness (Provitera & Esendal, 2008, p. 71) and it provides instructors with ways to understand the nature of lecturer – student encounters (Kassaian & Ayatollahi, 2010, p. 132).

**Grasha -Riechmann Student Learning Style Scales (GRSLSS)**

The GRSLSS was developed by Grasha and Riechmann in 1974. The original instrument included three learning styles: the dependent, independent and cooperative styles. Later on Grasha developed the instrument further to include 6 styles in the current inventory (Dülger, Aslan & Büyükkarci, 2010). Each style is measured with 10 items (1990, 1996). He categorised learning styles according to six modes of student behaviour in a tertiary learning environment: Independent, dependent, collaborative, competitive participative, and avoidant (Amir et al., 2011).
This inventory has been used widely in higher education and other educational settings for over two decades (Grasha, 1996, p. 181). The Grasha-Reichmann Student Learning Style Scales (GRSLSS) provides measures of preferences for social interaction along these six dimensions, which focus on student attitudes toward classroom activities, lecturers, peers and learning (Cassidy, 2012).

Evidence of the instrument’s reliability and validity has been presented by Baneshi, Alikaramdoust and Hakimzadeh (2013) who conducted an exploratory and confirmatory factor analysis of over 450 completed responses to the instrument. The findings from exploratory factor analysis (n=561) showed that GRSLSS includes six factors. The factors acquired from confirmatory factor analysis (n=478), was confirmed by indices in exploratory factor analysis. The internal consistency of each subscale, ranging from 0.58 to 0.80, was at an acceptable level. The GRSLSS is for this reason a popular instrument for studies examining student learning preferences (e.g., Diaz & Cartnal, 1999; Meeuswen, King & Pederson, 2005) despite the noted paucity of available reliability and validity data for the instrument (Novak, Shah, Wilson, Lawson & Salzman, 2006)

**Felder – Silverman Index of Learning Style (ILS)**

The Felder-Silverman Index of learning Style (ILS) is developed by Barbara A. Silverman and Richard M. Felder of North Carolina State University. Initially this inventory was developed for engineering students but has been used later for foreign and second language education, and management education students (Provitiera & Esendal, 2008). It is used in technology enhanced learning but was also designed for traditional learning (Graf et al., 2007). The authors considered learning style as consisting of characteristics, strengths and preferences in the ways individuals perceive and process a new piece of information, approach a new learning experience, and/or solve problems.

The ‘ILS’ is used to evaluate learning preferences according to four dimensions, which consist of sensing/intuitive, visual/verbal, active/reflective and sequential/global. Each
dimension has 11 questions associated with it. Learners’ individual preferences are presented with values between +11 to –11 for each dimension. When answering a question, for example, if +1 is added to the value of a sequential preference, the value of or a reflective preference decreases the value by 1.

This inventory is used for many reasons: (1) it depicts learning styles in detail with four dimensions. Felder – Silverman Index of Learning Style (ILS) is based on several theories and incorporates other learning style models (Moallem, 2007, p.219) developed by Kolb (1984), Pask (1976) and Myers-Briggs (Briggs & Myers, 1962); (2) this inventory measures learning styles as values between 11 and -11 so it distinguishes between strong and weak preferences; and (3) learning styles are regarded as tendencies, meaning that students have a core tendency for a specific learning style but can also act differently in particular situations (Liu & Graf, 2009).

Felder and Spurlin analysed the data in regards to the distribution of preferences for each dimension and provided the verifying reliability and validity of the instrument (2005). In research done by Litzinger, Lee, Wise and Felder factor analysis of the ILS identified eight factors associated with the four scales (2005). Analysis of the underlying construct for each of the factors revealed that they are appropriately matched to the intent of the scales. They provided evidence or construct validity in their analysis of the instrument (Litzinger et al., 2005). While these studies are likely to support the argument of whether ILS is reliable, valid and suitable, open issues arose, which need further examination (Graf et al., 2007). Felder – Silverman Index of Learning Style (ILS) is one of the most frequently used learning style models and some researchers even argue that it is the most appropriate model for use in adaptive learning systems (Carver et al., 1999, p. 34; Kuljis & Liu, 2005, p. 191).

‘Grasha Teaching Style Inventory’ (GTSI)

Based on the ‘GTSI’, teaching style is defined as a particular pattern of needs, beliefs and behaviours that lecturers display in the classroom. The GTSI shows that several
patterns describe the stylistic qualities of college lecturers. Expert (transmitter of information); Formal Authority (sets standards and defines acceptable ways of doing things); Personal Model (teaches by illustration and direct example); Facilitator (guides and directs by asking questions, exploring options, suggesting alternatives); and Delegator (develops students ability to function autonomously) (Grasha, 1996). The ‘GTSI’, is a standardized instrument that has been tested for reliability and validity by the authors of the instrument and has been exploited widely yielding valid and reliable results (Behnam & Bayazidi, 2013).

In this study three inventories were used to collect baseline data about the lecturers’ teaching styles and the learning styles of students respectively. They were administered during the data collection in the second and third semester of 2014 and the resulting data was employed to inform the focus of subsequent interviews.

3.6.3 Procedure

The data collection took place at the University of Johannesburg during the first and second semesters of 2014. The students who registered for mathematics modules and the lecturers who were teaching mathematics were chosen. The questionnaires for students were distributed in mathematics classroom with the permission of each lecturer. 302 students completed ‘Felder – Solomon learning style inventory’ and 276 students completed ‘Grasha - Riechmannn student learning style inventory’.

And for collecting data from the lecturers emails were sent to perspective participants for the qualitative part of this study: lecturers who were teaching mathematics to undergraduate students at that time. A brief overview of this study and participants’ intended role was presented through email. Perspective participants for the qualitative part of the study were identified at each faculty (Applied math, Pure math and Education). Lecturers who responded to the email were invited to participate in the
study and twenty one lecturers (including professors) completed questionnaires. 9 lecturers agreed to assist me with distributing learning style inventories to their students.

3.6.4 Data analysis and interpretation

Statistical Consultancy Service of the University of Johannesburg (Statkon) was used to code the data while Excel and SPSS were used to electronically re-organise and analyse data collected from the survey. Frequency counts and cross-tabulation helped to analyse the demographic information and the participants’ answers to separate items on each domain. In order to determine the dominant learning styles from the quantitative data, the researcher used common analytical methods. T-test or analysis of variance (ANOVA) statistical tests were used for parametric data and chi-square, Mann-Whitney U Test or Kruskal-Wallis Test were employed for non-parametric data (Fink, 2012).

3.7 Qualitative Mode

In a sequential mixed design, the qualitative phase proceeds off the back of the results obtained in the quantitative phase (Teddlie & Tashakkori, 2009; Creswell et al., 2003). A researcher who employs this design normally connects the two phases by selecting the participants for the follow-up interviews after having analysed the quantitative data. Another opportunity for integration might come during the development of the interview protocol grounded in the quantitative results from the first phase (Ivankova & Kawamura, 2010).

To answer the second research question, “What are the suitable teaching styles that effectively address these learning styles?” the participants were purposively selected and the interview protocol was developed. Both the selection of participants and the
content of the interview protocol were grounded in the statistical results from the quantitative phase.

### 3.7.1 Subjects

Since the second qualitative phase was implemented to explain the initial results in more depth, purposive sampling was chosen as the basis for selecting participants in the interviews. The purposive sampling technique was preferred to identify instances that are representative or typical of a particular type of case on a dimension of interest (Teddlie & Tashakkori, 2009, p. 175).

<table>
<thead>
<tr>
<th>No.</th>
<th>Participant</th>
<th>Independent / Dependent</th>
<th>Collaborative / Competitive</th>
<th>Participant / Avoidant</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A2</td>
<td>Mod. / Mod.</td>
<td>High / High</td>
<td>High / Low</td>
<td>A representative UJ male student</td>
</tr>
<tr>
<td>2</td>
<td>K</td>
<td>Mod. / High</td>
<td>High / High</td>
<td>High / Low</td>
<td>A representative UJ female student</td>
</tr>
<tr>
<td>3</td>
<td>D</td>
<td>Mod. / High</td>
<td>High / Low</td>
<td>High / Low</td>
<td>A representative of Education faculty</td>
</tr>
<tr>
<td>4</td>
<td>A1</td>
<td>High / Low</td>
<td>Mod. / High</td>
<td>High / Low</td>
<td>Independent &amp; Competitive male student</td>
</tr>
<tr>
<td>5</td>
<td>N</td>
<td>Mod. / High</td>
<td>High / Low</td>
<td>High / Low</td>
<td>Dependent &amp; Collaborative Female student</td>
</tr>
<tr>
<td>6</td>
<td>M1</td>
<td>High / Mod.</td>
<td>Mod. / Mod.</td>
<td>High / Low</td>
<td>Independent &amp; Competitive female student</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
<td>High / Mod.</td>
<td>High / Mod.</td>
<td>High / Low</td>
<td>Independent &amp; Collaborative</td>
</tr>
<tr>
<td>8</td>
<td>M3</td>
<td>High / High</td>
<td>High / High</td>
<td>High / Low</td>
<td>High in every domain</td>
</tr>
</tbody>
</table>

Table 13  The Interviewees’ Results of ‘Grasha -Riechmann Student Learning Style Scales (GRSLSS)’
With the intent of more in-depth information the participants were selected from the samples of quantitative survey. Eight students from each inventory (16 students in total) were selected from those who completed the surveys. In sequential explanatory mixed method design, individuals who participate in the qualitative phase must be individuals who participated in the quantitative phase (Creswell & Clark, 2007).

<table>
<thead>
<tr>
<th>No</th>
<th>Participant</th>
<th>A./R.</th>
<th>Sn./I.</th>
<th>V./Vr.</th>
<th>S./G.</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>M4</td>
<td>R. (Str.)</td>
<td>Sn. (Mod.)</td>
<td>V. (Str.)</td>
<td>S. (Mod.)</td>
<td>A representative of UJ predominant learning style combination (RSnVS)</td>
</tr>
<tr>
<td>10</td>
<td>T2</td>
<td>R. (Mod.)</td>
<td>I. (Bal.)</td>
<td>V. (Mod.)</td>
<td>S. (Mod.)</td>
<td>A representative of UJ predominant learning style combination (RSnVS)</td>
</tr>
<tr>
<td>11</td>
<td>T1</td>
<td>A. (Str.)</td>
<td>Sn. (Str.)</td>
<td>V. (Str.)</td>
<td>S. (Str.)</td>
<td>A representative of UJ predominant learning style combination (ASnVS)</td>
</tr>
<tr>
<td>12</td>
<td>A3</td>
<td>R. (Mod.)</td>
<td>Sn. (Str.)</td>
<td>V. (Bal.)</td>
<td>S. (Str.)</td>
<td>Strong ‘Sensing’ learner (Female)</td>
</tr>
<tr>
<td>13</td>
<td>J</td>
<td>A (Mod.)</td>
<td>I (Str.)</td>
<td>V (Mod.)</td>
<td>S. (Mod.)</td>
<td>strong ‘Intuitive’ (Male)</td>
</tr>
<tr>
<td>14</td>
<td>G</td>
<td>A. (Str.)</td>
<td>I. (Str.)</td>
<td>V. (Str.)</td>
<td>G. (Mod.)</td>
<td>Strongly Contrast</td>
</tr>
<tr>
<td>15</td>
<td>M2</td>
<td>R. (Bal..)</td>
<td>I. (Bal.)</td>
<td>Vr. (Mod.)</td>
<td>S. (Mod.)</td>
<td>‘Verbal’ learner</td>
</tr>
<tr>
<td>16</td>
<td>I</td>
<td>R. (Bal.)</td>
<td>I. (Mod.)</td>
<td>V. (Str.)</td>
<td>G (Mod.)</td>
<td>Strong ‘Visual’ learner</td>
</tr>
</tbody>
</table>

Table 14  The Interviewee’ Results of ‘Felder - Silverman Index of Learning Style (ILS)’

Sixteen student participants were purposively selected as representatives of UJ students’ learning styles. Criteria for selecting them for the qualitative phase included: (1)
being participants in the quantitative phase; (2) those who have typical types of learning style (strong ‘Collaborative’, ‘Competitive’ and ‘Participant’); and (3) having relatively contrast to each other in any domain. For instance, the participant no. 4 had strong ‘Independent’ learning style as opposed to ‘Dependent’ learning style and strong ‘Participant’ learning style as opposed to ‘Avoidant’ learning style. Also seven lecturers were selected on the basis of the differences they exhibit in terms of their teaching styles. Scores of each participant are provided in Table 13 and 14 with the references.

With regards to the ‘Social interaction learning style’, UJ students have a high average score in ‘Collaborative’, ‘Competitive’ and ‘Participant’ learning style (‘Collaborative = 3.69, ‘Competitive’ = 3.06 and ‘Participant’ = 4.03). Participants A2 and K (High scores in three domains) were selected as representatives of UJ students. The quantitative results show that the students in the faculty of education are more ‘Collaborative’ and ‘Participant’ than students in the faculty of science and engineering ($X^2 (2, n = 249) = 9.06, p = .011$). For this reason participant D was selected as a representative of the faculty of education. There is also statistically significant relationship between ‘Gender’ and the ‘Independent – Dependent’ learning style (U = 6587.0, Z = - 1.96, p = .05). Participants A1 (male) and N (female) were selected for the comparison.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Expert</th>
<th>Formal Authority</th>
<th>Personal Model</th>
<th>Facilitator</th>
<th>Delegator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>High (3.5)</td>
<td>High (4.0)</td>
<td>Mod. (3.625)</td>
<td>Mod. (3.0)</td>
<td>Mod. (2.5)</td>
</tr>
<tr>
<td>C</td>
<td>High (3.875)</td>
<td>High (4.0)</td>
<td>High (4.25)</td>
<td>Low (2.375)</td>
<td>Mod. (2.625)</td>
</tr>
<tr>
<td>D</td>
<td>High (3.75)</td>
<td>Mod. (3.5)</td>
<td>High (4.25)</td>
<td>Mod. (3.375)</td>
<td>Mod. (3.0)</td>
</tr>
<tr>
<td>G</td>
<td>High (4.125)</td>
<td>High (4.125)</td>
<td>Mod. (3.125)</td>
<td>Low (2.125)</td>
<td>High (3.375)</td>
</tr>
<tr>
<td>B</td>
<td>High (4.25)</td>
<td>Mod. (3.875)</td>
<td>Mod. (3.375)</td>
<td>Mod. (3.125)</td>
<td>High (3.25)</td>
</tr>
<tr>
<td>F</td>
<td>High (4.25)</td>
<td>Mod. (3.5)</td>
<td>Mod. (3.875)</td>
<td>Mod. (2.875)</td>
<td>High (3.25)</td>
</tr>
<tr>
<td>E</td>
<td>High (3.75)</td>
<td>Mod. (3.125)</td>
<td>Mod. (3.5)</td>
<td>High (4.125)</td>
<td>High (3.125)</td>
</tr>
</tbody>
</table>

**Table 15 The Results of ‘Grasha Teaching Style Inventory (GTSI)’**
In the bipolar relationship of the ‘Participant – Avoidant’ pair, all participants have contrasts to other learning styles. All have high score in ‘Participant’ learning style and low score in ‘Avoidant’ learning style. It is because the average ‘Participant’ and ‘Avoidant’ learning style of UJ students are obviously different from one another (‘Participant’ = 4.03, ‘Avoidant’ = 2.03). As a result participants M1, M3 and C were selected for the comparison of the ‘Participant – Avoidant’ learning style.

For the ‘Flexibly - stable learning style’ of UJ students, participants T4, M4 (RSnVS) and T1 (ASnVS) were selected as representatives (RSnVS – 18.2%, ASnVS – 17.8%). Participants A3 and J were selected for the sake of comparison. According to the quantitative results, male students are more ‘Intuitive’ learners and female students are more ‘Sensing’ learners. There is a significant association between ‘Gender’ and ‘Sensing – Intuitive’ learning style \( (X^2 = (2, n = 300) = 15, p = .001 \, \text{phi} = .22) \).

With regards to the ‘Flexibly - stable learning style’, the majority of UJ students have balanced learning styles (59.9% of balanced learning style in ‘information processing’, 68.2% of balanced learning styles in ‘information processing’, and 66.2% of balanced learning style in ‘information understanding’). By contrast the ‘Visual’ learning style (48%) is more than the balanced learning style (43.7%) in the ‘information receiving (Visual – Verbal)’ domain. For this reason, participants M2 (Verbal) and I (Visual) were selected for the comparison. The seven participants (lecturers) were selected based on their degree of each teaching style. The table 15 provided the scores of every participant.

### 3.7.2 Instrumentation

In qualitative research, the researcher interprets the data through personal analysis and insights, rather than through a standardized statistical instrument (Frey, 2012). The researcher should be able to make adjustments to data collection processes in response to information learned during the process of data collection (Merriam, 1998, p. 7). This flexibility facilitates the researcher’s understanding of the suitable teaching
styles that effectively address the dominant learning styles. According to Flick, semi-structured interviews best allow for focus on particular topics. The reason for this is that semi-structured interviews employ open-ended questions, hypothesis-directed questions and confrontational questions to disclose interviewees’ complex stock of knowledge about the topic (Flick, 2009, pp. 156-157).

A mixed semi-structured and unstructured format was chosen for this study. It allowed the interviews to examine students’ characteristic strengths and preferences in the learning environment and to obtain lecturers’ opinions about the results from the quantitative data. The content of the interview questions were related to the definitions of learning styles and teaching styles forwarded by Felder. Some questions were adapted Felder’s questions (1988, p. 675).

For the students, informal interview questions were divided into two: regarding the quantitative results and how lecturers teach in the mathematics class:

a) The personal attitude toward studying mathematics
b) The perception of the relationship between teaching styles and learning styles
c) Students’ views of the statistical results
d) The preferred way of perceiving information (Sensory – Intuitive)
e) The effective way of receiving information (Visual – Verbal)
f) The preferred way of processing information (Active – Reflective)
g) The favoured way of understanding information (Sequential – Global)

Through each lecturer interview, baseline data was gathered which formulated the suitable teaching styles that effectively address the learning styles of students. Lecturers were interviewed to ascertain their values and beliefs in relation to learning and teaching styles.
For the lecturers, informal interviews questions were also divided into two: regarding the quantitative results and how they teach mathematics in classes.

a) Their viewpoints of the statistical results of students’ learning styles
b) The type of information they emphasise (Concrete – Abstract)
c) Their stressed mode of presentation (Visual – Verbal)
d) Their preferred way of processing information (Active – Reflective)
e) Their favoured way of understanding information (Sequential – Global)

Interviews with lecturers allowed the researcher to gain more information about lecturers’ experiences and perceptions on how teaching style and learning style impact upon each other. The interviews were audio-taped and transcribed.

3.7.3 Procedure and Analysis

For the richness and the depth of description (Creswell 2012), three sources for collecting the data were used: (1) in-depth mixed semi-structured and unstructured interviews (2) researcher’s reflection notes on each participants’ responses immediately after the interviews and (3) electronic follow-up interviews with each participant to secure additional information on the emerging themes.

A grounded theory approach to gathering and coding data was adopted for the second phase, in which “data collection and analysis are interrelated processes” (Strauss & Corbin, 1990). A Grounded Theory approach to data collection and analysis is suitable for this study because it maintains that change is part of the process and individuals make choices based on their perceptions (Strauss & Corbin, 1990). Analysis started from the beginning of data collection and went on throughout the data collection process. Coding of transcripts utilised constant comparative methods (Strauss & Corbin, 1990), in which the researcher repeatedly tried to find similarities and differences to identify concepts and relate emerging themes. Researcher memos were kept to record
impressions from individual semi-structured interviews, and decisions made during the coding process. The findings from the quantitative and qualitative phases along with existing literature were utilized to answer research question no. 3 (the integrated phase). It was also to develop implications for a balanced instructional model.

### 3.8 Summary

In this chapter the research design and methodology were discussed. The complexity of the study requires a mixed method design (sequential explanatory mixed method design). Both the design and methodology are guided by the research questions. The process of data collection and data analysis procedures gave the reader a brief overview. In the next chapter an in depth analysis of data obtained will take place in each phase: quantitative, qualitative and integrated phase.
CHAPTER FOUR
ANALYSIS AND RESULTS

4.1 Introduction

The previous chapter discusses the sequential explanatory mixed methods design and elucidate the collecting, analysing and integration if quantitative and qualitative data. This chapter is concerned with the presentation of quantitative data analysis and subsequent qualitative results. It is organised around each research question; the quantitative results are followed by qualitative results and thereafter both results are integrated. The phase of integration takes the form of explicit assertions resulting from the analysis of relevant quantitative data, and the emergent themes drawn from the results of phase 2 with extracts.

4.2 Analysis and Results of Research Question 1

What are the dominant learning styles and teaching styles exhibited in mathematics class at an urban university in South Africa?

4.2.1 Interactive Learning Style (GRSLSS)

As mentioned in the chapter 3, two inventories are used to examine the learning styles of students. One is to examine an individual’s interactive learning style (Grasha - Riechmann Student Learning Style Scales (GRSLSS)), while the other assesses an individual’s approach to processing, perceiving, receiving and understanding information (The Felder – Silver Index of learning Style (ILS)).
The Grasha -Riechmann Student Learning Style Scales (GRSLSS) is used to observe the way students behave and respond to the learning environment. As mentioned in the chapter 3, this inventory explains students’ instructional preferences and interactions with the learning environment (Cassidy, 2004). To get an idea of the samples, table 16 shows descriptive aspects of samples for the ‘GRSLSS’ based on the fields of study, gender and year of study. This is also helpful for understanding significant comparisons between the learning styles of students and the demographic values of the samples.

<table>
<thead>
<tr>
<th>Discipline</th>
<th>Gender</th>
<th>The year of study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Engineering</td>
<td>44</td>
<td>20</td>
</tr>
<tr>
<td>Science</td>
<td>84</td>
<td>57</td>
</tr>
<tr>
<td>Education</td>
<td>19</td>
<td>52</td>
</tr>
<tr>
<td>Total</td>
<td>147</td>
<td>129</td>
</tr>
</tbody>
</table>

Table 16 Descriptive Aspects of the Samples for GRSLSS

The following analysis will begin by comparing the mean scores of the learning styles in order to determine which learning styles are dominant among the university students sampled. Afterwards, six learning styles are analysed according to ‘Gender’, ‘the year of study’ and ‘the field of study’

**The Dominant Interactive Learning Style**

Using the ‘SPSS 22’ software package, the descriptive statistics of learning styles is tabulated to determine the dominant learning styles exhibited by the students sampled. The range of the mean scores for each domain is marked as low, moderate, or high according to the ranges suggested by Grasha (1996). Table 17 shows that the scores of the ‘Collaborative’ (M = 3.69), ‘Competitive’ (M = 3.06) and ‘Participant’ (M = 4.03) styles are found to belong to the ‘High’ range. It can be said that these learning styles
are more prevalent among the university students sampled, this is particularly so for the ‘Collaborative’ and ‘Participant’ learning styles. This distribution is consistent with the learning styles evident among college students found in a national sample from USA (Zavarella & Ignash, 2009).

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Low</th>
<th>Moderate</th>
<th>High</th>
<th>Sample mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Independent</td>
<td>1.0-2.7</td>
<td>2.8-3.8</td>
<td>3.9-5.0 (78% ~)</td>
<td>3.39</td>
</tr>
<tr>
<td>Dependent</td>
<td>1.0-2.9</td>
<td>3.0-4.0</td>
<td>4.1-5.0 (82% ~)</td>
<td>3.96</td>
</tr>
<tr>
<td>Collaborative</td>
<td>1.0-2.7</td>
<td>2.8-3.4</td>
<td>3.5-5.0 (70% ~)</td>
<td><strong>3.69 (73.8%)</strong></td>
</tr>
<tr>
<td>Competitive</td>
<td>1.0-1.7</td>
<td>1.8-2.8</td>
<td>2.9-5.0 (58% ~)</td>
<td><strong>3.06 (61.2%)</strong></td>
</tr>
<tr>
<td>Participant</td>
<td>1.0-2.7</td>
<td>2.8-3.8</td>
<td>3.9-5.0 (78% ~)</td>
<td><strong>4.03 (80.6%)</strong></td>
</tr>
<tr>
<td>Avoidant</td>
<td>1.0-3.0</td>
<td>3.1-4.1</td>
<td>4.2-5.0 (84% ~)</td>
<td><strong>2.42</strong></td>
</tr>
</tbody>
</table>

**Table 17  The dominant learning styles of university students in mathematics**

Students with the ‘Collaborative’ learning style learn by sharing ideas and talents and by working with peers and lecturers. They prefer group discussion as a mode of interacting with the content being taught (Grasha, 1996). On the other hand, students with the ‘Competitive’ learning style learn in order to perform better than others. They enjoy getting attention and receiving recognition for their accomplishments. Unlike ‘Avoidant’ students, ‘Participant’ students attend classes regularly and take responsibility for getting as much as possible out of the course (Lang et al., 1999).
The Interactive Learning Styles based on Gender

Table 18 shows that male students have higher means (M = 3.47, SD = .58) than female students for the ‘Independent’ learning style (M = 3.31, SD = .62). Conversely, female students shows higher means in the ‘Dependent’ learning style (M = 4.07, SD = .42) as compared to their male counterparts (M = 3.87, SD = .51).

<table>
<thead>
<tr>
<th></th>
<th>Independent</th>
<th>Dependent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.47</td>
<td>3.87</td>
</tr>
<tr>
<td>SD</td>
<td>.58</td>
<td>.51</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.31</td>
<td>4.07</td>
</tr>
<tr>
<td>SD</td>
<td>.62</td>
<td>.42</td>
</tr>
</tbody>
</table>

Table 18  Mean & SD Distribution of Learning Styles based on Gender

Since the distribution of the ‘Independent’ learning style doesn’t violate the assumption of ‘Normality’, an ‘Independent-Sample T Test’ was conducted. But the distribution of the ‘Dependent’ learning style does violate the assumption of ‘Normality’, which necessitates a ‘Mann – Whitney U Test’ as this is the suitable non-parametric alternative to an independent samples t – test (Pallant, 2011, p. 227).

After conducting an ‘Independent-Sample T Test’, a significant difference in the scores of the ‘Independent’ learning style for male and female (t (247) = 2.115  p = .035, two-tailed) is observed. A ‘Mann – Whitney U Test’ also reveals a significant difference in the scores of the ‘Dependent’ learning style for male (Md = 4.0, n = 135) and female (Md = 4.2, n = 115) (U = 5889.5, Z = -3.297, p = .001 two-tailed) students.

This would mean that male students prefer to study on their own and female students benefit more from well-organised and structured teaching. Female students prefer and welcome lecturers who provide notes and learning materials. They benefit more from a well-structured lecturer, guidance and concrete hands-on experiences. This result is
compatible with other researchers (e.g., Amir & Jelas, 2010; Amir et al., 2011). Regardless of their field of study, female students are more agreeable and more conscientious than male students. Carson, Butcher and Mineka state that female students are much more likely to seek professional help. (Rubinstein, 2005).

The Interactive Learning Styles based on the Year of Study

Students in each year of study recorded different means for the various learning styles. With regards to ‘the year of study’, there are significant relationships in the scores of the ‘Independent’, ‘Participant’ and ‘Avoidant’ learning styles. Older students show higher scores on the 'Independent’ (M= 3.56, SD = .62) and ‘Avoidant’ (M = 2.54, SD = .6) learning style when compare to their younger classmates. On the other hand, younger students are more ‘Participant’ (M = 4.11, SD = .61) by nature as compared to their older classmates, as table 19 shows.

<table>
<thead>
<tr>
<th></th>
<th>Independent</th>
<th>Participant</th>
<th>Avoidant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>3.33</td>
<td>4.11</td>
<td>2.31</td>
</tr>
<tr>
<td>Mean</td>
<td>.56</td>
<td>.61</td>
<td>.54</td>
</tr>
<tr>
<td>SD</td>
<td>3.35</td>
<td>3.93</td>
<td>2.48</td>
</tr>
<tr>
<td>Mean</td>
<td>.63</td>
<td>.56</td>
<td>.53</td>
</tr>
<tr>
<td>SD</td>
<td>3.56</td>
<td>4.01</td>
<td>2.54</td>
</tr>
<tr>
<td>Mean</td>
<td>.62</td>
<td>.54</td>
<td>.60</td>
</tr>
<tr>
<td>SD</td>
<td>3.33</td>
<td>2.31</td>
<td>.54</td>
</tr>
<tr>
<td>SD</td>
<td>.56</td>
<td>.61</td>
<td>.54</td>
</tr>
<tr>
<td>SD</td>
<td>2.54</td>
<td>.60</td>
<td>.54</td>
</tr>
</tbody>
</table>

Table 19  Mean & SD Distribution of Learning Styles based on the year of study

A ‘One-way between-groups ANOVA’ are conducted to explore the impact of the year of study on learning style. There is a statistically significant difference at the \( p < .05 \) level in the 'Independent' learning style for three groups (\( F (2, 246) = 2.992, p = .05 \)). Post-hoc comparisons using the ‘Tukey HSD test’ indicates that the mean score for the 1st year students (\( M = 3.33, SD = .56 \)) is significantly different from the 3rd year students (\( M =
3.56, $SD = .60$). The 2\textsuperscript{nd} year students ($M = 3.35$, $SD = .63$) do not differ significantly from either the 1\textsuperscript{st} or 3\textsuperscript{rd} year students.

The bipolar relationship of the ‘Participant – Avoidant’ pair is generally stronger than those of the ‘Independent – Dependent’ and ‘Competitive – Collaborative’ pairs (Grasha, 1996; Ferrari, Wesley, Bamoto, Wolfe & Erwin, 1996)

The group of ‘the year of study’ is changed from three groups (1\textsuperscript{st} year/2\textsuperscript{nd} year/3\textsuperscript{rd} year) to two groups (1\textsuperscript{st} year/senior) and a ‘Mann – Whitney U Test’ is conducted to compare the mean scores of ‘Participant’ and ‘Avoidant’ learning styles. A ‘Mann – Whitney U Test’ is suitable, because the distribution of the ‘Participant’ and ‘Avoidant’ learning styles violate the assumption of ‘Normality’ (Pallant, 2011, p. 227). A ‘Mann – Whitney U Test’ reveals a significant difference in the scores of the ‘Participant’ learning style for the 1\textsuperscript{st} year students ($Md = 4.2$, $n = 110$) and senior students ($Md = 3.95$, $n = 146$) ($U = 6479.0$, $Z = -2.649$, $p = .008$ two-tailed).

To test the scores of the ‘Avoidant’ learning style, the same test is used. It shows a significant difference between 1\textsuperscript{st} year students ($Md = 2.3$, $n = 102$) and the senior students ($Md = 2.4$, $n = 147$) ($U = 6010.5$, $Z = -2.666$, $p = .008$ two-tailed). Diaz and Cartnal examine the associations between different styles (1999). And they ascertain the patterns in the relationships among the learning styles. There is a negative relationship between the ‘Independent’ and the ‘Collaborative’ and ‘Dependent’ learning styles. And there is a positive relationship between the ‘Collaborative’ and the ‘Dependent’ and ‘Participant’ learning styles. In other words, students who are more independent tended to be less ‘Collaborative’ and ‘Dependent’ and students who are more ‘Collaborative’ are more ‘Dependent’ and ‘Participant’. In a sense it can be said that senior students who are more independent tended to be less participatory.
The Interactive Learning Styles based on Discipline

Table 20 shows that students in the faculty of education are found to be more ‘Collaborative’ (M = 3.85, SD = .85) than students in the other fields. In order to compare the means of ‘Collaborative’ learning style based on ‘Discipline’, ‘Kruskal-Wallis’ test is conducted because the distribution of the ‘Collaborative’ learning violates the assumption of ‘Normality’.

<table>
<thead>
<tr>
<th>Learning Styles</th>
<th>Engineering</th>
<th>Science</th>
<th>Education</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative</td>
<td>3.79</td>
<td>3.56</td>
<td>3.85</td>
</tr>
<tr>
<td></td>
<td>.66</td>
<td>.70</td>
<td>.85</td>
</tr>
</tbody>
</table>

Table 20 Mean & SD Distribution of Learning Styles based on Discipline

The Test reveals a statistically significant difference in the ‘Collaborative’ learning style across three different groups of field of study (Engineering (n = 56); Science (n = 129); and Education (n = 64)), $\chi^2 (2, n = 249) = 9.06, p = .011)$. The students in the education faculty record a highest median scores ($Md = 3.9$) than the students in the other faculties ($Md = 3.8$ (Engineering) and 3.6 (Science)). It might be related to the characteristics of engineering students and science students. Weller & Nadler proposed that students of engineering and the natural sciences are more authoritarian than psychology and philosophy students (1975). Another study conducted by Rubinstein (1997) suggests that natural science students are more authoritarian than social science students. Another possible reason might be how students are taught. Considering the principles of effective teaching, education students are encouraged to make connections with one another and they have more opportunity to take part in discussions.
4.2.2 The Flexibly Stable Learning Style (ILS)

The ‘Felder - Silverman Index of Learning Style (ILS)’ assesses learning styles on four dichotomous dimensions with eight learning modalities (active/reflective, sensing/intuitive, visual/verbal, and sequential/global). As introduced in chapter 3, the Felder – Silverman Index of Learning Style (ILS) consists of 44 items with two possible choices for each question. The range of possible scores on each of the eight modalities is zero to 11. The learner preference across a respective dimension is calculated as the difference (differential) between the scores obtained for the two parallel polar modalities. Table 21 shows descriptive aspects of the samples of the ‘The Felder – Silverman Learning Index of Learning Style (ILS)’ based on the field of study, gender and year of study.

<table>
<thead>
<tr>
<th>The field of study</th>
<th>Gender</th>
<th>The year of study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Engineering</td>
<td>46</td>
<td>12</td>
</tr>
<tr>
<td>Science</td>
<td>92</td>
<td>60</td>
</tr>
<tr>
<td>Education</td>
<td>26</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>138</td>
</tr>
</tbody>
</table>

Table 21 Descriptive aspects of the samples for ILS

The following analysis focuses on individual (singular) learning modalities, balanced (bimodal) preference, and the combinations of modalities (four learning dimensions).

The Dominant Preference

Results of the ‘flexibly - stable learning style’ for individuals is obtained through analysing measures of central tendency and spread. Table 22 shows the mean, median and standard deviation of the students’ scores on the eight learning modalities of ‘ILS’ in
the four dichotomous learning dimensions: (1) processing information; (2) perceiving information; (3) receiving (input) information; and (4) understanding information. Since 5.5 is the mean of means, any mean score above 5.5 is regarded to be high, and any such mean score equal to or lower than 5.5 is regarded as being low. The greatest difference (3.1) regarding means is relevant to the ‘receiving information’ dimension; the visual modality was the most favoured learning modality among the university students who are studying mathematics.

Although the mean scores are quite close to each other in the four dichotomous dimensions, it is worth mentioning that the students’ preference scores are higher (X > 5.5) for the ‘Sensing’, ‘Visual’ and ‘Sequential’ when compared to the scores of their respective modalities (‘Intuitive’, ‘Verbal’, and ‘Global’, X ≤ 5.5).

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Modality</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing Info. (A–R)</td>
<td>Active</td>
<td>5.5</td>
<td>5.0</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Reflective</td>
<td>5.4</td>
<td>6.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Perceiving Info. (S–I)</td>
<td>Sensing</td>
<td>6.2</td>
<td>6.0</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>Intuitive</td>
<td>4.8</td>
<td>5.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Receiving Info. (V–V)</td>
<td>Visual</td>
<td>7.0</td>
<td>7.0</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Verbal</td>
<td>3.9</td>
<td>4.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Understanding Info. (S–G)</td>
<td>Sequential</td>
<td>6.1</td>
<td>6.0</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td>Global</td>
<td>4.9</td>
<td>5.0</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Table 22  Students’ learning style scores (0-11)

Analysing the distribution of preferences for each dimension indicates 52% are found to have a ‘Reflective’ modality, 64% a ‘Sensing’ modality, 79% a ‘Visual’ modality and 62% ‘Sequential’ modality. Table 23 shows strength of preferences for the eight modalities. The modalities of learners are classified into; strong/moderated (differences from 5 to 11 within bipolar modalities) and balanced (differences from 0 to 3 within bipolar
modalities). These results are compatible with many studies (i.e., Felder & Spurlin, 2005; Franzoni-Velázquez, Cervantes- Pérez & Assar, 2012). This suggests that the samples of this study are representative and can act as the basis for further analysis.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Processing Information</th>
<th>Perceiving Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Str./Mod.</td>
<td>Balanced</td>
</tr>
<tr>
<td>Strength</td>
<td>Active</td>
<td>16.8%</td>
</tr>
<tr>
<td>Percentage</td>
<td>69.1%</td>
<td>14.1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Receiving Information</th>
<th>Understanding Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Str./Mod.</td>
<td>Balanced</td>
</tr>
<tr>
<td>Strength</td>
<td>Visual</td>
<td>48.7%</td>
</tr>
<tr>
<td>Percentage</td>
<td>44.3%</td>
<td>7.0%</td>
</tr>
</tbody>
</table>

Note: Str./Mod. = Strong or Moderate;

Table 23 **Strength of Preferences (Distinguishing between Strong/Moderate and Balanced Preferences)**

Table 24 provides more detailed comparative results of preferences for eight modalities. The modalities of learners are classified into three; (balanced – differences from 0 to 3 / moderated – differences 5 / Strong – differences 7 to 11). Of all four dimensions, the lowest preference for an individual modality is related to 'Processing Information', where students show a very slight difference of 4 % for the ‘Active’ modality over the ‘Reflective’ modality. With regards to the ‘Perceiving Information’ dimension, the results suggest a greater preference for ‘Sensing’ learning with an overall frequency difference score of 28.7%. And as mentions with regard to the 'Receiving Information' input dimension, a very large majority (78.5%) of students indicates a preference for receiving information through the visual modality instead of the verbal modality (20.2%). An examination of the last ILS dimension (‘Understanding Information’) indicates that more than 60 p% of the students have a greater preference for 'Sequential' learning as opposed to 'Global' learning.
### Table 24 Comparative Results of Preferences for eight Modalities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACT</td>
<td>REF</td>
<td>SEN</td>
<td>INT</td>
</tr>
<tr>
<td>Balanced</td>
<td>1</td>
<td>50</td>
<td>61</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>42</td>
<td>53</td>
<td>49</td>
</tr>
<tr>
<td>Moderate</td>
<td>5</td>
<td>28</td>
<td>30</td>
<td>43</td>
</tr>
<tr>
<td>Strong</td>
<td>7</td>
<td>18</td>
<td>8</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Missing</td>
<td>4 (1.3%)</td>
<td>1 (0.3%)</td>
<td>4 (1.3%)</td>
<td>4 (1.3%)</td>
</tr>
<tr>
<td>Count</td>
<td>142</td>
<td>156</td>
<td>194</td>
<td>107</td>
</tr>
<tr>
<td>%</td>
<td>47.0</td>
<td>51.7</td>
<td>64.2</td>
<td>35.5</td>
</tr>
</tbody>
</table>

Note: ACT = Active; REF = Reflective; SEN = Sensing; INT = Intuitive; VIS = Visual; VRB = Verbal; SEQ = Sequential; GLO = Global

**The Preferred Combinations of Learning Style Modalities**

Since the ILS questionnaire proposes that students would express a preference type of the eight modalities in four domains, 16 appropriate types of combination of learning style modalities are obtained (See Table 25).

As illustrated in Figure 16, 15 out of the 16 learning style combinations are presented except ‘AIVrG’. The combinations of ‘RSnVS’ (17.5%) and ‘ASnVS’ (17.2%) were the predominant learning styles among 302 students. And the next three most frequent combination types were ‘RSnVG’ (9.2%), ‘AIVS’ (8.9%), and ‘ASnVG’ (8.2%). This result is compatible with research performed by Louange (2007) that the four most frequent combinations are the same as that of this research (‘ASnVS’, ‘ASnVG’, ‘RSnVS’, ‘RSnVG’).
<table>
<thead>
<tr>
<th></th>
<th>Combinations</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Active Sensing Visual Sequential</td>
<td>ASnVS</td>
</tr>
<tr>
<td>2</td>
<td>Active Sensing Visual Global</td>
<td>ASnVG</td>
</tr>
<tr>
<td>3</td>
<td>Active Sensing Verbal Sequential</td>
<td>ASnVrS</td>
</tr>
<tr>
<td>4</td>
<td>Active Sensing Verbal Global</td>
<td>ASnVrG</td>
</tr>
<tr>
<td>5</td>
<td>Active Intuitive Visual Sequential</td>
<td>AIVS</td>
</tr>
<tr>
<td>6</td>
<td>Active Intuitive Visual Global</td>
<td>AIVG</td>
</tr>
<tr>
<td>7</td>
<td>Active Intuitive Verbal Sequential</td>
<td>AIVrS</td>
</tr>
<tr>
<td>8</td>
<td>Active Intuitive Verbal Global</td>
<td>AIVrG</td>
</tr>
<tr>
<td>9</td>
<td>Reflective Sensing Visual Sequential</td>
<td>RSnVS</td>
</tr>
<tr>
<td>10</td>
<td>Reflective Sensing Visual Global</td>
<td>RSnVG</td>
</tr>
<tr>
<td>11</td>
<td>Reflective Sensing Verbal Sequential</td>
<td>RSnVrS</td>
</tr>
<tr>
<td>12</td>
<td>Reflective Sensing Verbal Global</td>
<td>RSnVrG</td>
</tr>
<tr>
<td>13</td>
<td>Reflective Intuitive Visual Sequential</td>
<td>RIVS</td>
</tr>
<tr>
<td>14</td>
<td>Reflective Intuitive Visual Global</td>
<td>RIVG</td>
</tr>
<tr>
<td>15</td>
<td>Reflective Intuitive Verbal Sequential</td>
<td>RIVrS</td>
</tr>
<tr>
<td>16</td>
<td>Reflective Intuitive Verbal Global</td>
<td>RIVrG</td>
</tr>
</tbody>
</table>

Note: A = Active, R = Reflective, Sn = Sensing, I = Intuitive, V = Visual, Vr = Verbal, S = Sequential, G = Global

Table 25 Combinations of Learning Style Modalities
The Flexibly Stable Learning Styles based on Gender

The distribution of female and male student’s responses are statistically significant on the dimensions of both ‘Perceiving Information’ and ‘Receiving Information’. As Figure 17 shows the mean score of females (6.6) is higher on average (6.2) for the ‘Sensing’ modality. By contrast, the mean score of males (5.1) is higher on average (4.8) for the ‘Intuitive’ modality. Regarding ‘Visual – Verbal’ modalities, male and female students exhibit contrasting responses even though the majority of male and female students consider themselves to be visual learners. The same result was found in Dobson (2009).

With regards to gender differences of learning style in both dimensions, many studies use the VARK questionnaire (Visual, Auditory, Read-Write and Kinaesthetic) (e.g., Choudhary, Dullo & Tandon, 2011; Saadi, 2014; Lau & Yuen, 2010). These studies
agree that the most female students preferred learning from touch, hearing, smell, taste and sight (the ‘K’ mode).

The dimension of ‘Perceiving Information’ expresses how a student becomes aware of content and describes students’ preference for gathering information. As table 26 indicates, there is a difference of 23.2% for female students over male students within ‘Sensing’ modality. On the other hand, there is a difference of 45.2% for male students over female students within ‘Intuitive’ modality. The sensing female student tends to enjoy details, examples, experiences and well-learned routines but gets anxious about new complexities (Rosati, 1999). The intuitive male student tends to prefer ideas, concepts, and theories and trusts his inspiration to connect to increasing complexity.

This ‘Perceiving Information’ dimension has a strong correlation with the ‘Sensing – Intuitive’ dichotomy in the Myers-Briggs Type Indicator (MBTI) (Cohen, 2008, p. 45). Felder, Felder and Dietz (2002) explore the effect of personality type on engineering
student’s performance and attitude. In their study female students are more ‘Sensing’ and male students are more ‘Intuitive’. While receiving information, visual learners remember best what they see, for example, in pictures, diagrams, films or demonstrations. Verbal learners remember what they hear or, even better, what they hear and then discuss.

<table>
<thead>
<tr>
<th></th>
<th>Sensing</th>
<th>Balanced</th>
<th>Intuitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>33</td>
<td>107</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>38.4%</td>
<td>59.1%</td>
<td>72.7%</td>
</tr>
<tr>
<td>Female</td>
<td>53</td>
<td>74</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>61.6%</td>
<td>40.9%</td>
<td>27.3%</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>181</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Visual</th>
<th>Balanced</th>
<th>Verbal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>89</td>
<td>69</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>61.4%</td>
<td>52.3%</td>
<td>28.6%</td>
</tr>
<tr>
<td>Female</td>
<td>56</td>
<td>63</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>38.6%</td>
<td>47.7%</td>
<td>71.4%</td>
</tr>
<tr>
<td>Total</td>
<td>145</td>
<td>132</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

**Table 26  Gender Difference in the ‘Perceiving & Receiving Information’ Dimension**

In order to further explore the relationship between learning styles in these dimensions and gender, ‘Pearson’s Chi-square tests’ is used, since the current data is collected in independent observations with categories that are mutually exclusive and exhaustive (Michael, 2001). A Chi-square measure of 15.0 (2, n = 300, \(p = .001\)) is attained for ‘Perceiving Information’ dimension and of measure of 8.7 (2, n = 300, \(p = .013\)) for ‘Receiving Information’. Compared to the effect size, the relationship between ‘Gender’ and the ‘Sensing–Intuitive’ modality is higher than the ‘Visual–verbal’ modality. By using phi coefficient, the relationship between ‘Gender’ and ‘Sensing–Intuitive’ modality is seen to have a medium effect size (\(phi = .22\)), while the ‘Visual-Verbal’ modality has a small effect size (\(phi = .17\)) (Pallant, 2011, p. 220).
The Flexibly Stable Learning Styles based on Discipline

Active learners learn more while trying things out and while working with others. They tend to be more engaged in communicating with others and prefer to learn by working in groups where they can discuss the learned material. On the contrary, reflective (R) learners learn more while thinking through materials and when working alone (Ültanir et al., 2012). Figure 18 shows the distribution of the responses on the ‘Processing Information’ dimension based on the field of study.

<table>
<thead>
<tr>
<th></th>
<th>Active</th>
<th>Balanced</th>
<th>Reflective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>11</td>
<td>34</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>22.0%</td>
<td>59.6%</td>
<td>28.6%</td>
</tr>
<tr>
<td>Education</td>
<td>24</td>
<td>63</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>26.1%</td>
<td>68.5%</td>
<td>16.8%</td>
</tr>
<tr>
<td>Science</td>
<td>15</td>
<td>109</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>10.1%</td>
<td>73.2%</td>
<td>59.5%</td>
</tr>
<tr>
<td>Total</td>
<td>57</td>
<td>149</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 27 Difference of Discipline in the ‘Processing Information’ Dimension

As table 27 indicates, there is a difference of 16.0% for Education students when compared to science students within ‘Active’ modality. On the other hand, there is a difference of 36.7% for Science students compared to Education students within ‘Reflective’ modality. Figure 18 provides more detailed comparative results of preferences for the ‘Active – Reflective’ modalities (balanced – differences from 0 to 3 / moderated – differences 5 / Strong – differences 7 to 11). Surprisingly, Science students who are actively involved in lab experiments are found to be more reflective learners than Engineering or Education students. It is possible that Education students are asked to be more active in classrooms and in field work projects. Also the nature of Education encourages students to apply new teaching methods and to use some educational activities with learners. These results are consistent with the findings of Alumran (2008).
4.2.3 Teaching Styles of Mathematics Lecturers

The Teaching Style Inventory (Grasha, 1996) assesses teaching styles on five modalities (Expert / Formal Authority / Personal Model / Facilitator / Delegator). This instrument consists of 40 items evaluated on five-point Likert type scale which is designed to measure differences between teaching styles. Table 28 shows ‘Expert’ was the most frequent modality of high score, the second most is ‘Formal Authority’ and followed by ‘Personal Model’. It means most lecturers still use traditional, teacher-centered styles in university settings.

The ‘Expert’ teaching style has the advantage of gaining knowledge and information, yet it may possibly make learners passive depending on whether knowledge and information are overused. The ‘Formal Authority’ teaching style focuses on clear expectations and acceptable ways of doing things in class. This style can result in a rigid and less flexible environment. The ‘Personal Model’ places emphasis on following
and emulating the role model (mentor relationship), but those who cannot live up to that role model are often left feeling inadequate.

<table>
<thead>
<tr>
<th></th>
<th>Expert</th>
<th>Formal Authority</th>
<th>Personal Model</th>
<th>Facilitator</th>
<th>Delegator</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>19</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Percent</td>
<td>90.5%</td>
<td>57.1%</td>
<td>33.3%</td>
<td>28.6%</td>
<td>42.9%</td>
</tr>
<tr>
<td>Moderate</td>
<td>2</td>
<td>9</td>
<td>14</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Percent</td>
<td>9.5%</td>
<td>42.9%</td>
<td>66.7%</td>
<td>57.1%</td>
<td>54.8%</td>
</tr>
<tr>
<td>Low</td>
<td>3</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
<td></td>
<td>14.3%</td>
<td></td>
</tr>
</tbody>
</table>

Table 28  The Scores of Teaching Styles of Mathematics Lecturers

Lecturers with the ‘Facilitator’ teaching style prefer asking questions and exploring options with students. They are open to alternatives and options but it might be time consuming and make learners uncomfortable. Lastly, the ‘Delegator’ teaching style contributes to learners’ professional development and confidence. Yet learners might be anxious if they don’t have the capability to function in an autonomous manner (Grasha, 1996).

<table>
<thead>
<tr>
<th>Number</th>
<th>Questions</th>
<th>Teaching style</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Sharing my knowledge and expertise with students is very important to me.</td>
<td>Expert</td>
</tr>
<tr>
<td>9</td>
<td>I typically show students how and what to do in order to master the mathematics lessons content.</td>
<td>Personal Model</td>
</tr>
<tr>
<td>10</td>
<td>I typically show students how and what to do in order to master the mathematics lessons content.</td>
<td>Expert</td>
</tr>
<tr>
<td>20</td>
<td>This course has very specific goals and objectives that I want to accomplish.</td>
<td>Formal Authority</td>
</tr>
<tr>
<td>2</td>
<td>I set high standards for students in my mathematics class.</td>
<td>Formal Authority</td>
</tr>
</tbody>
</table>

Table 29  The First Five Frequent Questions that Lecturers Highly Valued
Grasha classifies 5 teaching styles into 4 clusters; (1) Expert/Formal Authority (2) Personal Model/Expert/Formal Authority (3) Facilitator/Personal Model/Expert and (4) Delegator/Facilitator/Expert (1996). If these six clusters are divided into two groups (learner-centered teaching style & teacher-centered teaching style), number 2, 3 and 4 belonged to teacher-centered teaching style and only number 6 belonged to learner-centered teaching style. 50% of lecturers seem to perpetuate the teacher-centered teaching style.

After an in-depth analysis of the ‘Teaching Style Inventory’, the first five frequent items that mathematics lecturers regarded as ‘Very important’ are all closer to the teacher-centered teaching style (See Table 29).

4.3 Analysis and Results for Research Question 2

What are the suitable teaching styles that effectively address these learning styles?

This section presents findings concerning the suitable teaching styles that effectively address these learning styles. It is through the description of the categories and subcategories that emerged during analysis of sixteen interviews with students and with six mathematics lecturers. The transcribed interviews of the participants are analysed to find common themes amongst the students that are prevalent. The five themes that emerged through the data analysis are discussed below. Additionally, findings from electronic follow-up interviews with each participant are related to the thematic categories and subcategories.
4.3.1 Emerging Concepts and Categories

“Analysis means organising and interrogating data in ways that allow researchers to see patterns, identify themes, discover relationships, develop explanations, make interpretations, mount critiques, or generate theories” (Hatch, 2002, p. 148). The interviews with both lecturers and students were coded by using open and axial coding. The analysis draws similar thematic categories and subcategories that consistently emerged from both lecturers and students with regard to the effective teaching styles.

4.3.2 Categories and Subcategories

Interviews were analysed according to the grounded theory. The term grounded theory is often used in the research literature to refer to a variety of processes by which theory is derived from empirical data (Draucker, Martsof, Ross & Ruck, 2007). Schwandt described the process of grounded theory analysis (2001, p. 110):

Grounded theory requires a concept-indicator model of analysis, which in turn employs the method of constant comparison. Empirical indicators from the data (actions and events observed, recorded, or described in documents in the words of interviewees and respondents) are compared, searching for similarities and differences. From this process, the analyst identifies underlying uniformities in the indicators and produces a coded category or concept. Concepts are compared with more empirical indicators and with each other to sharpen the definition of the concept and to define its properties.

Contrast and comparison between existing individual constructions may be the dialectical constructivist answer to how should the researcher go about finding out knowledge (Annells, 1996, p. 388). In line with this, grounded theory analysis was chosen.
Grounded theorists have identified three types of coding: open, axial, and selective (Strauss, 1987). Open coding is the initial close, line-by-line or word-by-word examination of the data for the purpose of developing provisional concepts. The process of continuous comparison categorises these concepts. In axial coding, the analysis is purposely focused on an emerging category. Selective coding is the examination of the data for the purpose of unearthing the core category and achieving the integration of the theoretical framework.

When researchers attempt to make sense out of their data by organizing and interpreting them, a classificatory scheme needs to be chosen. Strauss and Corbin state that the process of analysis in the grounded theory is depending on the purpose (1990, p. 32): very useful description, conceptual ordering (classifying and elaborating) or developing theory. A conceptual ordering (high-level description) are important to the generation of knowledge and can make a valuable contribution to a discipline. Since the analysis of this research in qualitative phase is to classify and elaborate (conceptual ordering) teaching styles that effectively address learning styles, integrative selective coding was not included. Only open coding and axial coding were used.

Coding is done in three stages. First, open codes focuses on identifying, naming, and categorising phenomena in the text are determined. From the open codes, axial codes are done, which focused on relating open code categories. From the open codes, axial codes are done, which focused on relating open code categories. From these codes, the major themes and core concepts contained in the data become apparent. Constant comparison was employed throughout this process. Specifically, all data are compared to the emerged themes and to the rest of the data set. This helps to make sure that the emergent themes are factual to the data. An example of the coding matrix used is included in Appendix F.
<table>
<thead>
<tr>
<th>Categories</th>
<th>Sub-categories</th>
<th>Characterised Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertising</td>
<td>How to share knowledge</td>
<td>• Visual presentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cautious use of technology</td>
</tr>
<tr>
<td></td>
<td>Clear guideline</td>
<td>• Well-structured instruction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Importance of class attendance</td>
</tr>
<tr>
<td>Motivating Students’ Learning</td>
<td>Collaborative settings</td>
<td>• Peer assistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Useful tutorial time</td>
</tr>
<tr>
<td></td>
<td>Embracing Sensing students</td>
<td>• Providing practical problem solving</td>
</tr>
<tr>
<td>Climate Building</td>
<td>Adjustment to students’ understanding</td>
<td>• To be monitored</td>
</tr>
<tr>
<td></td>
<td>Active classroom environment</td>
<td>• Various ways of explaining</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Providing intervals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Approachable atmosphere</td>
</tr>
<tr>
<td>Participating in the Learning Process</td>
<td>Interactions</td>
<td>• Small group discussions</td>
</tr>
<tr>
<td></td>
<td>Options &amp; alternatives</td>
<td>• Consultation time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Diverse lesson activities</td>
</tr>
<tr>
<td>Flexibility for Individual Development</td>
<td>Visual understanding of abstract information</td>
<td>• From ‘Sequential’ to ‘Global’</td>
</tr>
<tr>
<td></td>
<td>A self-directed learning</td>
<td>• Context &amp; relevance-tied up</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Effective &amp; efficient lecturing time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Students’ dedication</td>
</tr>
</tbody>
</table>

Table 30 Categories and Subcategories

The core concepts relating to suitable teaching styles that first emerged are: ‘Expertising’; ‘Designing self-directed learning experience’; ‘Participating in the learning process’ and ‘Climate building’. As the analysis continues, ‘Expertising’, ‘Participating in the learning process’ and ‘Climate building’ rise to the level of categories and two additional concepts emerge and assume categorical status: ‘Motivating students’.
learning’ and ‘Flexibility for individual development’. Subcategories in each of the five categories also become evident.

Table 30 lists each category and its subcategories along with their properties. Each of these categories and subcategories are reviewed in detail in the following section. The quotations are edited to render them more readable without changing their accuracy. The line numbers after quotations refer to transcripts of individual interviews with students and lecturers.

4.3.2.1 Expertising

It is important for students to possess knowledge and expertise. Students with various learning styles value the professionalism of their lecturers. Every student is satisfied with the knowledge and experienced status of mathematics lecturers. For their self-comfort and better understanding, however, students refer repeatedly to a lecturers’ way of delivering information regardless of their learning style. They expect ‘clear guidelines’ from their lecturers. Especially students whose learning styles are ‘Dependent’ favour the ‘Expertising’ teaching style the most.

(1) How to share knowledge

The first sub-category is ‘how to share knowledge’ which is defined as ‘A way of delivering mathematics knowledge’. Many students appreciate lecturers’ knowledge and confidence in the mathematics class. However what students repeatedly mention is how lecturers share their knowledge. It has a considerable influence on students desire to be engaged with studying mathematics. Teaching methods vary and some instructors lecture, while others demonstrate or discuss; some concentrate on principles and others on applications; some emphasise memory and others understanding. Students describe the mathematics class as ‘lecturing and making notes’. Although there are diagrams
and pictures in class, lecturing depends on the student being a verbal learner (Ernest, 1994). A student being 'Visual' learner points out the importance of visual presentation.

We used to write down everything, drawing the diagram and looking at what is written on the board. Lecturers need to explain verbally, but it would be very hard to understand verbal explanation without visual presentation (diagram or the whole procedure). If a lecturer explains without writing down and showing us what is going on, it would be harder for students to get information (lines 678-682 from Appendix E).

Lecturers from different clusters of teaching styles (teacher-centered, learner-centered and neutral clusters of teaching style) also agree on the importance of the visual presentation of conceptual and procedural knowledge.

The best mathematics lectures that I have ever seen were those who used ‘chalk and talk’. (For instance) Top and well renowned people in my field, they arrive there (at the conference) with nothing and they write everything they want to say on the black board. It forces you not to go to fast. With slides it is too easy to go to fast and nobody has time to absorb what’s going on. A backboard is a piece of technology. We want technology that is most appropriate for what you want to do. For mathematics you need a lot of space to write, whether that is multiple document cameras or blackboards or overhead projectors (lines 900-908 from Appendix D).

Students emphasise not only the visual presentation of conceptual and procedural knowledge but also the cautious use of technology. Pertaining to utilizing technology, one student agrees with what this lecturer points out. The student says “My lecturer doesn’t come to class with fancy stuffs like a laptop or a projector. He uses a paper and a pencil only. Then we work together with him. For me this is why I understand mathematics better. If as lecturer comes with many slides or a ready-made presentation
and show us, saying ‘this is how we should do, work it out’, then I cannot follow” (lines 465-469 from Appendix E).

Even though technology is essential in learning and teaching mathematics NCTM’s (2000) and new instructional approach is added accordingly, technology should appropriately be used in mathematics class. However there is a discrepancy between faculty and students. Students regard educational technologies as a more effective and consistent means to meet their learning preferences and active lifestyles. Faculties, on the other hand, are concentrating on using electronic features that will assist them administratively (Wessels & Steenkamp, 2009).

Lecturers and students agree with each other concerning the visual presentation of conceptual and procedural knowledge with careful use of technology. One major disadvantage is no interaction between an instructor and students unless a multimedia-based course is carefully planned. Maintaining a high degree of student-instructor interaction is essential to preserving the overall quality of education (Karakaya et al., 2001, p. 89).

(2) Clear Guidelines

Another sub-category that comes up is ‘Clear guidelines’. This is favoured by both ‘Dependent’ and neutral students (having similar scores in both ‘Independent’ & ‘Dependent’). A student with the ‘Dependent’ learning style says “The lecturer I am attending, she is more expert level. She used to pick up the point and make sure everyone understands what she says. She stays on the topic until everybody comprehends what she says” (lines 278-280 from Appendix E). “When I go back and study, it is easy for me to remember. ‘oh, she mentioned this and that’, it is easier when you go back to text book because I remember what she was talking about” (lines 291-292 from Appendix E). And a neutral student (neither ‘Independent’ nor ‘Dependent’) says “I expect lecturers to briefly break down what I am going to do. What I expect from lecturers in the class is to explain what I should do to learn more by introducing the
topics and by directing me. Then I will go through in detail by myself” (lines 1202-1204 from Appendix E).

Well-structured instruction obviously give students comfort and confidence. Many lecturers point out the reason why students favour clear guidelines and much expectation from lecturers – the school system (it was called ‘spoon feeding’):

To be honest with you I think it may well be the school system; leading up to coming to university. The School system is very much… ‘We will lead you down the road and we will show you this and show you that and you sort of follow us and do as we say and do as we do’. To some extent it is good, because some of the skills you need to focus on and make sure you have all the details ironed out and reinforce it the whole time. But to some extent it makes them dependent on their lecturer lines 10-15 from Appendix D).

As much as ‘Guidance and expectation’ pamper students, attendance is imperative. Attending class and getting an idea from lecturers are repeatedly emphasised by students regardless of whether they were ‘Dependent’ or ‘Independent’.

I attended classes, you know, (I could get) something important mentioned or a significant, because I had a module I read through the textbook but I just get some piece of information without full understanding. Only in class, we pick up what the information is about in class (lines 26-29 from Appendix D).

Attending class is naturally emphasised by lecturers, yet for slightly different reasons. A lecturer belonging to learner-centered cluster of teaching styles says:

Getting the lecturer and listening to what they are saying is not something students can ignore because lecturers are trying to give them a bigger picture and highlight specific things in a lecture (lines 246-249 from Appendix D).
Another lecturer belonging to teacher-centered cluster of teaching styles explains why attendance is important. Especially for the benefit of ‘Dependent’ students, he says “They should be able to make a good class notes because they are not going to make something else at home (for themselves). It means they need to make sure that class time is sufficient” (lines 964-965 from Appendix D). Students feel desperate to have materials from lecturers. “Most of time he (her lecturer) speaks and we write down everything he said. Otherwise I would be lost when I study by myself. Actually we are asked to make a lot of class notes. With class notes I can recall whatever a lecturer said in the class and it is always helpful” (lines 1170-1173 from Appendix E). Another student also says “When I study by myself, I usually write down what we learned in the class and highlight key word. I believe it is important to understand the meaning of words so keeping on reading through and memorizing certain formulas or symbols help me”(lines 793-795 from Appendix E).

Since the majority of university students have weak backgrounds in mathematics (Howie & Hughes, 1998; Mkhize & Nduna, 2010) and rely heavily on their lecturers, they expect to have more self-study materials and feedback from lecturers. “During the holiday I would like to have more work; assignments, projects, more activities. So I can practice more. Once I finish practicing, lecturers or tutors can check and feed me back. In that way, I can find what I couldn’t understand and improve my knowledge” (lines 916-919 from Appendix E). Many students expect to receive self-study materials, such as more activities during the holidays, on-line quizzes, or study materials with exercises before class.

4.3.2.2 Motivating Students’ Learning

Since the collaborative learning style is the second dominant learning style of the university students sampled here, a collaborative-oriented environment is vital for accommodating as many students as possible. When two or more students work to find out the solution of a problem or assignment, they construct knowledge together and it
would suitably motivate them. Research show the correlation between collaboration and enhancement of learning ((Lou, Abrami & d’Apollonia, 2001; Slavin, 2014; Bouta & Retalis, 2013; Kolloffel, Eysink & Jong, 2011).

(1) Collaborative Settings

Taken the collaborative settings into account, the effectiveness of peer assistance is frequently as cited in students and confirmed by lecturers. Discussing new concepts and knowledge with peers in a collaborative learning setting could have a beneficial effect on students’ learning mathematics. A good opportunity for establishing a collaborative-oriented environment is during tutorial time. Tutorial times are practically used for the collaborative learning: “there is work to be done independently and on the other hand there is the more collaborative setup, which I try and implement in a tutorial setting” (line 686-687 from Appendix E). Tutorial times play an important role for students: “I studied by myself at home and next day I came here to see peers or tutors with unsolved questions. Then they helped me understand afterwards I learned again in class. Working with Peers and Friday tutoring time is helping me a lot. I prefer studying together to alone. Especially when it comes to mathematics” (line 454-457 from Appendix E). Students are quite satisfied with tutorial times for collaborative learning.

Tutorial time is perfect for me. A lecturer provides many exercises without lecturing and we can work on our own. If we have questions, we are allowed to questions constantly. I am so happy with tutorial time and there are a lot of opportunities to work together (line 565-568 from Appendix E).

Learning in small co-operative groups fosters students’ cognitive learning processes and motivation (Schmidt & Moust, 2000). Tutorial time can be also used for catering to students’ learning styles.

Usually for students in a large class, I use a tutorial time to cater for their differences. It is possible because, for example, if there are 4 classes then we
have 8 different tutorial times, which means a group of students definitely become smaller. If there are still a lot of student, my way of doing it is putting a lot of questions on the board and let them work group to group. Then I can approach and explain group to group (line 1232-1236 from Appendix D).

Tutorial time can be used even for the development of global thinking. “So during tutorials you (students) can come and ask questions but you have already tried the homework. I have posted the solutions and you should look at it. And in the tutorials questions I specifically try and focus more on the global picture. So they have done their homework. They should have practiced the step by step sequential and now I feel the next level is to understand the global picture” (line 367-373 from Appendix D). Taking into account students’ collaborative learning style and its benefits, lecturers thought of implementing this idea into the class next year (line 1198-1199 from Appendix D).

However, there is a concern over effective tutorial time. “That (tutorial time) does not work particularly well, because the independent guys do the problems and get them right and they are bored in the tutorials. Whereas the dependent timid ones, they did not really get them right and now they are too shy to ask” (line 690-693 from Appendix D). For collaborative-oriented learning environment, students have to take responsibility for their learning and have an active attitude.

(2) Embracing Sensing Learners

Most science courses including mathematics emphasises concepts rather than facts and translate symbols into what they represent, which are very favourable for intuitive learners, and not so for sensing learners. Many studies show that intuitive students obtain higher marks than sensing students (e.g., Felder et al., 2002; Cook, Thompson, Thomas & Thomas, 2009). Studying mathematics in higher grade doesn’t include a lot of concrete information. The content of mathematics is not something closely related to everyday life. Yet many students favour the sensing learning style over the intuitive
learning style. As a result, what students require is practical examples to support their learning:

My point is if lecturers give us practical examples then it would help students understand the concepts and theories. It will encourage us to reflect what we are learning. Or I can say if a lecturer explains some concepts from the origin, showing us where it comes from and how it derives, it can help students understand more and remember longer (line 524-527 from Appendix E).

Just receiving information such as theorems and new concepts cannot help students with figuring out and solving problems. Other student refers to this as ‘application examples’: “Application examples mean ‘to where we can apply what we are studying’. We heard many times that mathematics is useful in various fields but we don’t have any idea of how it applies” (line 1251-1255 from Appendix E).

A number of students struggle to connect mathematics to real world applications and this could be a reason for failure in mathematics (Chang, 2011). Relevant mathematics is emphasised in many studies (Abate & Cantone, 2005; Chang, 2011). Lecturers are aware of the importance of practical examples for supporting learning: “Both of them (concrete and abstract information) are important, because abstraction in mathematics only makes sense if you have enough concrete examples. Abstraction is completely useless if it does not abstract from concrete interesting things” (line 718-720 from Appendix D). Some of them try to give students an idea even though it is not completely related to the concepts: “So I try and explain it like that; giving them an idea of the abstract verses a concrete scenario. But it is often difficult, because the underlying basis is very important and there is a lot of deep mathematical theory related to that. So I will step back and give them an example which does not exactly correlate with it but give them an idea of how to interpret it” (line 227-230 from Appendix D):

For example, working with IT students relating for example formal logical languages to programming languages! Programming languages is something
from their everyday experiences, so in the sense that enables them to get a connection there. Also if you teach calculus in the second year, you can relate all these problems to projectiles etc; physics application of mathematics. Which could make it easier for a student with a sensing learning style to grasp. My answer would generally be, relating mathematics to applications and the applications comes from the everyday world, which is easier to grasp. And although I said, if you majoring in mathematics you need to deal with this abstraction, I think it is good for all of us- ultimately mathematics is justified by the applications that it has in the long run. I certainly would like to know what the applications that I do is. On the one hand there is the beauty of mathematics abstracts on its own. But it is important to relate that to applications. That is the way to engage the more sensing students. Because it somehow relates the abstraction they are dealing with, with the physical world and everyday life (line 761-774 from Appendix D).

Embracing students who have sensing learning style is related to personalised instruction. Personalised instruction possibly makes the study of mathematics more meaningful and motivating for students (Ku & Sullivan, 2002). Several studies find that personalisation affected students’ attitudes in a positive way (e.g., Ross, McCormick, & Krisak, 1986; Cordova and Lepper, 1996 as cited in Ku & Sullivan, 2002). However ‘personalisation’ is associated with some obstacles. The limitations referred to by lecturers are ‘time constraints’ and the number of students in one class. Students also mention ‘time constraint’ as an obstacle. For better personalisation, the issue of ‘how and when to assist students’ is a subject of discussion.

4.3.2.3 Climate Building

The behaviour of the lecturer probably affects the character of the learning climate more than any other single factor (Knowles, 1970, p. 41). The roles of lecturers are not only planning and controlling the learning environment, but also being concerned with the development of each individual learner.
(1) Adjustment to Students’ Understandings

The first sub-category is ‘Adjustment students’ understandings’ which is defined as the ‘Recognition of students’ mathematical background and their diversity’. Many students are aware of lecturers’ brilliant mathematical knowledge and work, yet many students say they struggle to understand their lecturers' explanation. One of the ‘Dependent’ students shared her experience:

I had a lecturer who was brilliant in mathematics. Once she explained to us, she thought we understood well. Yet we couldn’t understand at all. During that time, I had to do self-study a lot. Basically we didn’t understand. We stopped her and asked to explain again many times. Even we told her we don’t understand this specific concept and ask her to explain more, but she has never developed or changed her way of teaching. She just kept on repeating (lines 18-24 from Appendix E).

An ‘Independent’ student identified a disparity of conceptual knowledge between lecturers and students: “Sometimes they (lecturers) explain concepts in a very higher level. They don’t come down to students’ level. This is where the problem of students comes from” (lines 400-402 from Appendix E). “Usually I ask friends who understand something I couldn’t. The reason I prefer asking to peers is that they explain in a way how they grasp the new information. Then it would help me understand better. They use certain words which are easier, much more fun and understandable” (lines 992-994 from Appendix E).

This disparity becomes a sort of obstacle in real classrooms and for students’ tests. The following is what a lecturer observed:

“A lot of time there is a big discrepancy between what we are saying and what they are interpreting. And I notice that comes out in tests as well. I would say something and they would take it and interpret it in another way. I don’t always
realise that, because you know what you mean when you say it but when they interpret it they would say ‘no’, this is what you actually meant. And I notice in tests that occasionally some students completely misunderstood what I said. I would say ‘this’ but they would take it as meaning ‘that’ is not the bulk of them but there are some students who completely misunderstood” (lines 150-157 from Appendix D).

Many students expect lecturers to understand their weak conceptual knowledge. A student who visited her lecturer one day says “The other day I visited one lecturer to ask questions. I didn’t get what I wanted and in the end, I was confused more. I think it happened because I didn’t have enough basic knowledge. When they explained, they didn’t start from the beginning of course I didn’t ask them to explain from the beginning since it is time-consuming” (lines 771-778 from Appendix E). Though it takes long, one student acknowledged how much it help him when his lecturer explains in detail:

The lecturer whom I visited first time, she explained on that level and I couldn’t get it. The second lecturer started from the basic then I could understand the higher level later. If a lecturer starts to explain the basic knowledge then it would be easier to grasp the complicated concepts (this was what he did to me last semester. At that time I could even teach to my classmates (lines 402-407 from Appendix E).

For students’ individual development in mathematics it is recommended that conceptual knowledge between lecturers and students be adjusted to account for the students’ weak background in mathematics. Asserting and understanding what the learners already know are essential for virtually all subsequent learning (Ernest, 2010, p. 40).

Another alternative to adjusting to students’ understandings is to explain in diverse ways. “I do generally try to explain more than one way. Then when I go from a student to a student, I can help them. Looking at their eyes, we can easily see whether they understand or not. If they don’t understand, I explained again in other way. As hearing
their question, it is easy to pick up what they don’t understand” (lines 1224-1227 from Appendix D).

Since students have diverse backgrounds and different levels of understanding, it is important to approach this in a various ways:

Just approach things from multiple angles, is probably the best way to accommodate students. So even though we talk about the same concept or problem, by approaching it from different angles the light goes up for different people (lines 868-871 from Appendix D).

(2) Active Classroom Environment

The second sub-category is ‘Active Classroom environment,’ which is defined as ‘an interval given to students and approachable atmosphere built by lecturers’. Providing intervals instead of filling class time with lecturing and writing on the board is constantly mentioned by students. “Not every lecturer gives students a lot of opportunities to participate in the class. Some lecturers go through explaining everything and ask us ‘do you understand?’ then we can hardly say ‘yes’ or ‘no’” (lines 1229-1231 from Appendix E). One student who changed his qualification from engineering to science explains the disadvantage of straightforward lecturing:

I tasted a bit of differences of lectures last year and this year. Well, last year they just delivered information to you, you sort of fell along with them. Whereas this year I learned Mrs. G's class, she has a lot of hands-on, waling on class, helping people, getting students' problem to solve and moving on.. there is more interactive, people are impressed and expect to take Information (lines 664-669 from Appendix E).

What students expect in class is time to practice in place of merely receiving information. “It would make it hard students in a way like they just give information then expect
(students) to study. Although it is good because they give us information … feel like they put more pressure” (lines 513-515 from Appendix E). Felder and Silverman stated that an interval in a class was important to students, especially students with ‘Reflective’ learning style because it would be an opportunity to think about what they have been told (1988). Regardless of their learning style, students want to have time to practice in class: “If we are just sitting and listening, we cannot realise how much we are learning and understanding” (lines 335-336 from Appendix E). One of the students mentioned the benefit of practising in class.

I would like to have more exercise in the class. I know it is not always possible because lecturers need to cover the works. Apart from marking, if there are more practices it would be helpful because when it comes to marks I change my attitude due to pressure. I realise that when it comes to marks, I am no longer interested in understanding, but I just want to get the points and try to memorise something in order for me to pass. If I remember correctly, when I sit in the library and do self-study, I intend to more understanding and enjoyed it without pressure. Another thing is that I would like lecturers to make use of quiz on line. With the quizzes on line we can manage our time and arrange our schedule for self-study (lines 653-661 from Appendix E).

Another aspect of classroom environment is whether or not it is an ‘approachable atmosphere’. With their low level of self-esteem and anxiety, students expect amiable mood and approachable attitude of lecturer. Many students have low self-esteem in terms of studying mathematics. They don’t know how to pose questions in an appropriate way and even they were wondering whether or not lecturers accept their questions (lines 818-820 from Appendix E). One lecturer mentions the same thing: “The weaker ones in general feel they don’t have enough knowledge to even formulate what they want to ask” (lines 342-343 from Appendix D). A 3rd year student says “I don’t go to the lecturers. It is because I usually work behind the schedule so when I have something I couldn’t understand; I figure it out by myself with textbooks or the internet. I think lecturers also expect students to work hard, so I am wondering if I ask them, they
might be disappointed. If I study in advance then I am more willing to go and ask them") (lines 641-644 from Appendix E). This is not something to ignore and an approachable atmosphere can possibly lessen their anxieties. They said they would willingly ask lecturers if they understood more in class and if their lecturers were approachable (lines 995-1000 from Appendix E).

She is approachable. She tries to answer all means and encourage us to come to ask her again. After class, we can come to her and ask (lines 945-946 from Appendix E).

McLeod states that affective factors play a central role in mathematics learning and instruction. Both learners and Instructors regard the affective climate in the classroom as the cognitive responses and achievement (1991, p. 55).

4.3.2.4 Participating in the Learning Process

Participating in the learning process is regarded as an imperative factor to enhance their learning by lecturers and students. Since the university students preferred to take up accountability ('Participant’ learning style), much consideration is required on the development of the students' participation.

(1) Interactions

The first sub-category is 'Interaction’ which is defined as ‘Reciprocal influence among everyone in mathematics classes'. Lecturers and students all agree that student' interactions with peers and lecturers provide them with many opportunities.

If a student just write down whatever a lecturer writes on the board without thinking and questioning, it would be harder to take in information. I think sitting and watching what the lecturer is doing would help us very little. It is like the
more you practice the more your brain gets to know. Thinking and questioning by ourselves make us find our own problems. Like my lecturer, giving us time to exercise on our own and allowing us to ask if we cannot do by ourselves, it is very helpful. Everybody can participate in her class. Without practices, there is no benefit, I believe (lines 687-694 from Appendix E).

Active participation in class encourages students to think and question themselves and also helps them to concentrate more and remember what they learn for longer. “The more we do by ourselves the more we understand and remember. Just sitting and listening to make us sometimes wonder. If I have (more) opportunities (to participate) I would concentrate more” (lines 631-633 from Appendix E). As students explain, there is a personal aspect of why it is important to participate in class. Furthermore students’ active participation assists lecturers as well:

(If students actively participate) then actually lecturers know what we do understand, or what is going on, if we give him more answers he can give us theorem again or examples again so by telling them to repeat for us .. it actually tells lecturers what it is going on within us (students)( lines 61-63 from Appendix E).

Indeed if students actively participate in the mathematics class, lecturers would know what is going on in the process of learning and what they require. “Participation is not only helpful for students to learn but also it keeps our class alive” (line 425 from Appendix E). One student describes his class as alive, eagerly wanting to sit in front, raising hands, questioning and discussing (lines 694-695 from Appendix E). This could constitute a ‘virtuous circle’ but in reality this does not always happen in reality.

So I think a lot of the time is passive, because of time constraint but I do try to bring in some active participation on their part. But again that is not always well received. A lot of the students want to sit there and just sit. They say they are listening but I think most of the time they are just sitting there. So I think many of
my students are passive learners in they sense that they sit there and listen to you. But whether they actually hearing what you say is another story (lines 261-266 from Appendix D).

Many lecturers agree with the reasons for the passive participation in mathematics classes; time constraints, and the passive attitude of students. Moreover, students are not strong enough to actively participate in class: “Many of them are not a 100% sure and scared they are going to give the wrong answer” (lines 283-284 from Appendix D). Owing to their weak background, students’ participation in class becomes passive even though lecturers and students recognise the importance of active participation. Or some strong students dominate the class that makes other students take a back seat (line 359 from Appendix D).

Given that the concepts of mathematics are abstract, especially for students in their senior year, lecturers state what the right perspective related to the meaning of active participation is; i.e. to engage actively with the mathematics materials by themselves or in a group and to interact with their lecturers.

They have to be active participants in this process. It does not mean you have to ask questions in class all the time. But actively engaging the material; going through the work either by yourself or with a peer group or see the lecturer.. that is absolutely key. Because these concepts you encounter in mathematics are completely abstract. They have no obvious correlation with your every day experience. And the only way for these objects to become real to you is to engage them enough by yourself. In that way these things become real to you and you build intuitions about it how these things are suppose to work. That doesn’t happen by sitting passively and listening to a lecturer. It only happens by working out and assignments for yourself and going beyond what is just required in the course. That can happen either in a solitary setup or together with others. There is something to be said for both, working by yourself or with peers. Each of
those brings something different but at least one of those need to be there (lines 573-584 from Appendix D).

‘Small group discussions’ is the most frequently mentioned by students in terms of interaction in class. Many students agree that group discussions are a good opportunity to participate and even motivate them: “I was motivated by a group of people (my peers and tutors). Group studying really helps me to gain confidence. My mark went up and even people come and ask me to help them” (lines 1149-1150 from Appendix E). One student with the verbal learning style says “When I work in a group, if I have a chance to give explanation to others, it would always help me understand concepts” (lines 845-846 from Appendix E). The conclusion of the study conducted by the Socony-Vacuum Oil Company indicates that students retain 10 percent of what they read, 26 percent of what they hear, 30 percent of what they see, 50 percent of what they see and hear, 70 percent of what they say, and 90 percent of what they say as they do something (Felder & Silverman, 1988). The following attests to this:

“We sit in a group and work together for 3-4 persons. If someone has problems, 3 of us have a solution. In doing so, we teach others and when we teach other, it can also help us to understand more; explaining the concepts” (lines 738-740 from Appendix E).

Many lecturers shared the benefits of discussions with peers when they studied: “As a master’s students we did quite a bit of studying in groups, especially working on assignments and there I really saw the benefit” (lines 504-506 from Appendix D). When one of lecturers was asked about the time to discuss or to facilitate in classes, he says those times could support active learning:

It encourages active learning. If the lecturer just stands up and gives a performance – it is extremely easy for students to dose off. The discussion certainly breaks the monotony of them just listening to you. And it encourages
them to think for themselves - to be active in this process (lines 804-806 from Appendix D).

The effective and efficient learning of mathematics through small group discussion requires, as mentioned above, an active students attitude. If students actively collaborate in group discussions, it could have a positive effect (lines 544-546 from Appendix D).

For the interaction as reciprocal influence, all lecturers suggest a class with a small group of students in class. To give students many opportunities to participate and to interact, the class should be small. “Ideally the class should be smaller, in the sense that if you have a smaller group you can interact with them more. At least look them in the face and say overall they looked happy with this or they are not happy with this. Particularly, because many of them don’t participate. So I need to intuitively feel, they are happy with this or not and in a smaller group it is easier to do than in a bigger group. It is easier to make a connection with them in a smaller group than in a bigger group” (lines 451-453 from Appendix D). Small class sizes (20-30) may facilitate ampler interaction among students and with the lecturer (Laursen & Hassi, 2012).

Catering for the diversity of students is always a challenge for lecturers. Many lecturers share their difficulties especially when they teach a big class. They cannot but help focusing on the majority of student sitting in front and actively interacting with them. As a result, consultation times are regarded as useful time to cater for the diversity of students.

It is very difficult to cater for everyone in a big group. I would say being available if students come and see me personally. Weak students come with a lot of questions and strong students come with insight questions, so I can help them based on their needs during the consultation time. The best way for me to cater students is the consulting time because I can meet them on their personal level lines 1486-1490 from Appendix D).
The consultation time can play a good role for lecturers more individually to look after their students. In this regard, those who frequently visit lecturers say they get great benefits from the consultation time.

Last semester I attended the module of ‘descriptive mathematics (abstraction of normal mathematics)’. We all struggle because it was totally new concept to us. Therefore I tried to get the recipe, what is the best way to know the concepts and to pass. I visited one lecturer but I couldn’t get it. I read a book and tried to find ‘who else can explains what this book about?’ and then visited another lecturer. He explained very well and helped me inhabit the concepts. In the end my mark went from 60 to 80. Meeting lecturers are very good especially for studying mathematics (lines 393-398 from Appendix E).

One clue pointed out by the lecturers is students need to come and visit. “I can only comment on students who actually physically come and see me” (line 119 from Appendix D). Another lecturer says “I am tutoring at home, so if they can come and visit me like children who come for extra lesson, I think I would do great job for them even for free. I try to mention in my class ‘remember to come and see me’. I write ‘please come and see me’ for students who got particularly bad mark on their test paper, but they don’t always come” (lines 1215-1218 from Appendix D). Though students agree that consultation times are important, many students actually do not frequently visit lecturers for common reasons; low self-confidence or a different level of understanding. One student who is a student and a tutor at the same time explains why:

Let me say lecturers give us assignments. Sometimes you understand more from your peers because of interactions. Lecturers come to class, just speaking. Sometimes students come in with the problems they have in class, then having one & one interaction. Sometimes I understand in the way students understand it and pass it to them. Then it becomes easier. Lecturers teach right theorem, but students cannot understand. If I teach them in the way I would like to understand
them (the concepts), then it would be understandable for them (lines 372-377 from Appendix E).

An alternative for lessening time constraints is to use online communication: “I have an e-mail address that I have told them they can e-mail me questions, 24/7 and that I will get back to them as soon as I can” (lines 114-115 from Appendix D).

(2) Options and Alternatives

The second sub-category is ‘Options and alternatives’. Since one of the learning styles of university students is ‘Collaborative’ learning style, many chances to listen to, and appreciate, diverse viewpoints from peers would be helpful. Many researchers state that learning with, and from, one another without any implied authority would be of great benefit (e.g., Boud, Cohen & Sampson, 1999). Though learning mathematics necessitates introspective and reflective thinking, sharing opinions and suggestions are also supportive:

Just hearing what other students think about things is certainly beneficial. Other people might also have other interesting approaches or other people might suggests approaches that are not right and being able to think why these things aren’t right; that is certainly also beneficial. I definitely think it is beneficial for both sides (lines 819-823 from Appendix D).

For instance, lecturers encourage students to suggest their knowledge or put a question on vote. “‘Here is the problem’ and then well, have a discussion on how what you suggest the solution. You suggest this thing. Do you guys agree or do you see something wrong with this?” (lines 798-799 from Appendix D). “Ok who says this is what we should be doing and who says this… vote” (line 278-279 from Appendix D).

Considering those who are not strong enough to study by themselves learning from one another (peer learning) would be one of the ways to be successful in learning
mathematics. “I give them an open test. They are allowed to discuss to find the answer. In doing so, they can learn from one another and have better understanding. Also it would be helpful to prepare for the exam. It is because they don’t know enough to sit on their own and to write what they are supposed to know yet.” (line 1333-1337 from lectures). One student shares what benefits he could get from different strategies based students’ suggestions.

In a ‘Linear Algebra’ module, I had struggled and got 57%. After the first test before the second, he gave us time to revise. During the revision, there was ‘question and answer section’ which students bring any unsolved concept and we talk about it with one another. It helps me a lot (line 432-434 from Appendix E).

4.3.2.5 Flexibility for Individual Development

(1) Towards Visual Understanding of Abstract Information

Formal education engages in a logically ordered sequential progression from concept to concept. Most students with both ‘Sequential’ and ‘Global’ learning styles look satisfied with the step-by-step progression adopted in class. “I am very happy with the sequential explanation. It is easier for me to understand anything that comes up with step-by-step” (lines 1184-1185 from Appendix E). This is particularly true for those who are not strong in mathematics, step-by-step progression in mathematics class is supportive, as one student with neutral learning style (‘Sequential’ – ‘Global’) says: “I am comfortable with that. At least I can follow (though I don’t understand concepts completely)” (lines 823-824 from Appendix E). Indeed it happens in real classes. “90% of my students want to learn step by step. I try and do both. I explain the procedure and then explain what we are actually doing in the bigger scheme of things. Most of them are not interested in the global interpretation. They want a ‘Step 1 do this. Step 2 do that’” (lines 179-181 from Appendix D). There could be many reasons of why students favour a step-by-step so much.
That comes from the way things are approach at school all the way through. Because a lot of the way mathematics are taught, and unfortunately even at university you may pass your mathematics is by learning recipes, which are sequences of performing steps (lines 829-831 from Appendix D).

Or it could be because they get used to spoon feeding approach of teaching (lines 323, 1303 from Appendix D). Or they simply want to pass the tests, especially in mathematics. In real "At least 30-40% of the test is understanding of what it is that you are doing. In a way we try to force them, you have to know what it is that you are doing. But then still, some of them aim to get 50% so they feel they don’t need to know the global" (lines 380-382 from Appendix D). “They really struggle to understand what it is about. For most of students, mathematics is about solving problems using the appropriate methods. If I give them a slight different content, they cannot figure out because they don’t have concept image or visual understanding. They got a concept definition which comes from the book, but they don’t have image to provide them with the whole picture. Those who understand the whole picture, they are able to grasp the definition, of course, and re-create the definition on their own” (lines 1402-1409 from Appendix D). Considering the practical situation, though lecturers from all clusters conquered the importance of development of ‘Global’ way of understanding, it should begin with ‘Sequential’ teaching especially for weak students and gradually move towards global teaching.

I try to link sequential and global teaching. Once I am done step by step and once they have sorts of understandings, then I might show where students would use the concepts and practices when you leave the university and start to work. (I believe) Our aim should be like this: taking students in a baby-step (Sequential) and leading to and developing their global way of thinking (lines 1112-1116 from Appendix D).

For ‘Global' learners, the freedom to devise their own methods of solving problems and the advanced concepts should be exposed in class (Felder, 1988). Students with global
learning style say: “I don’t say I am not comfortable with that, but if a lecturer show the big frame and explain what we are going to do in the whole session and go to details, then it would help me understand more. Without knowing the whole story, I feel like being lost or not interested in that” (lines 647-650 from Appendix E). This global perspective would be supportive not only for the students with global learning style but also for the students with independent learning style (lines 130-131 from Appendix E).

Many lecturers agree that students may pass mathematics exams with learning recipes, yet passing exams without real understanding of what they are doing will not take students very far.

I hope and try and encourage people to look beyond the sequential step by step and see the global sense of being a problem solver (innovating) the problems that you have to model and confront you in the real world don’t come with a little list of steps you need to follow. You need to be able to contextualize them and then come up with a little list. I concur, the curriculum and even the exam does not require students to think globally. As longs as they can follow step by step they will pass. But as you said in the long term – must reach a certain level (lines 841-848 from Appendix D).

To lead students to the level where they can make out what they are doing beyond the sequential comprehension (visual understanding of abstract information), many new attempts would be constructive; presenting problems before offering explanations, deep consideration of the connections between concepts, or contextualised and relevance-tied up concepts.

By contextualizing what you do all the time. A lot of the actual time that you spend lecturing, is spent on step by step things. But to help students, in a sense, zoom out to the global picture. To remind them where are we going and that this is part of a bigger setting. Also asking challenging questions that requires students to go beyond the step by step. We present you something that isn’t part
of the standard step by step things. Now your step by step breaks down. If you want to go further you are now being forced to do something else. The only way to do that is to think in a more conceptual global level of what you are doing. That is what I do; by emphasising the bigger picture and how the pieces and concepts fits together. And by challenging students with questions that cannot be done with the standard procedures. Not necessarily incredibly difficult things but things that challenge the standard step by step thing (lines 850-860 from Appendix D).

(2) Self - Directed Learning Environment

All lecturers with both teacher-centered teaching styles and learner-centered teaching styles expect students to leave their course well prepared for further work and want them be studying independently. In other words the direction should possibly be independent and responsible students with a lot of self-directed learning experiences. With regards to this the ideal classroom environment, an effective and efficient lecturing time is suggested several times by lecturers: “Ideally, print out their notes or bring their laptops. In class they should not be rewriting what’s on edu-link, they can just download that to get it. They can rather focus on the extra. So the little things like ‘Oh ok, cool, I didn’t understand that, let me make a note.’ So theoretically I would like them to absorb something extra I give them in the class” (lines 439-442 from Appendix D). It is important for students to prepare in advance before coming to class for the productive lecturing time. Prepared students can easily absorb something in their classes that they can hardly obtain from their self-study.

From my ideal student I expect you to come to class prepared; look at the material beforehand. To participate in class, and this does not mean you need to ask questions or make remarks necessarily, just actively follow the work (silently participating). I also would expect independent work away from the classroom; solitary work or with a study group. Because the real learning does not happen in the classroom – it happens when you actually sit and engage problems that are just a little difficult for you. And then come and engage me based on the work
you do independently- “this is where I am struggling. These were my approaches.” To sum it up – I expect active participation in these various ways rather than a passive receptiveness and hoping that somehow you will be illuminated by being in this environment (lines 873-881 from Appendix D).

As one lecturer mentions mathematics is something that students need to figure out for themselves (actually sit and engage problems), coming to class prepared is involved in the effective and efficient lecturing time. Many students agree with that as well (lines 185-186, 574, 745 from Appendix E). Another suggestion under the consideration of time constraint is as cited in lecturers as follows:

It would be nice since time is a big issue. Preparing lecture tapes and giving that to students. They can watch at home and get the theory which they need and come to class. In the class, lecturers can help students with exercises that they do normally as their homework. In that process, students can be assisted with where they are weak. It would give students deeper understanding and assist them with critical thinking. Then we can have extra time. Actually what the lecturers are doing in the class can be taught just from the textbook. My opinion is very ideal, but it would be more value for students to work on much deeper understanding (lines 1436-1443 from Appendix D).

One of lecturers suggests recording the lecturers and putting them online as one of ways to cater for students' learning styles: “Diversifying the offering more online content! Use the actual face to face contact time for what you can’t do in an online environment- the one on one work, the discussions, that type of thing. If you put your lectures with videos online, people can follow that on their own pace. So just diversify what you are doing. Offer things with different angles. Material that does give you slightly a different exposition”(lines 925-928 from Appendix D). It might be a good alternative. “Usually if I have something that I don’t understand I go to Youtube. I learned the video from other universities. There are many different videos and different teaching styles. If I find
something different from my lecturer and sometimes I understand better” (lines 765-767 from Appendix E).

4.4 Analysis and Results for Research Question 3

*What can be done to reach out to students whose learning styles are not addressed the common instructional approaches in mathematics classes in South Africa?*

To address the research question no. 3, the findings from the first and second phases have been integrated. The integration of the quantitative and qualitative data is essential to provide informed thick description of findings.

4.4.1 A mathematics Classroom with Enhancing Active Learning

Active learning is typically regarded as the opposite of the passive model of supervised learning, or the traditional lecturer approach (Rosenthal, 1995; Beygelzimer, Dasgupta, & Langford, 2009). It can refer to any instructional method that employs students' participation in the learning process (Prince, 2004). From the perspective of active learning, interactions in class can make learning considerably more practical (Beygelzimer et al., 2009). Most mathematicians agree that the best way to learn mathematics is to actively do mathematics, to discuss it with others and to synthesise the major ideas (Rosenthal, 1995).

The quantitative data showed that one of the dominant interactive learning styles is ‘Participant’ learning (Table 17 showed 4.03/5.0). This style is usually associated with students who love to go to class and experience involvement with all aspects of instruction (Emanuel & Potter, 1992). However, students in mathematics classes in South Africa passively engage themselves in real mathematics classes. Students even
see themselves as passive learners (lines 69 & 556 from Appendix E). They seldom speak in class and even raise their hands. Only 10-20% of the students actually speak (lines 279-281 from Appendix D).

<table>
<thead>
<tr>
<th>Questions</th>
<th>Disagree</th>
<th>Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>6  I do whatever is asked of me to learn the content in my mathematics</td>
<td>6.2%</td>
<td>81.5%</td>
</tr>
<tr>
<td>classes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 Mathematics class sessions typically are worth attending.</td>
<td>4.7%</td>
<td>86.6%</td>
</tr>
<tr>
<td>18 I get more out of going to class than staying at home.</td>
<td>11.6%</td>
<td>78.6%</td>
</tr>
<tr>
<td>24 It is my responsibility to get as much as I can out of a mathematics</td>
<td>3.2%</td>
<td>94.2%</td>
</tr>
<tr>
<td>course.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 Mathematics classroom activities are interesting.</td>
<td>15.6%</td>
<td>64.5%</td>
</tr>
<tr>
<td>36 I try to participate as much as I can in all aspects of a mathematics</td>
<td>14.5%</td>
<td>69.2%</td>
</tr>
<tr>
<td>course.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42 I do all mathematics courses assignments well whether or not I think</td>
<td>6.2%</td>
<td>80.4%</td>
</tr>
<tr>
<td>they are interesting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48 I typically complete mathematics course assignments before their</td>
<td>18.1%</td>
<td>63.4%</td>
</tr>
<tr>
<td>deadlines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54 I complete required mathematics assignments as well as those that are</td>
<td>12.3%</td>
<td>66.7%</td>
</tr>
<tr>
<td>optional.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60 In my mathematics classes, I often sit toward the front of the room.</td>
<td>27.5%</td>
<td>56.5%</td>
</tr>
</tbody>
</table>

Note: ‘Disagree’ includes ‘strongly disagree’ & ‘somewhat disagree’ / ‘Agree’ includes ‘strongly agree’ & ‘somewhat agree’ in the ‘GRSLSS’ questionnaire (‘neither disagree nor agree’ was exempted).

Table 31 Percent of Agreement regarding ‘Participant’ Questions

Considering the results of questions regarding the ‘Participant’ learning style (See Table 29), the majority of university students are aware of their responsibility in studying mathematics (the highest agreement (94.2%) & the lowest disagreement (3.2%) among factors of ‘Participant’ learning style as the table 31 showed). Sitting in the front of the class is another indicator of the ‘Participant’ learning style. Low levels of agreement with the willingness to sit in front showed that the university students were not willing to
participate in the real class (the highest disagreement (27.5%) & the lowest agreement (56.5%) as the table 31 showed). These results are in line with the qualitative data.

The responsibility of students is emphasised by many participants in this study. “The problem is unprepared students. If we don’t prepare in advance, we don’t have any idea of what is going on in class. Without preparation, no one can participate” (lines 185-186 from Appendix E). “Students need to study in advance & prepare for the lectures. I don’t see how we can participate without preparation” (lines 571-572 from Appendix E).

With regards to sitting in the front of class, many lecturers say they are interacting with those who are usually sitting in the front (lines 989, 1445 from Appendix D): “I tried to interact with a group of students who are usually sitting in front. Most of student who are sitting back started to move or react once I write something on the board, because they want to copy and keep that for their exam” (1445-1447 from Appendix D).

Interestingly there is a discrepancy between what the university students think important and what they are really doing in mathematics classes. Even though university students are aware of the importance of participation, they don’t seem to participate in class. The main reason for this discrepancy, as mentioned by both lecturers and students, is low self-efficacy: “I don’t have good background regarding mathematics to digest mathematics and to have deeper understanding” (lines 1006-1007 from Appendix E). Self-efficacy (attitude, values and personality characteristics) indeed affects achievement and participation in the learning of mathematics and educators should take note of it (Yates, 2002).

Another dominant interactive learning style is the ‘Collaborative’ learning style (Table 17 showed 3.69/5.0). In other words, university students prefer studying together in a group. Collaborative learning is defined as any instructional method in which students work together in small groups toward a common goal. Many researches supported all forms of active learning along with collaborative learning (Prince, 2004). As mentioned in 4.3, many students agree with the benefits of collaborative learning (lines 738-740, 845-846, & 1149-1150 from Appendix E).
Since most professors and lecturers in the faculties of science and mathematics are themselves intuitors (i.e. Wilde, 1993 as cited in Jensen, Murphy & Wood, 1998); this collaborative environment could possibly not be considered so much. Yet it is critical to remember that collaborative learning would be helpful for ‘Sensing’ learners who are the majority of university students. In the experiential learning cycle (Kolb, 1984), the ‘concrete experience’ preferred learners with this learning style favored working in a group to set out different approaches to complete a project, to listen to and gather information (‘concrete experience’ and ‘abstract conceptualisation’ are closely related to ‘sensing’ and ‘intuition’ – Felder, 1996).

According to research done by Tait-McCutcheon (2008), there is a strong sense among students that talking with others is useful when they get stuck in mathematics. Students believe working in a group could improve their mathematics. Many researches prove that working in a group and classroom discourse develops learners’ cognitive development (e.g. Linchevski & Kutscher, 1998; Schoenfeld, 1992).

When compared to the whole class situations, students are more likely to ask questions when working in small groups. In doing so, students can reflect on their own work and make sense of what others are doing. Recent studies (e.g. Healy & Kynigos, 2010) also support students’ knowledge development through individual and collaborative activities (Jones, Geraniou & Tiropanis, 2013).

The benefits of collaborative learning are that students learn better and retain concepts longer when they are actively involved; students can learn from each other, and can learn from teaching each other; students can get practice working and communicating with others (an essential skill in many job settings); and students experience a warmer, more welcoming, and more caring atmosphere (Rosenthal, 1995, p. 3). A predictor of who may learn most in a group is the students asking questions of the others as many as possible in the group. And the students who learn the second most was the one who answers questions (Buela-Casal et al., 2003). In other words, students need to be actively involved in group work to gain more knowledge. In this regard, lecturers are
concerned about the side-effects of group work, even though they are aware of the benefits of collaborative learning: “So they feel if they got three or four people and they all doing the same thing then they feel little bit more confident with what they are doing. It could be a confidence thing but again it does not match up with their self-assessment” (lines 66-68 from Appendix D).

The problem is there is always grey area which means students who don’t want to work, and just want to copy of others. Therefore I would say working together would be good because those who are willing to participate will talk to one another, communicate each other and figure it out together. And yet it would be also bad because those who are not willing to participate won’t learn anything. They will never think (lines 968-973 from Appendix D).

The collaborative approach is recommended because it provides the opportunities for social interaction and possibly increases learners’ understanding that it provides. Yet Grasha (1996) acknowledges that a potential disadvantage of collaborative learning is excessive dependence on others.

To minimise the grey area, group work should be used to augment the collaborative learning style in mathematics classes. It should include; group tasks, group composition and group interactions (Buela-Casal et al., 2003). Group tasks should not be trivial but rather include more appropriate challenges to provoke shared thinking, taking into account the diversity of students (Davis & Sumara, 2009). In order to amplify group interaction, the range of attainment will be considered. The narrow range of attainment will be characterised by scant questioning and answering. If group members are similar in attainment, then the participants get on with tasks on the assumption that everyone in the group knows what to do. When the attainment range is broad, the participants at the extremes of the range engage in most of the questioning and answering. But the opportunity for those who are in the middle will be limited.
Although the results from various studies differ in strength, many kinds of activities are advised to enhance the ‘Participant’ and ‘Collaborative’ learning styles, especially for the benefits of students’ engagement (Prince, 2004). As a result, although mathematics tasks are regarded as more studies to individual work than a team work, no one can deny the benefits of activities that accommodate students with the ‘Participant’ and ‘Collaborative’ learning styles. In this regard, faculties should structure their courses to endorse participant and collaborative learning environments. It doesn’t mean that the entire course needs to be team-based, or individual responsibility needs to be absent. Arcavi mention when a classroom is considered as a micro-cosmos, as a community of practice, learning is no longer viewed only as instruction and exercising, but also becomes a form of participation in a disciplinary practice (2003, p. 76).

4.4.2 The Balanced Learning and Teaching in Mathematics (‘Sequential’ to ‘Global’)

Learners have preferred ways of understanding information; sequential (linear or serialist) and global (holist). Sequential learning starts with the basics whereas one thing is analysed at a time, and which builds up to the whole systematically. On the other hand, global learning entails the looking at the broad overview in order to understand its constituent parts to take place to take place. As the quantitative data shows, 67.1% of participants are included in a ‘Balanced’ modality, 25.2% are placed within the ‘Sequential’ modality and only 7.7% are within the ‘Global’ modality, when it comes to ‘Understanding information’ (See Table 23).

The frequencies of each question related to ‘Sequential-Global’ modality shows clearly that students prefer the ‘Sequential’ learning style. Especially when solving math problems is being considered, they favour working in step-by-step process (Sequential 81.9% / Global 18.1% - question no.12 as the Table 32 showed). This is compatible with the qualitative data. Many lecturers mention that students are not global learners: “To be global students, they need to be very good students. Seeing a bigger picture and find
the relevance are not applicable to all students” (lines 1102-1104, line 1426 from Appendix D). Since students are predominantly ‘Sequential’ learners, lecturers recommend learning step-by-step first and move to getting a bigger picture (lines 1108-1110 from Appendix D). “In mathematics, students need both skills (writing down step-by-step) and understanding overall” (line 1417 from Appendix D).

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions</th>
<th>Seq./Glo.</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td><strong>When I solve math problems I usually work my way to the solutions one step at a time</strong></td>
<td>Seq.</td>
<td>81.9%</td>
</tr>
<tr>
<td></td>
<td>When I solve math problems I often just see the solutions but then have to struggle to figure out the steps to get to them.</td>
<td>Glo.</td>
<td>18.1%</td>
</tr>
<tr>
<td>16</td>
<td><strong>I think of the incidents and try to put them together to figure out the themes.</strong></td>
<td>Seq.</td>
<td>74.8%</td>
</tr>
<tr>
<td></td>
<td>I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.</td>
<td>Glo.</td>
<td>25.2%</td>
</tr>
<tr>
<td>28</td>
<td>When consider a body of information, I am more likely to focus on details and miss the big picture.</td>
<td>Seq.</td>
<td>26.5%</td>
</tr>
<tr>
<td></td>
<td>When considering a body of information, I am more likely to try to understand the big picture before getting into the details.</td>
<td>Glo.</td>
<td>73.5%</td>
</tr>
</tbody>
</table>

**Table 32 Frequency of Sequential & Global Learning Preference according to Questions (Felder - Silverman Index of Learning Style)**

With regards to global learning in mathematics, there are many terms that describe preference for learning; visualisation (Presmeg, 1997), visual inscriptions (Roth, 2004) visual thinking (Giaquinto, 2007) or visual representation (Arcavi, 1999). Presmeg (1997) defined ‘visualisation’ as processes of constructing and transforming both visual mental imagery and all of the inscriptions of a spatial nature that may be implicated in doing mathematics.

Mathematics relies heavily on visualization in its different forms. It is not merely applicable to the field of geometry. Spatial visualisation goes beyond this. Visualising
provides an almost effortless way of acquiring new information, and its results often come with a degree of immediacy, clarity, and force that makes visualization apt as a means of discovery and explanation (Giaquinto, 2007, p. 264).

In learning mathematics learners need “the 'cognitive technology' help them transcend the limitations of the mind … in thinking, learning, and problem solving activities"(Arcavi, 2003, p. 56). In other words, visual understanding of abstract information is important (lines 1410-1413 from Appendix D). It might be the reason why students with ‘Intuitive' learning style can be better in mathematics since mathematics requires understanding a lot of abstract information.

Being intuitive means visual and holistic as opposed to detailed analytic and the importance of intuition is emphasised in learning mathematics (Burton, 1999). According to the quantitative data, university students prefer the ‘Sensing’ learning style. As table 23 shows, the preference for the ‘Sensing’ learning style is more than twice that of the ‘Intuitive’ learning style (28.7% / 11.0%). Since the majority of the university students are ‘Sensing' learners, the faculty should consider learners’ enhanced way of thinking and balanced curriculum.

In this regards, grasping abstract information (visualisation) is essential in learning and teaching mathematics.

It is because abstract information, I believe, develops students’ thinking and analysing for believe develops students’ thinking and analysing, for example the world situation. It encourages me to do research and gives me time to think over ‘what it is about?’ I believe interpreting and analysing abstract information will help me develop my way of thinking and viewpoint (lines 172-174 from Appendix E).

According to Tobias (1993), all kinds of learners are equipped to learn mathematics, yet some learners do not learn well in the traditional manner (step-by-step). People who approach learning from a global perspective sometimes experience difficulties in
mathematics courses, which traditionally emphasises sequential, step-by-step, deductive and rule-based instruction (Sloan et al., 2002, p. 86). It is suggested that educators and practitioners should take into account a balanced learning environment which include both sequential and global learners (Felder & Brent, 2005, p. 60; Bernold et al., 2000; Ngambeki et al., 2012).

4.4.3 Teacher - Centered Teaching Style Moving towards Learner - Centered Teaching Style

Two major teaching styles are identified; one is characterised by a responsive, collaborative, learner-centered approach mode and the other by a controlling teacher-centered approach (Conti, 1989). Dupin-Bryant defines learner-centered teaching style as “a style of instruction that is responsive, collaborative, problem-centered, and democratic in which both students and the instructor decide how, what, and when learning occurs” (2004, p. 42). On the other hand, the teacher-centered teaching style is considered “a style of instruction that is formal, controlled, and autocratic in which the instructor directs how, what, and when students learn”.

Originating from constructivism, a teacher-centered teaching style is being replaced by a learner-centered teaching style in higher education during the last few decades (Zophy, 1982; Weimer, 2002; Pillay, 2002). It is because the learner-centered approach is better suited to more self-directed and independent learners who not only participate but also construct their own learning experiences. The quantitative data shows that traditional, teacher-centered teaching styles are still dominating in university settings with some exceptions (See Table 28). Students from both ‘Dependent’ and ‘Independent’ learning style address the disadvantage of the teacher-centered teaching style.

Sometimes if a lecturer has a too teacher-centered teaching style, then I realise some students get only concepts-base. What happens in the class is that after a
lecturer carry on the works and tell them (lecturers) that we don’t really understand. Then lecturers got back. Though students ask the lecturer to give more details, we students don’t really get the concepts. That is where we students start to fall out in terms of mathematics (lines 8-12 from Appendix E).

The typical method of teacher-centered teaching style is a conventional approach to lecturing: “I think sitting and watching what the lecturer is doing would help us very little. It is like the more you practice the more your brain gets to know. Thinking and questioning by ourselves make us find our own problems” (lines 689-691 from Appendix E). Although students realise the disadvantage of teacher-centered teaching style, most of students have already adjust themselves to a ‘spoon feeding’ approach of education (lines 323-325, lines 1303-1304 from Appendix D). It entails that students with strong ‘Dependent’ learning style are not yet ready to learn in a learner-centered teaching environment.

The quantitative data shows a correlation between ‘Independency’ and ‘Mark’. The relationship between ‘Independent / Dependent’ learning styles and ‘Mark’ is investigated using ‘Spearman Rank Order Correlation’ coefficient and ‘Pearson product-moment correlation’. Since the ‘Independent’ student population violates the assumptions of normality, ‘Spearman Rank Order Correlation’ coefficient is used. There is a positive correlation between ‘Independent’ and ‘Mark’, $\rho = .29$, $n = 238$, $p < .01$ with high levels of ‘Independent’ learning style associated with high level of ‘Mark’. On the other hand, there is negative correlation between ‘Dependent’ value and ‘Mark’, $r = -.152$, $n = 214$, $p = .01$, with high levels of ‘Dependent’ learning style associated with low level of ‘Mark’.

This result reveals that ‘Dependent’ students, who do not show intellectual curiosity, try to learn only what is required. Even though they are actively participating in class, it is not out of intellectual curiosity (lines 1465-1468 from Appendix D). As a result, they have lower marks than ‘Independent’ students who like to think for themselves and are confident in their learning. All lecturers agree that ‘Dependent’ students are weak in mathematics: “Because they are weak students, in high school, they were not very good
and consequently they don’t have enough skills or knowledge to work independently” (lines 1459-1460 from Appendix D). This is related to students’ self-confidence (lines 69-70, lines 634-635 from Appendix D). Another possible reason mentioned by lecturers is a wrong perception of self-assessment (lines 41-43 from Appendix D). This could possibly be a reason why most lecturers still retain the teacher-centered teaching style, even if they all expect students to be independent. Since the crucial element of the learner-centered approach is the shift in the learning process from the lecturer to the student (Liu, Qiao & Lie, 2006, p. 78), students with a more ‘Dependent’ learning style, who are characterised by low self-confidence and wrong self-assessment, could not freely participate in the learning process.

Grow develops ‘The staged self-directed learning model’ that described four stages in young adult growth towards a more independent approach toward learning independence (1991, p. 129). The model suggests that this process begins with, a Dependent’ stage (or stage 1) to a more ‘Self-directed’ stage (which is stage 4). Weimar also mentioned these stages (2002):

1. Students are dependent and need explicit instruction and coaching to move forward (Dependent).
2. Students are interested and begin to set goals for themselves. Lecturer enthusiasm is motivating to these students (Interested).
3. Students are involved and begin to see themselves as participating in their own learning process. They should be asked for progress reports to support their own goal-setting (Involved).
4. Students are self-directed. They can set their own goals and standards that they want to meet (Independent).

According to the quantitative and qualitative data, the lecturers and students in mathematics classes at university are in the first stage of this developmental model. It is advisable for university level mathematics classes to move towards a learner-centered teaching style, and to facilitate the process increasing the number of ‘Independent’
students. To achieve this student’ dedication and active attitude is critical, as many students emphasis this themselves.

4.5 Summary

The quantitative and qualitative analysis shed some light on the relationship between learning styles and teaching styles for a more balanced instructional approach. Mathematics classroom should be a learning environment, not teaching environment in terms of learners’ active and vigorous engagement and a lecturer’s role as a facilitator or a delegator. Another finding was that affective factors (belief, emotional factors and attitude) should be considered.
CHAPTER FIVE
SUMMARY, IMPLICATION, AND RECOMMENDATIONS

5.1 Summary

As discussed in chapters 1 and 2, there are many debates about the relationship between and the effects of learning styles and teaching styles. Regardless of the inconsistent results from two constructs, there are many benefits for being aware of learning and teaching styles. It may lead to the improvement of various areas of learning and teaching (Peacock, 2001, p. 4); provision for different views of learning and teaching (Abu-Asaba et al., 2014, p. 573); aid the learning process (Gokalp, 2013, p. 1636) or enhance lecturer training, development and assessment (Willingness, 1988 as cited in Abu-Asaba et al, 2014). An awareness of the value of learning and teaching style is very useful for a more balanced instruction (Felder, 1996, p. 8). Considering the diversity of students' backgrounds and abilities in South Africa, it is essential to know the learning styles of students and lecturers’ teaching styles at tertiary level.

This study purposefully identified the dominant learning styles of students and teaching styles of lecturers in mathematics class and provided different views of learning and teaching for a balanced instructional approach and for learning-conducive environment. For this purpose, an explanatory sequential mixed-methods approach was used to explore the following research questions.

1. What are the dominant learning styles and teaching styles exhibited in mathematics classes at an urban university in South Africa?
2. What are the suitable teaching styles that effectively address these learning styles?
3. What can be done to reach out to students whose learning styles are not addressed by the common instructional approaches in mathematics classes?
A mixed-methods approach is desirable when seeking a more ‘robust analysis’ than either qualitative or quantitative research alone is able to provide (Ivankova et al., 2006, p. 3). The sequential explanatory mixed-methods design called for an initially round of quantitative data collection, which was followed by a qualitative data collection.

In the first phase of data collection, three questionnaires were used to determine the prominent teaching and learning styles in the participants selected for this study; Grasha -Riechmann Student Learning Style Scales (GRSLSS), Felder - Silverman Index of Learning Style (ILS), and Grasha Teaching Style Inventory (GTSI). The survey was distributed to participants that included 21 professors or lecturers, and 578 university students (302 students completed ‘ILS’ and 276 students completed ‘RSLSS’). Descriptive statistics were analysed to address the research questions of the current study. Quantitative data were also used to select the participants for the qualitative phase, using a maximum variation sampling strategy, based on their responses to the survey questions.

Quantitative findings showed that the dominant learning styles of the university students were ‘Collaborative’ and ‘Participant’ in terms of interactive learning style (Grasha - Riechmann Student Learning Style Scales – GRSLSS was used). There was also a statistically significant difference between ‘Independency’ and ‘gender’. Among the four domains of the GRSLSS, the bipolar relationship of the ‘Participant – Avoidant’ pair is generally stronger than others (Lang et al., 1999). The 1st year students lean significantly more towards the ‘Participant’ learning style opposed to 3rd year students who have ‘Avoidant’ learning style. However, according to the discipline, students from the faculty of education preferred ‘Collaborative’ learning style. This gives an indication of how the characteristics of students differ according to the discipline of their study or area of specialisation.

As regards to ‘the flexibly stable learning style (Felder-Silverman Index of Learning Style)’, university students preferred ‘Sensing’, ‘Visual’ and ‘Sequential’ over ‘Intuitive’ ‘Verbal’ and ‘Global’. The preferred combinations of university students are ‘RSnVS
(Reflective, Sensing, Visual and Sequential)’ and ‘ASnVS (Active, Sensing, Visual, Sequential). In the domain of information processing’, Science students are found to be more reflective learners than Engineering or Education students. It is possible that Education students are required to be more active in classrooms and in field work projects. Also the nature of Education encourages students to apply new teaching methods and to use some educational activities with learners. These results are consistent with the findings of Alumran (2008).

From the two inventories of learning style, there is a gender difference. Male students tended to be independent and female students were inclined to depend on lecturers although the majority of lecturers didn’t agree with that result. In terms of perceiving and receiving information, female students favour ‘Sensing’ and ‘Verbal’ learning style and male students preferred ‘Intuitive’ and ‘Visual’ learning style.

With reference to the teaching style, the majority of professors or lecturers who were teaching mathematics had a teacher-centered teaching style (‘Expert’ & ‘Formal Authority’) rather than a learner-centered teaching style (‘Facilitator’ & ‘Delegator’). Out of five teaching styles (‘Expert’, ‘Formal Authority’, ‘Personal Model’, ‘Facilitator’ and ‘Delegator’), ‘Expert’ teaching style is the most frequent modality of high score, the second most is ‘Formal Authority’. It means most lecturers still use traditional, teacher-centered styles in university settings. The first five frequent items in the teaching style inventory that mathematics lecturers regarded as ‘Very important’ are all closer to the teacher-centered teaching style.

In the second phase of the study, qualitative data were collected by conducting open-ended face-to-face interviews. Qualitative data were utilised to complement quantitative data in the process of answering the major research questions of the current study. A grounded theory approach was adopted for the second phase, in which data collection and analysis are interrelated processes (Strauss & Corbin, 1990). The interviews were recorded, transcribed, and analysed by using open coding and axial coding.
With the analysis of qualitative data, there were five categories of the suitable teaching styles that effectively address these learning styles. The categories and the sub-categories follow:

- ‘Expertising’ – ‘how to share knowledge’ and ‘Clear guideline’
- ‘Motivating students’ learning’ – ‘Collaborative settings’ and ‘Embracing Sensing students’
- ‘Climate building’ – Adjustment to students’ understanding’ and ‘Active classroom environment’
- ‘Participating in the learning process’ – ‘Interactions’ and ‘Options and alternatives’
- ‘Flexibility for individual development’ – ‘Visual understanding of abstract information’ and ‘A self-directed learning’

As qualitative data showed many students who are studying mathematics had low self-efficacy. Self-efficacy has the potential to facilitate or hinder mathematics learner’s motivation, use of knowledge, and disposition to learn (Tait–McCutcheon, 2008). When students think they are incapable of achieving in mathematics, they have a negative attitude toward mathematics that results in high levels of failure and lack of interest in any course involving mathematics (Bramlett & Herron, 2009). It is critical to create an environment to encourage students to do the necessary activities that result in enhancing their achievement levels.

In the third phase, the quantitative and qualitative data were integrated. The university students favoured the ‘Dependent’ learning style according to quantitative data (Mean: ‘Independent’ learning style 3.39 and ‘Dependent’ learning style 3.96) and qualitative data (many students preferred directed instruction with materials provided by lecturers). Students expect more directed instruction with the material provided by lecturers. It may be said that the teacher-centered teaching style is more suitable at the moment.

Quantitative data showed that ‘Collaborative’ is one of the dominant learning styles of university students. And qualitative data proved that the collaborative setting of
mathematics classroom should be considered as the effectiveness of peer assistance was frequently cited by students and confirmed by lecturers. Various forms of peer, collaborative or cooperative learning have been used within university courses to assist students meet a variety of learning outcomes (Topping, 2005). Tutorial times were practically used for the collaborative learning.

Another dominant learning style of students is ‘Participant’, yet there is a discrepancy between students’ learning style and how they participate in mathematics class. All lecturers mentioned that students’ attitude is quite passive and there is little interaction between lecturers and students in mathematics classroom. Many studies state that students typically do not participate actively (Rudduck & McIntyre, 2007). However, their perceptions of instruction determine their learning behaviour (Entwistle, 1991) and it affects learning environments (Könings, Brand-Gruwel & van Merriënboer, 2005). To empower students with the ‘Participant’ learning style, there should be more opportunities to participate, such as small group discussion or group projects. Diverse lesson activities will help students to involve and be more active in the learning process.

All lecturers, not surprisingly, expect students to leave their course well prepared for further work and want them be studying independently. The direction should be for students to be more independent and responsible with a lot of self-directed learning experiences. Independent and self-directed learning is closely linked to the capacity for acquiring knowledge and skill that leads to desirable academic achievement (Zimmerman, 1990).

In terms of flexibly stable learning style, the majority of university students who are studying mathematics have ‘Sensing’ learning style. However, many studies show that intuitive students obtain higher marks than sensing students (e.g., Godleski, 1984 as cited in Felder & Silverman, 1988; Cook et al., 2009). It is possible because mathematics content does not include a lot of concrete information and students can hardly relate to everyday life. As many students struggle to understand lecturers' explanation of conceptual mathematical knowledge, lecturers should monitor whether
they grasp concepts and put an effort to explain in various ways. And also providing practical problem solving is necessary for embracing as many students as possible. Felder and Silverman stated that providing intervals in class is also necessary for ‘Sensing’ students to practice on their own and for ‘Intuitive’ students to reflect what they hear (1988).

Formal education engages in a logically ordered sequential progression from concept to concept. However, mathematical concepts and ideas comprise visual relationships that are intuitively connected. The use of them is greatly beneficial to present and manipulate mathematical concepts if students are capable of relating visual image of abstract information in an intuitive way (De Guzm’an, 2002). To lead students to the level where they can make out what they are doing beyond the sequential comprehension (visual understanding of abstract information), many new attempts would be constructive; presenting problems before offering explanations, deep consideration of the connections between concepts, or contextualised and relevance-tied up concepts.

In conclusion, to facilitate a more balanced instructional approach, mathematics classroom should be a learning-conducive environment, not teaching environment. Learners need to vigorously engage in the learning process which leads to active and effective teaching (Mischel, 1993) and lecturers as facilitators should also learn from self-reflection (De Bem 2013).

5.2 Conclusions

5.2.1 Empowering Learners

According to Gates and Vistro-Yu, mathematics “acts as a ‘gatekeeper’ to social progress” (2003, p. 32). It is because mathematics can firstly be a powerful tool to
explore, conjecture and secondly a way to understand real-world problems across cultures, genders and other boundaries by connecting mathematical ideas with ideas from other disciplines in the same or related contexts.

To gain mathematical power learners are required to explore conjecturer, discern relations, reason logically, and use a broad spectrum of mathematical methods to solve a wide variety of non-routine problems. ‘Routine’ problem solving does not contribute to learners’ mental development (Polya, 1973). Being involved in ‘Non-routine’ problem solving might develop learners’ higher order of understanding, analysis and discovery (Özgen & Alkan, 2012, p. 1175). It means “undergird mathematical power includes not only some traditional paper-pencil skills, but also many broader and more powerful capabilities” (Leder, 1992, p. 82).

In terms of undergraduate mathematics education, there is a shift toward a more learner-centered approach to mathematically empower students (Brandt et al., 2012). When learning new mathematics, learners engage in “exploring mathematical problems, proposing and testing conjectures, developing proofs or solutions, and explaining their ideas” (Laursen et al., 2011, p. 73). To be successful in their mathematical engagement, learners should perceive the importance of what they learn and continually check and update their understanding based on new knowledge. In a sense, learners should make a productive contribution to lead effective and efficient teaching as active participants.

Cuoco, Goldenberg, and Mark suggest that certain principles of mathematics curricula should be organised through a variety of tasks that confirms learners’ habits of mind to that of mathematicians (1996). In other words, learners should learn mathematics by engaging in activities similar to the activities mathematicians do: searching for patterns, experimenting, communicating, exploring ideas, inventing notation, visualizing relationships, and making conjectures. In this process, learners will be mathematically proficient and empowered with conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (NRC, 2001).
There are three ways to foster activities in a mathematics class and to encourage learners to do mathematics. Firstly, mathematical tasks should be authentic and meaningful. This is more likely to motivate students (Hiebert et al., 1997). Students with ‘Sensing’ learning style prefer ‘what is real’ and tend to deal with real, tangible things (facts, data, and experimentation). As a result, ‘Sensing’ students are less favorable to study mathematics than ‘Intuitive’ students. They might learn better using a case-based approach (opportunity for vicarious experimentation). Bostrum, Olfman, and Sein confirmed a predicted interaction between ‘Sensing/Intuitive’ learning styles and case-based versus non-case-based instructional methods (1990).

Although connecting mathematics to the real-world applications is emphasised (Abate & Cantone, 2005; Chang, 2011; Matthews, Adams & Goos, 2009; Pennell, Avitabile & White, 2009), a majority of students have difficulties in making mathematics relevant. This could be a reason for failure in mathematics (Chang, 2011). Using authentic and real-world examples is considered essential to empower learners mathematically. For example, room temperature and humidity can be used in calculus course (Niu & Shing, 2010). Or real-time data from an experimental pendulum can be utilised in mathematical modeling course (Reid & King, 2009).

Secondly, group-based tasks are advisable, especially for students with ‘Collaborative’ and ‘Participant’ learning styles. Research shows that collaboration between students can enhance learning (Lou et al. 2001; Slavin 1995; van der Linden, Erkens, Schmidt & Renshaw, 2000). Compared to learners in independent and competitive settings, learners who participate in small group activities achieve higher grades. They learn at a deeper level, retain information longer, acquire greater communication and teamwork skills, and gain a better understanding of the environment in which they will be working as professionals. As a result, they are less likely to drop out of school (Felder, & Elhajj, 2004). Those who are exposed to collaborative learning tend to be more concerned with identifying the central point of an argument, getting points that remain unclear and questioning conclusions (Gregory & Thorley, 2013). Peer interaction is important in logical-mathematical thought in disequilibrating the learners’ conceptualizations (Slavin,
Elçi, Bukova-Güzel, and Alkan (2006 as cited in Özgen & Alkan) state that mathematical activities based on a constructivist learning styles and learning approaches would provide learners with significant advantages in constructing concepts.

Thirdly, open-ended problems and exercises that call for analysis and synthesis are imperative to develop a global (holistic) way of thinking. Most university students are ‘Sensing’, ‘Visual’ and ‘Sequential’ learners which are not comfortable with more abstract and conceptual-oriented problems. Experts in any academic field values concrete aspects when handling the corresponding abstract objects. They are able to perceive and manipulate concepts and methods through a visual image in a more analytical and logical way. (De Guzmán, 2002). In mathematics, this capability is called ‘visualisation’ which is defined as “the ability to mentally manipulate, rotate, or twist, or invert a pictorially presented stimulus object” (McGee, 1979 as cited in Phillips, Norris, & Macnab, 2010).


Visual understanding of abstract information (visualisation) is very important not only in mathematics but also in other subject because it enhances better understanding and manipulating the common structures of many real things (De Guzman, 2002). Unfortunately, however, the practice of procedures and formulas (normal school instruction) in mathematics leads to habituation, which takes a learner away from the visual method. Non-visual methods teaching focuses on orderly logical progression of information that does not include visual examples (Presmeg, 1986, pp. 306-307). Habre (1999) also mentions habituation in a discussion about a university calculus class.
Even though lecturers emphasised on visualisation, most students preferred the analytical approach, because of traditional schools of mathematical instruction.

Contextualising mathematics has been reported frequently to enhance students’ experience (Abate & Cantone, 2005; Chang, 2011; Matthews et al., 2009; Reid & King, 2009) and develop ‘Global’ learning style. The most successful mathematics courses are well integrated in the engineering curriculum facilitating contextual relevance of mathematical abstracts to engineering concepts (Henderson & Broadbridge, 2007). For instance, in an engineering subject that is mathematically intensive, remote experiments have been used in the classroom to visualise and show the applicability of the differential equations used in implementing control algorithms (Abdulwahed & Nagy, 2011). Another example is a mathematics course which utilises image processing examples from computer science to contextualise abstract ideas from linear algebra (Chang, 2011). It might be ideal for mathematics instructors to collaborate with personnel from science and engineering domains to design contextualized mathematical courses (Matthews et al., 2009).

5.2.2 Balanced Learning and Teaching Mathematics

Mathematics can and should play an important role in the education of undergraduate students. In fact, few educators would dispute that students who can think mathematically and reason through problems are better able to face the challenges of careers in other disciplines – including those in non-scientific areas. Add to these skills the appropriate use of technology, the ability to model complex situations, and an understanding and appreciation of the specific mathematics appropriate to their chosen fields, and students are then equipped with powerful tools for the future. (Ganter & Barker, 2004, p. 1)
To adequately prepare learners for further studies and become mathematically trained workers, mathematicians and mathematics educators have the responsibility to create a balanced course and curricula while maintaining the intellectual integrity of mathematics. Different educators hold different views of the type of balance in a mathematics class. Some regard it a response to a political, rather than a pedagogical problem (Mokros & Russell, 2000). Others say there should be a balancing of different philosophies of learning, for example problem solving, communicating, connecting, and reasoning. In terms of undergraduate mathematics, many researches developed a number of explanatory frames regarding balanced learning and teaching mathematics: this includes procedural versus conceptual understanding (Hiebert, 1986); process versus object conceptions (Breidenbach, Dubinsky, Hawkes & Nichols, 1992); concrete versus abstract modes of reasoning (Wilensky, 1991); instrumental versus relational understanding (Skemp, 1976); synthetic versus analytic thinking (Sierpinska, 2000); and operational versus structural reasoning (Sfard, 1991).

Learning styles of most students and teaching styles of most lecturers are mostly incompatible. For instance most students perceive information in a realistic and practical approach (‘Sensing’), whereas mathematics instructors prefer working with mathematical symbols at an abstract level (‘Intuitive’). Montgomery (1995) also mentions that traditionally used lecture method is incompatible with most of learners’ learning style (‘Active’, ‘Sensing’, ‘Visual’, and ‘Sequential’). The fact that college-age students in schools grew up with television, movies, video, and video-games exacerbates the situation. To require these college-age learners to only sit and listen to the lecturers is like teaching the blind with pictures and teaching the deaf with the spoken words. Her analysis of learning styles versus lectures reveals that in all categories but ‘Sequential’, the learning styles of students favour teaching formats other than the lectures which are given.

In South African context, college-age learners prefer team-work, structure, interactivity and image-rich environments because they grow up in an IT and media-rich environment. They are more visual learning style; have a desire for customised
experiences and choices; have low thresholds for boredom and an unwillingness to memorise text; prefer multi-tasking; and prefer active learning (even better when it is peer learning) (Wessels & Steenkamp, 2009). Dreyer (1998) shows there is style disparities between teachers and students. The majority of teachers were intuitive and introverted, preferring abstract ideas and independent work. In contrast, the students tended to be concrete-sequential and extraverted, and prefer large amounts of linear structure and abundant classroom interaction.

Schroeder acknowledges that accommodating learning styles could improve the teaching-learning process and balanced curricula in higher education (1993). For balanced learning and teaching mathematics, it is important to understand learners’ way of taking in and processing new knowledge and how they attempt to solve mathematical problems (learning style). It may serve to assist lecturers in implementing instructional interventions designed to help students develop mathematical thinking and reasoning and organising mathematical tasks to build upon learners’ mental dexterity. In order to bring about actual reform in undergraduate mathematics, not only should revisions of the mathematical content but also how lecturers view the nature of mathematics and the effectiveness of their teaching, which are closely linked to teaching style, be considered (Soto, 2010).

According to Felder (1996), the main objective of education is to help learners build their skills in both their preferred and less preferred modes of learning. Learning style models with four categories will provide good frameworks for designing instruction with ‘teaching around the cycle’. He suggests the following teaching methods to address all learning styles (1988).

- ‘Sensing/Intuitive’ learning style: (1) provide a balance of concrete information (facts, data, real or hypothetical experiments and their results) (sensing) and abstract concepts (principles, theories, mathematical models) (intuitive); (2) provide explicit illustrations of intuitive patterns (logical inference, pattern recognition, generalization) and sensing patterns (observation of surroundings, empirical
experimentation, attention to detail); and (3) follow the scientific method in presenting theoretical and conceptual material (intuitive) along with concrete examples of the phenomena the theory describes or predicts (sensing).

- ‘Active/Reflective’ learning style: (1) balance material that emphasises practical problem-solving methods (active) with material that emphasises fundamental understanding (reflective); (2) during class, small-group brainstorming activities that take no more than five minutes are extremely effective for this purpose (active) and brief intervals for students to think about what they have been told (reflective); and (3) give students the option of cooperating on homework assignments to the greatest possible extent (active).

- ‘Visual/Verbal’ learning style: Use pictures, schematics, graphs, and simple sketches liberally before, during, and after the presentation of verbal material (visual).

- ‘Sequential/Global’ learning style: (1) assign some drill exercises to provide practice in the basic methods being taught (sequential) and provide some open-ended problems and exercises that call for analysis and synthesis (global); (2) develop the theory or formulate the model (sequential) and show how the theory can be validated and deduce its consequences with present applications (sequential); and (3) as much as possible, relate the material being presented to what has come before and what is still to come in the same course, to material in other courses, and particularly to the students’ personal experience (global).

In many cases, ‘Reflective’, ‘Intuitive’ and ‘Global’ learning styles are correlated with one another (Franzoni-Velázquez et al., 2012). To implement these teaching methods, it is important to consider affective factors. Philipp (2007) provides an overview of research involving beliefs of preservice and inservice K-12 teachers: (1) beliefs are fairly stable and resistant to change. Beliefs act as a filter for what they see, making change difficult without observation and reflection on practice; (2) lecturers’ beliefs regarding
mathematics and mathematics teaching associate with instructional practice. If a lecturer has calculation-oriented belief, his or her classroom practice will tend to focus on developing procedural skills. On the other hand, there are apparent inconsistencies between a lecturer’s stated beliefs and their actual classroom practice. Thompson also confirms a lecturer’s beliefs affect the way that his or her practices the teaching of materials and concepts related to those beliefs (Thompson, 1992). Whether there is a consistency or not, this stable and resistant belief of lecturer affect instructional strategy.

Talley asserts the impact of instructional strategies in undergraduate mathematics (2012). Particularly at college level, learners should have a foundation of prior knowledge to navigate through mathematics requirements and specialized courses in their respective fields of study. However, ill-prepared students who lack sufficient prerequisite skills flooded post secondary classrooms, especially in South Africa. Professors and lecturers should attend to course objectives designed to build upon the much needed prerequisite courses such as algebra, trigonometry, and geometry. The insights with respect to lecturers’ belief should be carefully considered as developing balanced learning and teaching mathematics at university.

Lecturers’ beliefs are not only factors to enhance the whole learning and teaching approach. The impact of learners’ beliefs are related to their perceptions and attitude along with lecturers’ beliefs. (Stipek, Givvin, Salmon & MacGyvers, 2001). Learners’ beliefs add another dimension to the whole process of teaching and learning of mathematics (Beswick, 2002). Among undergraduate learners, their mathematical beliefs are interconnected to their academic achievement (Suthar et al., 2014) together with self-efficacy (Bandura, 1986; Matthews, 1999), self-evaluation (Flett, Hewitt, Blanckstein & Gray, 1998), self-motivation (Zeidner, 1995), self-esteem, and self-confidence (Koivula, Hassmen & Fallby, 2002).

It is important for lecturers to know how their learners feel, think, and act, about, within, and toward mathematics. It will provide ideas for balanced instruction and curricula
followed by learners’ active participation in the learning process of mathematics (Yates, 2002, p. 4).

In doing mathematics learners need to play an important role as not only a microscopic constructor of knowledge but also social implementing builder. They have to actively participate. Ideally one of dominant learning styles of university student is ‘Participant’. In line with that, there will be the following benefits if mathematicians and mathematics educators enhance ‘Participant’ learning style: firstly learners’ active participation will ultimately improve the quality of learning processes. Secondly, it will develop meta-cognition and reflection on learning through gaining a deeper understanding and awareness of learning (Bovill & Bulley, 2011). The more learners engage, the higher will their levels of individual responsibility, self-motivation and self-confident be (Bovill, 2013). Thirdly, learners will learn how to discuss, how to deal with discomfort and conflicting ideas, and to revise their sense of self (Cohen, Cook-Sather, Lesnick, Alter, & Decius, 2013).

Individual learners “differentially and selectively attend to and process learning materials based on their prior knowledge, understanding, values, attitudes, styles and resultant motivation” (Renzulli & Dai, 2001, p. 23). The goal of empowering learners will be accomplished when instructors focus more on the balanced instruction by considering how their learners learn and encouraging them to actively apply mathematical knowledge to non-routine situations and problems. (Renzulli & Dai, 2001).

5.3 Implications

Depending upon student expectations and whether the curricular structure is rigid or flexible, an instructional approach can be chosen in order to provide an opportunity for learners to develop multidisciplinary skills. Learning and teaching in a constructivist class is so personal and subjective that it cannot be confined within a structure of a
framework (Belbase, 2011, p. 21). Certain learning environments can be creative and constructive for one learner whereas for another student it can be disturbing, for example participation in group activities.

The research on learning and teaching style from constructivist perspective focuses on application to either different categories of learners or the learning of different categories of material. This provides mathematicians and mathematics educators with insights into individual differences in learning and performance (Fowler, Armarego & Allen, 2001, p. 3). The challenge is to identify effective and efficient strategies or to modify the learner’s approaches to learning (McLoughlin, 1999), while having a controversy around match or mismatch.

The results of this study, which is related to learning and teaching styles, can be interpreted in various ways depending not only to which side of the match or mismatch proponents one belongs but also on the perspective of balanced teaching. The quantitative and qualitative data revealed that there are some definite forms of preferred methods of learning and teaching, but these can be contingent. In other words, the results of identifying individual learning and teaching style were doubtful in terms of what they produced (Coffield et al., 2004). Hence, it would be appropriate for the mathematics lecturers to take into consideration what this present study suggests:

- Teaching styles of lecturers and learning styles of learners are not fixed but rather processing states. Since they are to change over a period of time, teaching styles and learning styles are affected by their affective factors, the nature of subject or topics, and their studying methods and educational philosophy.

- If lecturers use specific methods and aids in certain mathematics classes respectively — such as the incessant lecturing, the considerable use of visual representations, small group discussions, and group project — it could have a great bearing on how students view what they prefer.
- Weaker learners tend to be more dependent learners, while the more able learners are more independent. The student’s state of self-confidence could be masking as a learning style, yet in reality there is huge disparity of their own self-esteem.

Kilic argues that learning styles form the basis of learner-centered learning and teaching (2010, p. 80). In a learner-centered approach, lecturers and learners are perceived in a different way. Lecturers are not merely information-deliverers, but also architects of educational experiences. The lecturers’ role is to select mathematical tasks and manage classroom dynamics, and shape discussions as a “guide on the side” instead of a “sage on the stage” (King, 1993). Lecturers are recommended to focus on satisfying individual differences as much as possible while discussing with students as to what they think works for them, instead of trying to cater for their learning styles. They can also use a combination of common sense, observation data or academic performance results. In doing so lecturers could work together with other lecturers and researchers to get a hold of useful information to construct an instrument for a learner’s learning-related preferences. At the same time learners need to actively engage with learning process, because their individual learning needs should be addressed. In this regard, it can be beneficial to recognise the various learning and teaching styles.

Many learners come to university unprepared and somehow with emotional scars that cause students to ineffectively study mathematics. As the quantitative data showed many student at university were firstly weak in mathematics and had low self-confidence. For this reason, considering the affective domain was necessary. Teaching through the affective domain might require considerable commitment and personal training from the lecturers; otherwise, it might hamper the learners’ mathematical growth.

To facilitate the proficient mathematics classroom, lecturers should help students become self-directed and independent learners through providing active interactions, valuing of each student’s contributions and encouraging them to set high achievable
standards. Furthermore, this environment cannot exist within the conventional mechanism which is controlled totally by the instructors. There is the need to endorse students to be independent: ‘to work increasingly with less structured teaching materials and with less reliance on lecturers (Moore, 1984). Students need to be empowered to question and to know the function and importance of their own learning.

5.4 Recommendations for further study

There is a controversy surrounding research on learning style and teaching style. The literature showed the divided opinions on the issue of compatibility of teaching and learning style (Cassidy, 2004; Denzine, 2005). For instance, some researchers asserted that matching the lecturer’s learning style with the students’ learning will enable students to perform higher academic records (e.g., Borg & Stranahan, 2002; Charkins et al., 1985; Clark & Latshaw, 2012). On the other hand, others argue that there is no significant relationship resulting from matching of teaching and learning style (e.g., Campbell, 1989; Coffield et al., 2004b; Tucker et al., 2003).

It has seemingly become more and more difficult to establish credibility of research results pertaining to the two subjects. However there is a need for a unified credible theory. Firstly, it is for lecturers or instructors to take into account different ways of teaching, which can improve the mental dexterity that learners need to reach their potential. Secondly, it is for facilitating maximum learning for as many students as possible. It will lead a balanced instruction to meet the learning needs of all students in a mathematics class.

What follows are suggestions for further study in these areas.
There is more range for collaborative scale research as to the real nature of learning and teaching style in mathematics classroom, and how to effectively and efficiently measure it.

How do mathematics lecturers link and corporate their instructional approach to students’ learning style preferences?

Could it be possible to engage in teaching-learning experiences which counterbalance lecturers and students in a mathematics class of up to 50 students?

To what extent are students involved in the planning and delivery of teaching learning experiences for enhancing active learning? Would this be a practice of mathematics lecturers only or is this universal among lecturers?

Focusing on ‘Sequential to Global’ way of understanding, to what extent are students to be given the freedom to devise their own methods of solving problems? How much would they be improved in terms of the ‘visualisation of abstract information’?
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Miller, B. (2010). *Brookfield’s four lenses: Becoming a critically reflective lecturer.* The University of Sydney: Art Teaching and Learning Network.


Appendix A:

Grasha -Riechmann Student Learning Style Scales (GRSLSS)

About yourself

- Student number
- Gender
- Campus
- Faculty
- The year of study
- Race

I would like to thank you for sparing your time to answer this questionnaire. This questionnaire is to determine your learning preferences and is not a test. Therefore, there is no right or wrong answers. There are only answers that are true for you. What you see in front of you is a questionnaire designed to extract information on how to help students become better and more successful learners. The results will also help the school and your teachers to better understand how to assist you in learning mathematics.

There are 60 questions in total and each question requires only one tick in one of the four empty boxes. Please choose only one answer for each question and answer each question as honestly as possible. Otherwise, I won’t be able to use your questionnaire as part of my research. Thanks again.

PhD. at the University of Johannesburg,
Sarah Coetsee
Use the following rating scale when responding to each question.

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1. I prefer to work by myself on assignments in my mathematics modules.
2. I often daydream during mathematics classes.
3. Working with other students on mathematics class activities is something I enjoy doing.
4. I like it whenever lecturers clearly state what is required and expected in mathematics classes.
5. To do well in mathematics classes, it is necessary to compete with others students for the lecturer’s attention.
6. I do whatever is asked of me to learn the content in my mathematics classes.
7. My ideas about the mathematical content often are as good as those in the textbook.
8. Mathematics class activities are usually boring.
9. I enjoy discussing my ideas about mathematics course content with other students.
10. I rely on my lecturer to tell me what is important for me to learn.
11. It is necessary to compete with other students to get a good mark.
12. Mathematics class sessions typically are worth attending.
13. I study what is important to me and not always what the lecturer says is important in mathematics class.
14. I very seldom am excited about material covered in a mathematic course.
15. I enjoy hearing what other students think about issues raised in mathematics class.
16. I only do what I am absolutely required to do in my mathematics courses.
17. In a small group discussion, I must compete with other students to get my ideas across.
18. I get more out of going to class than staying at home.
19. I learn a lot of the content in my classes on my own.
Use the following rating scale when responding to each question.

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<th>Strongly Disagree</th>
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20 I don’t want to attend mathematics classes even though I am expecting to.

21 Students should be encouraged to share more of their mathematical ideas with each other.

22 I complete mathematics assignments exactly the way my lecturers tell me to do them.

23 Students have to be more active even aggressive to do well in mathematics courses.

24 It is my responsibility to get as much as I can out of a mathematics course.

25 I feel very confident about my ability to learn on my own in mathematics class.

26 Paying attention during mathematics class sessions is difficult for me to do.

27 I like to study for mathematics tests with other students.

28 I do not like making choices about what to study or how to do assignments regarding mathematics course.

29 I like to solve problems or answer questions before anybody else can in a mathematics class.

30 Mathematics classroom activities are interesting.

31 I like to develop my own ideas about mathematics course content.

32 I have given up trying to learn anything from attending mathematics classes.

33 Mathematics class sessions make me feel like part of a team where people help each other learn.

34 Students should be more closely supervised by lecturers on mathematics course projects.

35 To get ahead in mathematics class, it is necessary to step on the toes of other students.

36 I try to participate as much as I can in all aspects of a mathematics course.
Use the following rating scale when responding to each question.

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<th>Strongly Disagree</th>
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<td>37</td>
<td>I have my own ideas about how mathematics classes should be run.</td>
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<td>38</td>
<td>I study mathematics just hard enough to get by.</td>
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<td>39</td>
<td>An important part of taking mathematics courses is learning to</td>
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<td></td>
<td>get along with other people.</td>
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<td>40</td>
<td>I write down everything the lecturer said in mathematics</td>
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<td>Being one of the best students in my mathematics classes is</td>
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<td>very important to me.</td>
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<td>42</td>
<td>I do all mathematics courses assignments well whether or not I</td>
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<td>think they are interesting.</td>
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<td>If I like a mathematical topic, I try to find out more about it</td>
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<td>on my own.</td>
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<td>I typically cram for exams.</td>
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<td>45</td>
<td>Learning the mathematical material was a cooperative effort</td>
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<td></td>
<td>between students and lecturers.</td>
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<td>I prefer mathematics class sessions that are highly organised.</td>
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<td>To stand out in my mathematics classes, I complete assignments</td>
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<td>I typically complete mathematics course assignments before</td>
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<td>I like mathematics classes where I can work at my own pace.</td>
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<td>I would prefer that lecturers ignore me in mathematics class.</td>
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<td>51</td>
<td>I am willing to help other students out when they do not</td>
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<td>understand something about mathematics.</td>
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<td>Students should be told exactly what material is to be covered</td>
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<td>I like to know how well other students are doing on exams and</td>
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<td>I complete required mathematics assignments as well as those</td>
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<td>When I don’t understand something about mathematics content,</td>
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<td>I first try to figure it out for myself.</td>
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Use the following rating scale when responding to each question.

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<th>56 During mathematics class sessions, I tend to socialize with people sitting next to me.</th>
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<td>57 I enjoy participating in small group activities during mathematics class.</td>
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<td>58 I like it when lecturers are well organised for a mathematics session.</td>
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<td>59 I want my lecturers to give me more recognition for the good work I do.</td>
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<td>60 In my mathematics classes, I often sit toward the front of the room.</td>
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Appendix B:

Felder - Silverman Index of Learning Style (ILS)

About yourself

- Student number: ______________________________
- Gender: □ Male □ Female
- Campus: □ APK □ SWC
- Faculty: □ Engineering & Built Environment □ Science
  □ Education □ Others (__________)
- The year of study: □ 1st □ 2nd □ 3rd □ 4th
- Race: □ Black □ White □ Others (__________)

I would like to thank you for sparing your time to answer this questionnaire. This questionnaire is to determine your learning preferences and is not a test. Therefore, there is no right or wrong answers. There are only answers that are true for you. What you see in front of you is a questionnaire designed to extract information on how to help students become better and more successful learners. The results will also help the school and your teachers to better understand how to assist you in learning mathematics.

There are 60 questions in total and each question requires only one tick in one of the four empty boxes. Please choose only one answer for each question and answer each question as honestly as possible. Otherwise, I won’t be able to use your questionnaire as part of my research. Thanks again.

PhD. at the University of Johannesburg,
Sarah Coetsee
<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Option (a)</th>
<th>Option (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I understand something better after</td>
<td>(a) try it out.</td>
<td></td>
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<td></td>
<td></td>
<td>(b) think it through.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>I would rather be considered</td>
<td>(a) realistic.</td>
<td></td>
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<td></td>
<td></td>
<td>(b) innovative.</td>
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<tr>
<td>3</td>
<td>When I think about what I did yesterday, I am most likely to get</td>
<td>(a) a picture.</td>
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<td></td>
<td></td>
<td>(b) words.</td>
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</tr>
<tr>
<td>4</td>
<td>I tend to</td>
<td>(a) understand details of a subject but may be fuzzy about its overall structure.</td>
<td></td>
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<td></td>
<td></td>
<td>(b) understand the overall structure but may be fuzzy about details.</td>
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</tr>
<tr>
<td>5</td>
<td>When I am learning something new, it helps me to</td>
<td>(a) talk about it.</td>
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<td></td>
<td></td>
<td>(b) think about it.</td>
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<tr>
<td>6</td>
<td>If I were a teacher, I would rather teach a course</td>
<td>(a) that deals with facts and real life situations.</td>
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<td></td>
<td></td>
<td>(b) that deals with ideas and theories.</td>
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<td>7</td>
<td>I prefer to get new information in</td>
<td>(a) pictures, diagrams, graphs, or maps.</td>
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<td></td>
<td></td>
<td>(b) written directions or verbal information.</td>
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<td>8</td>
<td>Once I understand</td>
<td>(a) all the parts, I understand the whole thing.</td>
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<td></td>
<td></td>
<td>(b) the whole thing, I see how the parts fit.</td>
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</tr>
<tr>
<td>9</td>
<td>In a study group working on difficult material, I am more likely to</td>
<td>(a) jump in and contribute ideas.</td>
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<td></td>
<td></td>
<td>(b) sit back and listen.</td>
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</tr>
<tr>
<td>10</td>
<td>I find it easier</td>
<td>(a) to learn facts.</td>
<td></td>
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<td></td>
<td></td>
<td>(b) to learn concepts.</td>
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</tr>
<tr>
<td>11</td>
<td>In a book with lots of pictures and charts, I am likely to</td>
<td>(a) look over the pictures and charts carefully.</td>
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<tr>
<td></td>
<td></td>
<td>(b) focus on the written text.</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>When I solve math problems</td>
<td>(a) I usually work my way to the solutions one step at a time.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(b) I often just see the solutions but then have to struggle to figure out the steps to get to them.</td>
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<tr>
<td>No.</td>
<td>Description</td>
<td>Option (a)</td>
<td>Option (b)</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>13</td>
<td>In classes I have taken</td>
<td>(a) I have usually gotten to know many of the students.</td>
<td>(b) I have rarely gotten to know many of the students.</td>
</tr>
<tr>
<td>14</td>
<td>In reading nonfiction, I prefer</td>
<td>(a) something that teaches me new facts or tells me how to do something.</td>
<td>(b) something that gives me new ideas to think about.</td>
</tr>
<tr>
<td>15</td>
<td>I like teachers</td>
<td>(a) who put a lot of diagrams on the board.</td>
<td>(b) who spend a lot of time explaining.</td>
</tr>
<tr>
<td>16</td>
<td>When I’m analysing a story or a novel</td>
<td>(a) I think of the incidents and try to put them together to figure out the themes.</td>
<td>(b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.</td>
</tr>
<tr>
<td>17</td>
<td>When I start a homework problem, I am more likely to</td>
<td>(a) start working on the solution immediately.</td>
<td>(b) try to fully understand the problem first.</td>
</tr>
<tr>
<td>18</td>
<td>I prefer the idea of</td>
<td>(a) certainty.</td>
<td>(b) theory.</td>
</tr>
<tr>
<td>19</td>
<td>I remember best</td>
<td>(a) what I see.</td>
<td>(b) what I hear</td>
</tr>
<tr>
<td>20</td>
<td>It is more important to me that an instructor</td>
<td>(a) lay out the material in clear sequential steps.</td>
<td>(b) give me an overall picture and relate the material to other subjects.</td>
</tr>
<tr>
<td>21</td>
<td>I prefer to study</td>
<td>(a) in a study group.</td>
<td>(b) alone.</td>
</tr>
<tr>
<td>22</td>
<td>I am more likely to be considered</td>
<td>(a) careful about the details of my work.</td>
<td>(b) creative about how to do my work.</td>
</tr>
<tr>
<td>23</td>
<td>When I get directions to a new place, I prefer</td>
<td>(a) a map.</td>
<td>(b) written instructions.</td>
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</tr>
<tr>
<td>24</td>
<td>I learn at a fairly regular pace. If I study hard, I'll &quot;get it.&quot;</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>in fits and starts. I'll be totally confused and then suddenly it all &quot;clicks.&quot;</td>
</tr>
<tr>
<td>25</td>
<td>I would rather first try things out.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>think about how I'm going to do it.</td>
</tr>
<tr>
<td>26</td>
<td>When I am reading for enjoyment, I clearly say what they mean.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>like writers to say things in creative, interesting ways.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>When I see a diagram or sketch in the picture.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>class, I am most likely to remember what the instructor said about it.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>When considering a body of focus on details and miss the big picture.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>information, I am more likely to try to understand the big picture before getting into the details.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>I more easily remember something I have done.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>something I have thought a lot about.</td>
</tr>
<tr>
<td>30</td>
<td>When I have to perform a task, I master one way of doing it.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>prefer to come up with new ways of doing it.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>When someone is showing me data, charts or graphs.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>I prefer text summarizing the results.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>When writing a paper, I am more work on (think about or write) the beginning of the paper and progress forward.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>likely to work on (think about or write) different parts of the paper and then order them.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>When I have to work on a group have &quot;group brainstorming&quot; where project, I first want to everyone contributes ideas.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>brainstorm individually and then come together as a group to compare ideas.</td>
<td>(b)</td>
</tr>
<tr>
<td>34</td>
<td>I consider it higher praise to call sensible.</td>
<td>(a)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>someone imaginative.</td>
<td>(b)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When I meet people at a party, I am more likely to remember</td>
<td>(a)</td>
<td>what they looked like.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>what they said about themselves.</td>
</tr>
<tr>
<td>36</td>
<td>When I am learning a new subject, I prefer to</td>
<td>(a)</td>
<td>stay focused on that subject, learning as much about it as I can.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>try to make connections between that subject and related subjects.</td>
</tr>
<tr>
<td>37</td>
<td>I am more likely to be considered</td>
<td>(a)</td>
<td>outgoing.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>reserved.</td>
</tr>
<tr>
<td>38</td>
<td>I prefer courses that emphasise</td>
<td>(a)</td>
<td>concrete material (facts, data).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>abstract material (concepts, theories).</td>
</tr>
<tr>
<td>39</td>
<td>For entertainment, I would rather</td>
<td>(a)</td>
<td>watch television.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>read a book.</td>
</tr>
<tr>
<td>40</td>
<td>Some teachers start their lectures with an outline of what they will cover. Such outlines are</td>
<td>(a)</td>
<td>somewhat helpful to me.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>very helpful to me.</td>
</tr>
<tr>
<td>41</td>
<td>The idea of doing homework in groups, with one grade for the entire group,</td>
<td>(a)</td>
<td>appeals to me.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>does not appeal to me.</td>
</tr>
<tr>
<td>42</td>
<td>When I am doing long calculations,</td>
<td>(a)</td>
<td>I tend to repeat all my steps and check my work carefully.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>I find checking my work tiresome and have to force myself to do it.</td>
</tr>
<tr>
<td>43</td>
<td>I tend to picture places I have been</td>
<td>(a)</td>
<td>easily and fairly accurately.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>with difficulty and without much detail.</td>
</tr>
<tr>
<td>44</td>
<td>When solving problems in a group, I would be more likely to</td>
<td>(a)</td>
<td>think of the steps in the solution process.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(b)</td>
<td>think of possible consequences or applications of the solution in a wide range of areas.</td>
</tr>
</tbody>
</table>
Appendix C:

Grasha Teaching Style Inventory (GTSI)

I would like to thank you for sparing your time to answer this questionnaire. This questionnaire is to determine your teaching preferences. As you know very well, there is no right or wrong answers, only true answers for you.

There are 40 questions in total and each question requires only one tick in one of the five empty boxes. Please try to answer each question as honestly & objectively as possible. Resist the temptation to respond as you believe you “Should or ought to think or behave” or in terms of what you believe is the “expected or proper thing to do.”

The results will be given to you via email and it will also help you to better understand yourself in teaching mathematics.

Sarah Coetsee, 2014
PhD. at the University of Johannesburg,
Use the following rating scale when responding to each question.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Somewhat Disagree</td>
<td>Neither Disagree or Agree</td>
<td>Somewhat Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

**Very Unimportant**

**Aspect of My Approach to Teaching Mathematics**

1. Facts, concepts, and principles are the most important things that students acquire.
2. I set high standards for students in my mathematics class.
3. What I say and do models appropriate ways for students to think about issues in the content.
4. My teaching goals and methods address a variety of student learning styles.
5. Students typically work on mathematics projects alone with little supervision from me.
6. Sharing my knowledge and expertise with students is very important to me.
7. I give students negative feedback when their performance is unsatisfactory.
8. Students are encouraged to emulate the example I provide.
9. I spend time consulting with students on how to improve their work on individual and/or group projects.
10. Activities in mathematics class encourage students to develop their own ideas about content issues.
11. What I have to say about a mathematics topic is important for students to acquire a broader perspective on the issues in that area.
12. Students would describe my standards and expectations as somewhat strict and rigid.
13. I typically show students how and what to do in order to master the mathematics lessons content.
14. Small group discussions are employed to help students develop their ability to think critically.
Use the following rating scale when responding to each question.

1 2 3 4 5

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Somewhat Disagree</th>
<th>Neither Disagree or Agree</th>
<th>Somewhat Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
</table>

**Very Unimportant**

**Aspect of My Approach to Teaching Mathematics**

**Very Important**

**Aspect of My Approach to Teaching Mathematics**

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Students design one or more self-directed learning experiences.</td>
<td></td>
<td></td>
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<tr>
<td>16</td>
<td>I want students to leave this course well prepared for further work in this subject area.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>17</td>
<td>It is my responsibility to define what students must learn and how they should learn it.</td>
<td></td>
<td></td>
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<tr>
<td>18</td>
<td>Examples from my personal experiences often are used to illustrate points about the material.</td>
<td></td>
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</tr>
<tr>
<td>19</td>
<td>I guide students’ work on course projects by asking questions, exploring options, and suggesting alternative ways to do things.</td>
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<tr>
<td>20</td>
<td>Developing the ability of students to think and work independently is an important goal.</td>
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<tr>
<td>21</td>
<td>Lecturing (direct exposition where the lecturer does about 80% to 90% of the talking) is a significant part of how I teach each of the class sessions.</td>
<td></td>
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<tr>
<td>22</td>
<td>I provide very clear guidelines for how I want tasks completed in relation to this subject area.</td>
<td></td>
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</tr>
<tr>
<td>23</td>
<td>I often show students how they can use various principles and concepts.</td>
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<tr>
<td>24</td>
<td>The mathematics activities encourage students to take initiative and responsibility for their learning.</td>
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<tr>
<td>25</td>
<td>Students take responsibility for teaching part of the class sessions.</td>
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<tr>
<td>26</td>
<td>My expertise is typically used to resolve disagreements about content issues.</td>
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<tr>
<td>27</td>
<td>This course has very specific goals and objectives that I want to accomplish.</td>
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<tr>
<td>28</td>
<td>Students receive frequent verbal and/or written comments on their performance.</td>
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<tr>
<td>29</td>
<td>I solicit student advice about how and what to teach in this subject area.</td>
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<tr>
<td>30</td>
<td>Students set their own pace for completing independent and/or group projects.</td>
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<td></td>
<td></td>
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<tr>
<td>31</td>
<td>Students might describe me as a &quot;storehouse of knowledge&quot; who dispenses the fact, principles, and concepts they need.</td>
<td></td>
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<tr>
<td>32</td>
<td>My expectations for what I want students to do in this mathematics class are clearly defined in the learning guide and course curriculum.</td>
<td></td>
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</tr>
<tr>
<td>33</td>
<td>Eventually, many students begin to think like me about mathematics program content.</td>
<td></td>
<td></td>
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<tr>
<td>34</td>
<td>Students can make choices among activities in order to complete mathematics program requirements.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>35</td>
<td>My approach to teaching is similar to a manager of a work group who delegates tasks and responsibilities to subordinates.</td>
<td></td>
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</tr>
<tr>
<td>36</td>
<td>There is more material in this mathematics program than I have time available to cover it.</td>
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<tr>
<td>37</td>
<td>My standards and expectations help students develop the discipline they need to learn.</td>
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<td></td>
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</tr>
<tr>
<td>38</td>
<td>Students might describe me as a &quot;coach&quot; who works closely with someone to correct problems in how they think and behave.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>I give students a lot of personal support and encouragement to do well in this mathematics program.</td>
<td></td>
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<tr>
<td>40</td>
<td>I assume the role of a resource person who is available to students whenever they need help.</td>
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</tbody>
</table>
Appendix D: Lecturers’ interview transcripts

I. **DR.B (201306914 / Science / 2nd year)**

<table>
<thead>
<tr>
<th>1</th>
<th><strong>INTERVIEWER</strong>: The theme is to explore the teaching styles of lecturers and the learning styles of students. Initially I though whether it can match or not, while doing so (I realised) matching is not important (rather) from lecturers side it is important to teach in a various way. We call it ‘teaching around the cycle’ to encourage students to develop their way of thinking. I would like to share what I found until now and to hear what you think about these results. (Explained the learning styles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td><strong>DR.B</strong>: They are leading more participants. That is encouraging. Also more towards dependent (tendency)!</td>
</tr>
<tr>
<td>3</td>
<td><strong>INTERVIEWER</strong>: Why do you think students who study Maths are more dependent?</td>
</tr>
<tr>
<td>4</td>
<td><strong>DR.B</strong>: To be honest with you I think it may well be the school system; leading up to coming to university. The School system is very much a , we will lead you down the road and we will show you this and show you that and you sort of follow us and do as we say and do as we do. To some extent it is good, because some of the skills you need to focus on and make sure you have all the details ironed out and reinforce it the whole time. But to some extent it makes them dependent on their teacher. The teacher says this is what you have to do, then they do it. And if the teacher say you don’t have to do it, they don’t question it. There are a couple of students I have noticed who are a little bit more “I did it this way; is that cool because it is not the way you did it? But I think a lot of the students will like “if you tell me to do it this way, then I will do it this and not do it that way.” I think it is mostly the school system. I could be wrong. I think most of them went to public schools and the public school system is very much geared towards…..?? I tell you to do exercise 2 and you must do it like this and makes it dependent on what the teacher says and that is what you do otherwise you don’t do it. I could be wrong. But I think that is possibly the case.</td>
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<td><strong>INTERVIEWER</strong>: how about this..students are generally quite weak in Mathematics</td>
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<td><strong>DR.B</strong>: That is true which probably adds to it as well, because if you don’t feel very comfortable with the work you not going want to branch out and do your own thing. You are going to very</td>
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much be “if you say I must do it like this” then that is the way it goes. So it thinks that is also the

case. And again many of the students with their background at school level is not 100%

preparing them for university. So many of them do decently well at school but as soon as they

come here with a little bit of independence where we no longer run after them asking them if

they did their homework etc. .. even that for them is a bit of a wakeup call because they feel there

should be someone watching and seeing what they are doing. To some extent that is also a factor

why they are generally weak in Mathematics and they are obviously not going to branch out on

their own. That is only my opinion, I could be wrong.

INTerviewer: They are not avoidant but participant- little bit strange. Because if they want to

participate then at least they need to know what is going on … they are weak in math and also

dependent but they are willing to participate. It doesn’t really make sense to me.

Dr.B: Perhaps it is to do with the fact that they did well in Maths at school. Many of them think

that based on their school results they (got an A or whatever) they think it is very achievable to

get an A at school level just because it is a case if you practice and do what you are suppose to

be doing then you should get an A. Then when they come here they still very comfortable

maths when they are actually not that comfortable with maths. Many of them has a misguided

impression of where their maths skills lie. They feel that they are very strong with maths when

they are actually not that fantastic. That is my experience. Many of them will tell you that they

love maths and are good with maths but their marks do not reflect that. Is again the levels

change from University to school and they have not yet quite get into it that their marks are not

in relation where they think their strengths are.

INTerviewer: does it mean that they do not know themselves?

Dr.B: Yes. A lot of the time I will ask my students after handing in their semester tests and

exams “How did it go?” and above board almost all of them would be like “It was alright. It was

ok?” but when they get their marks back it is not ok. Which is worrying for me, because it

means there is a discrepancy between how the feel they are with the work and how they are

actually with the work. ..I don’t know how to fix that though. I don’t wont to discourage them

and tell them you need to work hard, because its not happening. But at the same time if I was

student and I got back a mark and I thought I got a 70% and I got back a mark of 30% then I

would know there is a big problem here. Not only do I not know where I am at with the work

but I am also not comfortable with the work. Some of them just plod along.
INTERVIEWER: Another fact is strongest learning style is collaborative.

DR.B: In my opinion, the strongest students typically study on their own. They typically are honest. When I say honest, they have got their friends but they will go their separate ways to study. I don’t know if it is again the outcomes based education system where they were encouraged to work as a team to solving things. I am honestly not too sure. To be honest when I was studying as a student, I know many of my friends in residence were very big on studying in groups. And they did not come through the outcomes based education system. So I don’t think it is entirely that but I don’t know. I don’t know if it is a confidence thing again. Where they feel they not quite confident that what they are going to study is what they need to study. So they feel if they got three or four people and they all doing the same thing then they feel little bit more confident with what they are doing. It could be a confidence thing but again it does not match up with their self-assessment. They feel that they are comfortable with the work…it is a bit strange. Largely I think it is a self-confidence thing. You’ve got three or four of your friends and they could work on it together, because “I am not sure if what I am doing is right” I think that is how they feel about it. But at the same time some of them mark themselves as high in their ability to do well in tests.

INTERVIEWER: compared to the norm, they are Competitive and collaborative.

DR.B: There are a lot of subtleties within the groups. There are many things that I find in conflict with the students. You would imagine that either you are competitive which means we go our separate ways. I’ll do my thing and you do your thing and we sees who wins. But at the same time they want to work together. So it is a bit strange…Cultural thing might have something to do with it. Culture among black south Africans are one of together we will go through things and we will do things together. Whereas the western way of doing things is you go your way. So it is a good point which will account for the fact that the collaborative is not in sink with the other things you would expect. So they still want to compete but the cultural background encourages them to work as a team. That is good observation and maybe it is more that than the feel they are not strong enough to study on their own. It could be more a cultural thing.

White Students: typically more independent. Evenly split. Half of them do the independent thing (come and see me on their own) and half is doing the collaborative thing. If I think about
it particularly the students that are in Residence are in close proximity to one another and the temptation is great for them to sit down together and do things together. You have a point.

Probably more of a cultural thing.

**INTERVIEWER:** Male and female. Male is more independent and female more dependent.

**DR.B:** I don’t know. Above board I cannot say that men are more independent than the women in general. I think it is subtle. If I look at my students I would say the women are independent as well as the men. From my side there doesn’t seem to be a big difference to me, between independence across genders. That is only what I see. Because if they come and see me on their own, then my feeling is that they probably study on their own. Whereas if they come and see me as a group, 3-4 students, then they probably study together. I don’t know, but as for me the two are balanced.

Both male and female students – the strongest students will be independent and the weaker dependent. But I often also found that there are weaker students who have remarkable independence from me. They’ll come to me and say they don’t come to class but study through “carniecann???” upon which I will say it is fine as long as you are doing what we are doing. Sadly though, many of those students are weak students and it doesn’t make sense to me, because I feel they in particular could benefit from someone with experience even if they dislike me I got more experience than they do. At the very least they should feel, “Well I could learn something from class and supplement by doing something else.” But students do their own thing and you can see it is not working out. And I see students who come and repeat the course. In the first year that is what they did and they do the same thing in the second year. So I am not quite sure how to get through to them that it is a good idea to come to class. Even if they don’t like my teaching style, for I understand that there are students who don’t quite match the way you think and they feel you are teaching differently from the way they interpret things. I feel just being present in class, what a lecturer emphasise and then going back and studying on your own is very important.

In terms of the gender thing I would say I cant pick up that the female students more dependent on me than the male students. I have an e-mail address that I have told them they can e-mail me questions, 24/7 and that I will get back to them as soon as I can. And if I look at the gender breakdown there I would say it is pretty balanced between male and female. So by mailing me
and asking questions there are some form of dependence.

It is hard to tell from our (lecturer) perspective. And some student are dependent but they don’t come and see us. And I can only comment on students who actually physically come and see me or e-mail me. Then I can say they wouldn’t have been able to manage with this section if I was not there. But maybe it is also hard for us to tell from a lecturer’s perspective.

INTERVIEWER: Correlation between learning style and marks. The more dependent the lower the marks and the less dependent the higher the mark.

DR.B: If the student is very much dependent on the lecturer, particularly with a subject like maths, I think it is good that they are dependent on me to a certain extent not like the students who go and study on their own. I think they need to interact with you and depend on you to some extent. But I think generally there are some students who can’t survive without you. If you give them the same section of work and read through it on your own, they won’t get through it. They don’t have the self-confidence and proficiency in that to get through it on their own. So to me it makes sense to a certain extent, because the very dependable students are the weaker students. Whereas the more independent students are the stronger students.

INTERVIEWER: Avoidant and participant.

DR.B: Agree – avoidant students marks are lower than students who participate in class and go through the work.

INTERVIEWER: Active - reflective

DR.B: Active learner want to try out (apply) whereas reflective learner needs more time to think. No major discrepancies. But with my students they are more active and not as keen on the reflective side of things. Depends on different situations though.

INTERVIEWER: Sensing – Intuitive.

My students much more want to see something than be true to understanding. Particularly with the course that I teach. There are two components – there is the doing and the seeing and the drawing. Then there is the interpretation thereof. The interpretation is more intuitive. So I would say to them – “Do you think this is true or false. Just go with your intuition.” You can see with them it is a no go. They would rather want to know. They don’t want to feel whether it is right or wrong. Most of the students are more sensing than intuitive.

INTERVIEWER: Problem: Lecturers are intuitive learners/teacher whereas students learning
style is sensing. So there is a clash.

DR.B: In my class I tend to guard against that. I would tell them that essentially this is what something is about. Even if it is less mathematical just to give them a rough idea of what it is about. Then we do the other stuff. Think you are quite right. A lot of the time there is a big discrepancy between what we are saying and what they are interpreting. And I notice that comes out in tests as well. I would say something and they would take it and interpret it in another way. 

I don’t always realize that, because you know what you mean when you say it but when they interpret it they would say “no this is what you actually meant. And I notice in tests that (occasionally) some students completely misunderstood what I said. I would say “this” but they would take it as meaning “that”. Is not the bulk of them but there are some students who completely misunderstood.

INTERVIEWER: Think it is a language problem?

DR.B: No. Sometimes the language is an issue; at least when I find them expressing themselves (written work) they struggle to express themselves. Particularly mathematically. May be the language thing but most of time it is their strength in mathematics. The stronger students would have known that you did not possibly have meant the “other thing”, you meant “that”. Whereas the weaker students might have thought maybe he meant “this”. But I don’t think it is necessarily the language problem.

INTERVIEWER: Visual and verbal

DR.B: 1st year is quite visual, you can draw graphs and you can show them physically what it is about. When you reach third/fourth year it becomes more abstract and the visual becomes harder and harder to do. You can’t represent something if you can’t see the space. That is often a problem. They want to look at a picture and say this is what I am doing. But sometimes I can’t.

INTERVIEWER: Most students are visual- but 2-4year modules become abstract information that is little bit hard to explain in a visual way. It is a problem so how do you try and help them?

DR.B: I do try to include visual representation whenever I can. But even the visual representations are abstract. For example I would be talking about a set and draw it like this. But intuitively they would like to see a graph. So I do try and incorporate visual representation but it is not always possible. The biggest problems in the tests is, the sections of the work that does not have visual interpretation is typically the worst done sections. So it is a bit tricky- especially 3rd
year. There is very little to draw and mostly theoretical write down.

INTERVIEWER: Sequential and global

DR.B: 90% of my students want to learn step by step. I try and do both. I explain the procedure and then explain what we are actually doing in the bigger scheme of things. Most of them are not interested in the global interpretation. They want a “Step 1 do this. Step 2 do that.” So for me this need to be worst than currently reflecting in terms of the discrepancy.

INTERVIEWER: How long have you been a Mathematic Lecturer?

DR.B: I started in my 2nd year, 3rd year and honors when I was a student assistant in tutorial classes. Sometimes I would host the tutorial class where I would work through examples. So I did informal teaching, mainly in my 3rd and honors year. I was helping out with informal tutorial classes for 1st years. Were you studying here? Yes. I studied here and carried on. It is quite long?

Yes, I have been here a long time. But officially I have taught a class here on my own in my Masters, which was in 2005. So Officially I started teaching in 2005; which makes it 9 years.

INTERVIEWER: How do you cater for the difference in your students learning style and understanding of concepts?

DR.B: It is tricky. This is something we struggle with a lot in the course that I teach. Because as I said to you, there is a step by step but there is also the understanding of what you are doing. And I find that with the step by step we reach most of the students. But with the understanding really what we are doing – it is difficult. During my classes I try to do both. I set it out as this is the procedural thing but at the same time I want you to know why we are doing. I spend some time and I explain that but that is part is less visual. So the step by step is “this is what we are doing” and the verbal one unfortunately is the understanding; and that is where they are the weakest. So when you give them the verbal explanation of this is what we are doing; half of them is not into it. They want to see it written down – this is what you are doing…this and this and this. To some extent that is a bit of an issue.

I do try to sort off put in, even in weird…I will give them a random example, which is not exactly tied in with the nuts. But I feel just to give them a broader idea of what it is that we are doing. That is one thing that I try and do; fit in an actual example even if it is not 100% in line with the work but to just give them a vague idea of what it is we are dealing with. But it is very tricky to get between the sort of “how they are learning- which is the step by step thing- and the actual
understanding of what it is that they are doing. With this course we particularly struggle with
that.

INTERVIEWER: Please describe your preferred teaching style, method, procedure. Firstly what
kind of information do you emphasise: concrete or abstract?

DR.B: I try to do both. The course that we are doing is quite abstract. So there has to be the
abstract component. But I also try to make it conceptual as well. I try and strive for balance
there. I think they possibly interpret the concrete side of things than the abstract. But I do try
and strive for balance between the two, between the concrete (actually physically doing it and
looking at what the procedures and steps are) and then understand the theoretical side of
things.

INTERVIEWER: One of your students mentioned that though Maths is abstract, you always try
to make it practical. Example?

DR.B: For example, I would say to them if we have a basis and a basis is when you have ...???
Space ...you’ve got a set and basically what a basis is in the set, it is representatives in the set, so
maybe two or three members that if you work algebraically, those two members generate
everything in the set. One of the ways I explain that is: if you think of a group project, you might
have 10 people in your group all working on a project. But in group projects not everyone is
working. So there is probably only two people doing all the work. So the basis members (those
two guys doing all the work) are the representatives who represent what everyone else is doing.
Essentially you can get rid of the other 8 members of the group, and you will still have a project.
So I try and explain it like that; giving them an idea of the abstract verses a concrete scenario.
But it is often difficult, because the underlying basis is very important and there is a lot of deep
mathematical theory related to that. So I will step back and give them an example which does
not exactly correlate with it but give them an idea of how to interpret it.

INTERVIEWER: Visual and verbal:

DR.B: I do the visual, but a lot of the time I am verbally trying to explain to them. For example,
that example I have just given you; it is more of a verbal explanation than it is a visual
explanation. But just because the visual explanation is harder often with the abstract results. But
again I do try and strike a balance, but a lot of the time it end up more verbal than visual which
doesn’t actually help them that much. So I try to get a bit of both going but it is difficult.
INTERVIEWER: Do you expect students to listen carefully to what you say?

DR.B: Yes. I said to them before that if you don’t write anything down and you just sit and listen, I would prefer that. When we do an example I would typically say: you do it and then I'll do it and then we compare. So I give you 5-10 minutes then we'll compare. Then I want them to actually physically go and do it. But the rest of time I feel they should be listening and if they come across something needs to be clarified, they can write a little note. I give them notes they can print out in advance. And then if there is something there they want to make a note of; great. But look there are students who rewrite everything I say in class and I don't think that is very beneficial. I would prefer them to listen what I am saying. That to me is the difference between studying on your own and having a lecturer. Because if you study on your own you can look at the book and rewrite it and summarize it. Yet getting the lecturer and listening to what they are saying is not something students can ignore because lecturers are trying to give them a bigger picture and highlight specific things in a lecture. So I think the verbal does feature prominently with me and some of students probably think there is too much verbal and too little visual. But again I think the concrete and abstract thing is misaligned with the course as well.

INTERVIEWER: Active and passive student participation

DR.B: Again I try and do a bit of both; depending on how much time I have. I do try and give them time to look through an example and try and them on their own. Say for example 1. I will do example 1 with them and say “this is how you do it, can you do example 2?” Then there is at least some sort of participation. I also try and stop frequently for questions; and see if everyone is happy with this and if not asks some questions. This makes them think about the work. But depending on how much time I have, and I have found with the course that I teach there is very little time. So I don't have, say 20 minutes to let them do 4 examples but 5-10 minutes where they can do 1 or two examples on their own. So I think a lot of the time is passive, because of time constraint but I do try to bring in some active participation on their part. But again that is not always well received. A lot of the students want to sit there and just sit. They say they are listening but I think most of the time they are just sitting there. So I think many of my students are passive learners in they sense that they sit there and listen to you. But whether they actually hearing what you say is another story. I think they think when they come to class and sit there,
they are doing something. So I do try and get them to do some examples but even then some of
them will just sit. I will say “Do example 2.” And they will just sit there. So I will say go and try
this, I know you are tired and if you can sort this out now, when you go home you are sorted. But
it is difficult to get the active part from them. Many of them I think are passive learners. They are
happy for you to re-explain things; 400 times. But whether they will go and do something on
their own; not as much.

INTERVIEWER: But doing mathematics is important.

DR.B: Exactly – this is it. That is the only way, as a Maths or science person you have to sit down
and on your own deal with the concepts. And if I constantly telling you this and this and this , if
you don’t develop yourself as a mathematician…so it is tricky. But I think the passive is typically
the dominant thing; whether I want it to be or not, because many of my students don’t interact
as much as I like. Even then, I will stop and say “Ok, who says this is what we should be doing
and who says this..vote” and then a quarter of my students will vote and the rest will just sit
there. They wont even raise their hand and say which of the two options they would have gone
for. They would just sit there and maybe 10-20% of the students who actually say. (Those sitting
in the front) For me that is a very mild form of active participation. They really only need to
raise their hand choosing between 1 or 2 options. But many of them are not a 100% sure and
scared they are going to give the wrong answer.

INTERVIEWER: What is another form of active participation that you give them?

DR.B: As I said, I try and promote active participation by asking questions and at least voting on
things are one or two of the other things we do. Generally that’s it. I’ll give you time to do
examples and look at it. And even then I walk around while doing the examples. But many of
them won’t ask. They would just sit there and wait until you have gone through it, because they
know that you have given the example and will go through it and then wait until he does it (I do
it.) And then they write down what I say but they don’t do it themselves. Which I think is
unfortunate, because you try and bring the active thing in but they are very resistant to that.
They prefer to just sit there and watch. There are one or two other things, as I said – I often stop
and ask “What do you think; this or this?” And even that 10-20% of the students will participate
and the rest will not. I thought students in your class are very active? They are to some extent,
and I think it varies. Look, in my opinion – 1st year a lot of participation and active/interactive.
Because I taught 1st year a while back. Second year is a lot less. 3rd year is much much less. So it seems the older they get, the less they like to interact with me. I don’t know. I don’t know.

DR.B: I don’t know if they feel they are too old to want to seem enthusiastic.

INTERVIEWER: …One 3rd year student said the 3rd year classes are small and they are too proud.

DR.B: This is it, I think there pride kicks in. The irony is that if you look at the 1st year group, there is a lot more students. So for me if I was a person in that class I will ask a question, because there are more students to feel embarrassed about. Whereas in a small class, you feel we are only 20 students and I cant really embarrass myself.

Amongst themselves. He said they are third year and they expect me to know a lot. So I don’t want to embarrass myself by saying something stupid. That is true. There is more pressure the higher the level, not to ask stupid questions. Whereas in 1st year, everyone don’t know what is happening.

Maybe it is that. The higher you go the more you worry that you should be at a new level and if you are not quite there, while everyone else is there then you worry that you are going to be one of the few people who is not at the level you need to be at. They barely pass. They are only sitting.

And also not strong enough to actively participate. That is it. For many of them they are not sure.

You will ask them something and they’ll be “I am just sitting here watching you lecturer.” They are not going to participate, because I am not really listening. From lecturer’s side, you cant push them to participate. This is it. There is only so much you can do. When I walk around I notice, I’ll say do the example. But they just waiting for you to go, because they know you will do it. So then I feel, well “Should I not do the example then it forces them to do it on their own” Instead of saying “Well this is the answer. But then I feel, at the same time that half the class has not done that example. So I should probably do it. It is a bit tricky. And as I said, even when I walk around I’ll notice there are some students, who will then…they will see I am walking around and they will pick up a piece of paper but they will pretend they are doing something but they will only actually do it when you do it with them. Which is annoying, because this is not for me. I understand the work. You need to do it. But to get them to actually do it on their own is difficult.

And again it is possibly the spoon feeding thing. At school you sit there and every week you do factorization, and the teacher runs after you and you have to make sure you get it right. So I think when they get the chance to not do anything and just sit there, they would rather do that.
INTERVIEWER: And do you think the higher the level the more they need to participate?

DR.B: Yes, exactly. You would hope so. I think at least at the higher levels, it is more important for them to get the global theoretical understanding if things. And I feel there is more time as well. In my second year groups classes I have got close to 200 students. So I cant talk with each of them individually. A lot of the time it is a case of well, they can ask questions but at some point I have to draw the line and say, we have to carry on. Whereas in a third year group, you’ve got 60 students in your class. So I would much prefer...it is a better opportunity to interact and say “look I did not completely understand that, can you go through that again?” Which for me is perfect. But it is almost the opposite of what you would like it to be. And it is important, especially honors level, it is important for them to reason things out and then touch base with you. To decide what they thought is true is in fact true. But unfortunately most of them don’t do it. My honors class I think is my least interactive classes. The students, they just look at you and watch you. The very strong students will interact with you. But I have noticed in the last two years, I have had very strong students where the rest of the class was not that strong. The strong students will interact with you and the rest of the class will not. Which is the exact opposite of what it needs to be.

INTERVIEWER: Can I interpret the strong students have confidence and ability to participate?

DR.B: That is right. The weaker ones in general feel they don’t have enough knowledge to even formulate what they want to ask. The irony is, that those are the students you particularly want to participate. They can say "Is this what you meant by that?" I can say, "no no, I did not mean that. I meant this." And you can clarify. Which is unfortunate. Sometime the very weak students, will participate but then in a way it is a good thing, because they will ask a question that is not a good question. But you can at least emphasise and clarify for the students that aren’t were strong. There is sometimes a discrepancy there. The very strong or the very weak students will participate. The weak students are so weak that they don’t know that it was a terrible question to ask. But I try to encourage that. Although it is not a good question, I will say “That is a valid point. Let us look at this." Trying to encourage and elicit what they think, because if they think this is true but it is not then I would rather sort that out. Often there is a very strong group of students and they tend to dominate the class. The rest of the class feel they are not on that level so they need to be quiet and let them ask the questions. So to some extent if you don’t have
many strong students, the weaker students can ask questions. Which probably is a good thing.

But if there is a group of strong students the other students feel, “Well, I can’t ask questions like that so I am not going to ask.” So you would want to encourage both the participate. You want the strong questions, because it makes everyone feel they need to raise their game. Because there are students who are asking good questions. So I like having those students. But sometimes they do dominant which means others students take a back seat.

INTERVIEWER: Sequential and global

DR.B: Again, I try to do both. With linear algebra, particularly, there is a big component that needs understanding because the work goes very deep. There is a lot of ways to think about the work. So you can approach it from this avenue or you can go back and say well “We did this two weeks ago and you can actually think about it like that or like that.” So a lot of the thing is global. I want them to get the bigger picture of what we are doing. But I try to emphasise there are the routines as well. Make sure you can do the routine. In class in particular I will focus more on the sequential and then I will also spend some time on the global. But in the tutorial classes I try to look more towards the sequential, you should have done the homework. I posted the solutions. So during tutorials you can come and ask questions but you have already tried the homework. I have posted the solutions and you should have looked at it. And in the tutorials questions I specifically try and focus more on the global picture. So they have done their homework. They should have practiced the step by step sequential and now I feel the next level is to understand the global picture. But many of them for the tutorial class will not come. If there is not an assessment for that class, they feel “No, I am not going to come.” They want the answers to the tutorial solutions. But they are not so big on actually go through and actually understanding what it is they are doing on their own. So I do try and strike a balance there. But I think in the physical class when I am introducing it for the first time I focus more on the sequential. But I do mention the global. I think many of them only notice the sequential.

INTERVIEWER: The tests and exam does not require them to know the global way.

DR.B: This is it. In our tests we try have a component, at least 30-40% of the test is understanding of what it is that you are doing. In a way we try to force them, you have to know what it is that you are doing. But then still, some of them aim to get 50% so they feel they don’t need to know the global. I only need to do my techniques right then I will pass. Global learning, students need a desire. Exactly, that is true. The stronger
students want the global thing. They want to know the bigger picture. It is important. As a science student, it is important not only to be able to do…. I often said to them; if you can only do the calculations, there is a computer program that can do that faster than you and not going to make mistakes. You are completely replaceable if that is all that you can do. But many of them don’t pick up on that. It is difficult to get them away from the sequential thing. And as we saw with the results, many of them are sequential, but global thing they are not so keen on. That in particular is the one thing they should get from me the lecturer. Because I can explain the bigger picture to them. Whereas the book will explain the techniques. I said to them, that is why you should come to class for that is what you are not going to get from your book.

INTERVIEWER: What do you think between the relationship between learning style and teaching style in general and in particular for you?

DR.B: There is a bit of a rift between the two. I will try to make sure that they get both, the sequential and the global but they will only focus on the sequential. A lot of the time their learning styles and my teaching styles are a bit out of sync, because I need them to understand the global as well. So there is often a discrepancy between the two. And again with the active and passive thing; I will try and encourage them to do the active thing but their learning style is more towards the passive. So it is difficult, because if you cater only for their leaning style they are missing out on a portion of the work. It is difficult. Then they will be upset, because you are spending too much time on the global thing. But you know you need to pull them away from the sequential thing. But many of them shut down. If I am explaining there and am giving them an explanation, they waiting for you to write something on the board. They’ll completely ignore me until I write something on the board. I’ll say to them, this is why you are here, I am giving you an explanation. But they’ll completely ignore me and then as soon as I writing something on the board they will write it down. Then again, there is a bog discrepancy between what I am saying and what they are actually getting from it. Which is a difficulty. Many of the times I try to make it visual my explanation just so they write something down towards the explanation. Because if I waive my arms, they are just completely ignoring me until I write something down. So in a way you’ve got to not cater for their leaning style with your teaching style. You have to have a bit of a discrepancy. So you have to cater towards what they can do and also pull them away from their learning style, because it is not in line with what it needs to be. From a lectures point of view you
try and try, but they completely ignore you until the point where you want to leave it. Let me just give them what they want. Exactly. That is the difficulty. You almost apposing what they want you to do. I have spoken to my colleague many times about this. We spend a lot of time doing the global but in a way it is quite sad, because you feel that time you could rather have spent making the sequential clearer to them. So you could have done 6 examples and no explanation and in a way they would have preferred that. But you are standing there saying “this is what we are doing…”. So in a way you have to get them away from their learning style. So I try and cater toward their learning style but also pull them out of their comfort zone.

INTERVIEWER: In the past while studying, did you have a teacher who tried for example who catered for both sequential and global way? So when you study, you try both ways?

DR.B: It is just the way that I am. I don’t like to probably just do things. I want to know why they work. For myself, even if my teacher did not go through the understanding I would try and figure it out, because it is important. In general the teachers I did not enjoy was were the ones who said “just do this. You don’t need to know why, just do this.” I don’t like that. I think it is important to be able to do it but for me those lectures 10 years later I cant do the procedure anymore, because I don’t understand how it works. Whereas the procedures I can understand, even though it was a long time since I studied, I can almost remember the procedure because I know what we are trying to do. That is what I am trying to impress on them. If they can understand what it is that they are doing, it almost covers the sequential part of it as well.

INTERVIEWER: The lecturer’s teaching style reflect how they studied.

DR.B: That is probably true. If you studied very sequentially you will teach sequentially. So it is very interesting.. So I try to do both but again with the time constraints..in a way I would like to spend the normal lectures just doing the sequential and then have an extra lecture where we talk about the global things fit together. Most of the time it is a time constrain thing.

INTERVIEWER: What do you expect from students firstly in terms of the class room environment?

DR.B: Ideally, print out their notes or bring their laptops. In class they should not be rewriting what’s on edu-link, they can just download that to get it. They can rather focus on the extra. So the little things like “Oh ok, cool, I didn’t understand that, let me make a note.” So theoretically I would like them to absorb the extra I give them in the class. Explaining what it is that we are doing; that is the part of class that I expect them to get from me. Sequential, we will spend a lot
of time in class on that but that is the sort of stuff they can do on “carn-academy” or in the
library on their own. But if they are coming to class, and I give them time to practice it I would
like them to do it as well. So my ideal student is one that participates and asks questions and
also listens to the global interpretations and makes a couple of remarks themselves to aid their
understanding. What I get from my students is not always that.

INTERVIEWER: What is the ideal class room in terms of how the class operates in student
numbers?

DR.B: Ideally the class should be smaller, in the sense that if you have a smaller group you can
interact with them more. At least look them in the face and say overall they looked happy with
this or they are not happy with this. Particularly, because many of them don’t participate. So I
need to intuitively feel, they are happy with this or not and in a smaller group it is easier to do
than in a bigger group. It is easier to make a connection with them in a smaller group than in a
bigger group. So, ideally if you could have a smaller class it would be much better. Unfortunately
then they would need 12 lectures to teach a course, that is not going to happen. There are only 2
of us for 330 students and it doesn’t split evenly. There are thee classes and I taught two of them
and the other lecturer taught the other one. So I taught 2 thirds of the students, which means at
least a 100 in each class which means big number in classes and you have to try and get them all
with you. Which is hard. I was chatting with my colleague, Chantelle, her classes are usually a bit
smaller than mine. She often said for her she can go a bit quicker, because she only got 20-30 at
a time to worry about. Whereas I have to get a massive students through at the end of the day. It
is a bit tricky to get them all on the same page. Then I will find half of them will be and half of
them wont be. And I’ll find you have to re-explain which takes time away from the class.

INTERVIEWER: What can be done to reach out to students whose learning styles are not
addressed by the common/institution approach, specifically in the mathematic class room?

DR.B: The students learning style that is not in line with the masses, particularly with the
numbers..you got a hundred in the class, you really are to some extent catering for the masses. If
you prefer to get the global, and you only want the global, you are not going to get it all the time.
The best that can be done is try to have multiple approaches. As we said, with sequential spend
some time on the sequential and also spend a bit of time on the global so that everyone gets a
little piece of what they want, if not all they want. I try and do that, I really do. But it is difficult.
Many lectures afterwards I go “Did I get through to them. Should I rather ignore the global and only done the sequential.” Only do examples with them and left the explanation, because the explanation they completely miss. It is difficult to get the two related. But I try and mix it up a little bit so that everyone can get a piece of what they want. But still I get some students who come to me and say, “They don’t come to my class, because we don’t get on in the sense that they don’t identify with my teaching style. But I do try and cater what works for everyone. The downside to that is, in the fine amount of time to try and balance the different approaches in 45 minutes, get the main idea across and the global it is a fine art. I spend most of my time trying to get my notes streamlined so I can go through them quickly but at the same time cover all the essentials. I think that is the one thing we can try and do, to spend time on different approaches. You know different learning styles. Time will help with that. If we had more time for the class, and smaller classes it would help with that.

II. Prof. C

INTERVIEWER: I would like to know your opinion about what I found so far.

Prof. C: I remember you classified students according to the learning styles. And you also did lecturers based on the questionnaire and you look at whether there is a correlation between teaching styles and learning styles.

INTERVIEWER: What I found is that male students are more independent and female more dependent?

Prof. C: I don’t know. I don’t know what to make of that. If I take the students I see during consultation, it is more likely to be a female student that come and consult and wants help on the work. What you say resonates with my experience. I would not want to venture a conjecture to the cause of why there exists this division. But my experience agrees with what you observe over there.

INTERVIEWER: According to the interview with students, also I can see male students they want to study by themselves, female students they both of them are eager to study by they expect more from the lecture.

Prof. C: Did you follow studying with peers? Like studying in a group.
INTERVIEWER: yes, I did. Collaborative learning style. Firstly I was thinking it relates in terms of race, but one of white students say he can see the benefit of studying in a group.

PROF. C: As an undergraduate student I completely studied on my own. But as a master student we did quite a bit of studying in groups, especially working on assignments and there I really saw the benefit.

INTERVIEWER: Race is not relevant or reliable, because white students are so little……

Generally UJ students are dependent. What do you think about that? Why students are dependent? Do you think it may correlate with the way they come out of school..that this is something that is formed in school…but I don't know...if you are dependent you are really dependent..I wonder if it is a personality trade thing…

PROF. C: I don’t know. I really have no idea., why it skewed like that. I just remember now, teacher’s centered teaching style and student centered teaching style…but so far at UJ lecturer are teacher centered….so the dependent learning style quite suit the teacher centered teaching style, so that is why the developed in that way. If that is the way you come out of your schooling..that is actually worrying in the mathematics context I think, because you can do so little in a maths lecture, really…I mean 90% of the learning happens when you sit on your own and work through those problems and struggle with them until you get it right. Did you look at these two learning styles and performance? They are higher, independent students gets higher mark and dependent students get lower marks. That makes absolute sense. We can spend so little time with students, For a module I have three lecture periods for a week and there is a little bit of consultation and they can see the tutors a little bit but it makes perfect sense to me. Mathematics is something you need to figure out for yourself. The lecture can only point the direction. If you really are that dependent then it doesn’t really surprise me of not doing that well.

INTERVIEWER: So can I say that independent students are strong in mathematics, mathematic knowledge, and confidence whereas dependent students are weak?

PROF. C: I am not sure what is the cause and what is the effect here?

But I certainly think that working independently will help anybody in learning mathematics. In the end of the day you need to grapple with these problems. I would think that
an independent learning style is certainly better for learning mathematics. I don't know what is
the interaction between these things...so if I am already strong in mathematics does that give
me more confidence to work independent. Then the independent work...it is like a snowball
effect...and conversely on the dependency side. So as I told you, collaborative learning style is
quite strong....many students said they work better when they work together. But I think
working together, as you separate them – that is certainly something different from being
dependent on the lecturer. If you work together and you are an active participant in that
process...I get the impression that perhaps the dependent people, because lot of the people I see
during my consulting hours, they don’t really engage. They just want you to show the answer
and then they say, “Oh Ok” Whereas I think , if you are in a group and you collaborate, (I am
sure there are those who just there for the ride and don’t benefit from it or benefit the group)
but if you collaborate actively, I think that is an excellent way. My figuring out by yourself, I don’t
mean you have to completely on your own, but you can figure it out in a group as long as you
are an active participant in this process. My guess would be if you fall into the dependent
group, you are more of a passive receiver. Either you can be active completely by yourself or
active as a member of the group. I think that is key. Just be active in the process. Not be this
passive sponge.

INTERVIEWER: What about students in class, are they active?

PROF. C: We’ve got big classes. 3rd year Mathematics I've got between 60-80 students in class
. So if you are confident enough to participate, there are certainly active participating students
in class (but they are in the minority) The setup makes it difficult for all of them to actively
participate. There are those who do very well but they are just shy. The will never open their
mouts in class, but get 90% for the module nevertheless. I was certainly one of those students
In my 1st and second year, I never said anything in class, but in my third year in a smaller group
I had more confidence to participate more actively. It is surprising that you have students that
participate very actively in class, and you would think they are the stronger students but they
are not strong at all. It is not always the strong students that participate, surprisingly. I think
the class participation has got much more to do with self-confidence and not as much with
being a strong maths student; class participation particularly. Maybe, weekly
---you are likely to be strong than not if you are an active class participant. Say again. If you
actively participate in class it would be a reasonable guess that the student is one of the
stronger students but it is certainly not always the case.

**INTERVIEWER:** Other lecture said that those who participate in class is either extremely
strong student or very bad/weak.

**PROF. C:** I agree with that. Maybe, the really bad ones are just the really confident ones
but got nothing to do with the mathematics. I agree with that observation.

It cuts across and is not polar divine. It does not really indicate...being active that I am talking
about is sitting on your butt, working by yourself or in a group.

**INTERVIEWER:** Do you think it is important for students studying mathematics to be active?

**PROF. C:** Certainly. They have to be active participants in this process. Which it does not mean
you have to ask questions in class all the time. But actively engaging the material; going
through the work either by yourself or with a peer group or see the lecturer...that is absolutely
key. Because these concepts you encounter in mathematics are completely abstract. They have
no obvious correlation with your every day experience. And the only way for these objects to
become real to you is to engage them enough by yourself. In that way these things become real
to you and you build intuitions about it how these things are suppose to work. That doesn't
happen by sitting passively and listening to a lecturer. It only happens by working out
and assignments for yourself and going beyond what is just required in the course.

That can happen either in a solitary setup or together with others. There is something to be
said for both, working by yourself or with peers. Each of those bring something different but at
least one of those need to be there.

**INTERVIEWER:** does it mean their attitude is important?

**PROF. C:** I think so. Attitude of being willing to engage the material and be willing to struggle
with it. Because of the setup from school and also the university we have so little time in the
class setup- you cant really show students how you engage with a problem, if you don't have a
clue. We give them the problem and then the answer and solution pretty quickly because of
time constraints. This also comes from school. If they have the impression, very often, if you
cant see the solution in two minutes, there is something wrong and now you have to go and ask
somebody for the solution. They don't get that it is alright to sit and struggle with a problem for
three hours. That is something I try and bring across. They are so drilled from school, that a
lecturer puts up a problem and the lecturer does not see the solution immediately – they sort of
surprised. That’ve got this idea that mathematics is something you look at and solve
immediately. So they think something is wrong if they cant solve the problem immediately and
they give up. (Not the strong students) There is not the perception that it is normal as part of
the process, to struggle with stuff and to work for a long period on a problem until you have
figured it out. This is absolutely key. It is a huge thing that floors a lot of students. They can do
everything you can solve quickly and then if I cant do this, I am not going to struggle with it and
try and make a plan; I am going to see the lecturer or get the solution somewhere.

INTERVIEWER: UJ students are not really good at math but nevertheless they want to try.

PROF. C: Perhaps the fact that lots of our students are relatively from disadvantage back
grounds, the fact they have
to make big sacrifices to be here. And this is a big opportunity for them, they are more
motivated to succeed. Whereas if you are looking at a wealthy country like America, more of
their students are taking it for granted. They have got relatively wealthy parents to fall back on
if it does not work out or for whatever reasons to study. That is very encouraging to see.

INTERVIEWER: Collaborative and competitive is quite opposite – UJ students have a
collaborative attitude but at the same time competitive.

PROF. C: Me speaking from my ignorance, South Africans tend to help each other (Ubuntu)
There is a big culture of helping and assisting each other and I wonder if that does not feed into
this collaborative spirit. I certainly see students forming a little collaborative group coming to
see me together, “We are struggling with these problems. Can you please help us?” But also
simultaneously the competitiveness is higher. I would wonder if that can’t be accounted for in a
similar way than the avoidance is lower- that “We’ll going to help each other but at the end of
the day each of us is in it for ourselves. At the end of the day you have to succeed individually.
And the consequences can be quite dire if you don’t succeed. Even if they want to work
together, but in a group they are still competitive to each other. I think so. At the end of the day
you are not going to be hired as a group but as an individual. You have to pass your exam as an
individual. These numbers would indicate that although our students are very willing to help
each other and learn from each other, they realize that at the end of the day they are judged as
individuals. We are in an incredible competitive job market after all. The big employers of
mathematic graduates, they go for the cream of the crop and not hire every mathematic
graduate easily after they graduate. Also getting into honors programs, it is incredibly
competitive. Especially these programs that are associated with highly paid jobs – financially
mathematic programs – it is absolutely the top students that gets into those things. So I think
our students realize that. So you can help your friends but at the end of the day you need to do
better than them if you want to be successful.

INTERVIEWER: A third year student said, if something is difficult to understand, they don’t ask
they keep it to themselves, make a note and try
figure it out by himself. So I asked why, and he said he is too proud to ask in the class.

PROF. C: Third year class is quite silent. Definitely, and I think it is a self-confidence thing
again. You never know as a student am
I the only one that is not understanding this in that class setup. You are afraid to look stupid.

Am I the only one who does not have a clue what is going on here. So hit the nail on the head –
pride along with “Am I the only the one?” But the third year class is remarkably silent (compare
to first year) We use to have quite a few engineering students in the 3rd year class until the
engineering syllabus phased out mathematics. It is remarkable how the atmosphere of the
classes changed, since the engineers have left. The atmosphere was more lively with the
engineers there. They were much keener on asking questions and much more willing to engage
the work and risk that. My interpretation of that has been, the engineering students know each
other and work together. They have to work on projects, they work in small groups. Whereas
the BSc students never have to work together, they don’t do project together. The IT guys do a
third year project together. Mostly you work completely on your own. Especially the
mathematic science. At least in physics and chemistry you have a lab partner. But for
mathematic science, also drawing from my experience as an undergraduate, you can do a BSc
in mathematics without talking to anybody for 3 years. So I think the BSc maths majors do not
know each other as well as the engineering students do. They don’t collaborate much with each
other, I don’t know if you picked that up – collaborating among engineers versus BSc? Not
based on faculty. Coming back to that, it is a confidence thing. If I know I fare number of my
peers, and I don’t understand something, I’ll be more confident that they also don’t understand
either and therefore I am more confident to ask a question. If I know very few people in the
class, I don’t really work together with them. I am making the assumption that probably they do understand and I am the only one who is the stupid one. So I rather shut up and go and figure this out myself. That is how I interpret this dynamic, based on my experience as a student and as a lecturer. You try different things to get students to come out of their shells and ask with varying degrees of success.

**INTERVIEWER:** What is the % of students that go into honors?

**PROF. C:** There are typically 60 students in third year and there are 10 honor students. So about 20% or less. So if we consider that in terms of 1st year students, that % is very low. I only think of maths majors now. I don’t know in total of people; BSc first years who actually go onto honors in something. But we’ve got more or less 60 maths majors in third year and of that, about in our honors programs, which includes students from other institutions as well and of course our guys do things all over. They go and stats at WITS or financial maths - that is not a reliable statistic. So I would guess about 15-20% maths majors go on to do a honors degree. It is quite small but given the marks it is what you would expect. For an honors student, you ideally want a guy who has 65% average in the third year and there are not many of them. The bulk of student lies in the fifties. And with that the chances of making it through the honors program is very low.

**INTERVIEWER:** How long have you been a mathematic lecturer?

**PROF. C:** 12 Years

**INTERVIEWER:** In the last 12 years, how do you cater for the difference in your students learning and understanding of Mathematics?

**PROF. C:** Having lectures and consulting hours. Firstly, students that avoid exposure in class, they have the opportunity to come here. Those who are more confident can participate in class. In terms of exercises, on the one hand we encourage independent work which is good for the independent people (learners) on the other hand there is a degree of being prescriptive, saying do these and these and these exercises. In a tutorial setting, rather than look at a list of problems they had to work on independently, make it a together setup in the class. So that is again the independent versus the dependent learning styles. On the one hand there is work to be done independently and on the other hand there is the more collaborative setup, which I try and implement in a tutorial setting. Initially I, and this was quite
a standard style here at UJ in mathematics..it was pretty standard to give students a list of
problems in advance and say ok prepare these for the tutorial and then you can come and ask
questions for those who struggled. That does not work particularly well, because the
independent guys do the problems and get them right and they are bored in the tutorials.
Whereas the dependent timid ones, they did not really get them right and now they are too shy
to ask. That did not really work very well. On the one hand, I'll say these are important things to
work on and ask me if you have problems. Then the tutorial is more of a collaborative thing,
here is a problem we are all working on it now and people work in groups and I go from group
to group. That is a bit of accommodation of dependent and independent style.

INTERVIEWER: Competitive and collaborative

PROF. C: To facilitate collaborative, once again trying to encourage working in a group with
your friends. Competitive – on the one hand, and this did not work very well, I tend to make a
big fuss about those who do well and hand out everyone who gets distinction in the
semester tests in class. For those who are competitive this is great, because it is great
affirmation. But then I was talking to a colleague of mine, I did this and she said oh my word. If
you did this while I was an undergraduate student I would make sure I will never get a
distinction, because I don't wont to be singled out in class. So it is not quite clear. It is good for
the competitive guys but not so good for the shy ones, who might be competitive but who do
not want to be singled out, for any reason good or bad.

INTERVIEWER: Avoidant and participant

PROF. C: In general I try to encourage participation, I don't think you should encourage
avoidance. Really trying to make the class a friendly atmosphere where people feel free to
ask questions. That is successful to a certain extent. But of course it is a large group of people,
and some people are too shy it is
not that great. But once again the tutorials is where that comes to the fore. There you can
participate with the people you know, sitting around you at least. That is a saver environment
to participate in. Hopefully, by working with those people in that setting - that is something
that is carried forward by forming a little study group.

INTERVIEWER: what kinds of information do you emphasise concrete or abstract?

PROF. C: Both of them are important, because abstraction in mathematics only makes sense if
you have enough concrete examples. Abstraction is completely useless if it does not abstract from concrete interesting things. I hope that I manage to maintain a balance between the two. Usually mathematic information is quite abstract as a lecturer you need to engage students in both sides. It depends on what you mean how concrete. On the one hand I can give you a definition of a group ??? abstract thing. Then I can give you concrete examples of groups – with ??? and ??? those I would regard as concrete examples of an abstract idea. On third year I cant really relate this to Sally running around on the rugby field, students need to be able to engage that level of abstraction or they should not be majoring in mathematics. Many third year students said they struggle. Abstraction is something our students in general struggle with.

**INTERVIEWER:** Sensing and intuitive Students are quite sensing learner not intuitive.

**PROF. C:** The hallmark of mathematics is abstraction. I want to say that if you want to get your hands dirty you should not be majoring in mathematics. Then you have made the wrong choice of degree

**INTERVIEWER:** Many professors and lecturers are intuitive learners and think in an intuitive way. But students are sensors they struggle to understand theoretical…..you don’t teach students. who are only studying mathematics...

**PROF. C:** No, I am only teaching mathematics majors so I feel if you are sitting in my class you need to be committed to mathematics. I am sure this is different in a first or second year level, where you’ve got engineers and optometrists in your class. But I am speaking from someone who is lecturing mathematics majors. If you have chosen to major in mathematics, you need to be willing to engage with the abstraction. If I am teaching an engineer or IT student or something ..I do sometimes teach second year IT students and there we all the time trying to relate discrete mathematics we teach to information technology and computer science. We do four logical languages and how they relate back to computer language. We do automated proof systems and relate that back to automated deductions. There I absolutely agree with you, that is extremely important.

**INTERVIEWER:** When I started doing research on my thesis I thought it is important to match learning styles with teaching styles. But the as I continued I realized it is not about matching but developing students in various ways. So my question, you only teach 3rd year majors and
the content of the module is more abstract. So how would help if there is out of 60 students say
10 students who are sensing learners. How would help them?

**PROF. C:** Sensing, I would guess to make things more visual; drawing diagrams and that sort of
ting. I would think a more visual presentation. But I think that is good for anybody. A lot of
mathematics problems; draw a sketch of the situation to help you understand what is going on
there. So on the one hand I would think make things more visual would be helpful. I think that a
good mathematics learner does in any case. If something can be pictorially represented in an
engaging way, then do that. Which always gives you insight into the problem in simply
manipulating strings and symbols. If you can reformulate something into an everyday problem.

But once again sensing you engaging the senses, visually. We can’t taste or smell mathematic.
And the default way of talking about this thing is audio. Sensing learners like to think about
people and everyday experiences, not about an idea. So once again, relating things to the
applications of the mathematics you are doing. For example, working with IT students relating
for example formal logical languages to programming languages. Programming languages is
something from their everyday experiences. So in the sense that enables them to get a
connection there. Also if you teach calculus in the second year, you can relate all these
problems to projectiles etc; physics application of mathematics. Which could make it easier for
a student with a sensing learning style to grasp. My answer would generally be, relating
mathematics to applications and the applications comes from the everyday world, which is
easier to grasp. And although I said, if you majoring in mathematics you need to deal with this
abstraction, I think it is good for all of us- ultimately mathematics is justified by the applications
that it has in the long run. I certainly would like to know what the applications that I do is. On
the one hand there is the beauty of mathematics abstracts on its own. But I agree with you, it is
important to relate that to applications. That is the way to engage the more sensing students.
Because it somehow relates the abstraction they are dealing with, with the physical world and
everyday life.

**INTERVIEWER:** Visual and verbal presentation- many students are visual.

**PROF. C:** Personally I am more visual. Don’t talk mathematics to me, I want to see it. I would
expect that, the overwhelming students here are visually orientated. Usually in you
mathematics classes you try to use visual presentations. Yes. You need to write on the black
board or slides or pictures or something. Of course as a lecture you yack on unceasingly through the lecture, hopefully that provides the audio. But I definitely think that most mathematicians are more visually orientated. You want to see it, So even if it is just writing down the symbols. You mean the procedure? Yes, you want to see it physically. You can’t just talk it through; there is too much complexity. In a sense you can’t process that, if you can’t write down the procedure. I think that a mathematics lecture who just talks, is a very bad mathematician; unless it is about the history of mathematics. Otherwise, the material is too complicated to understand by just hearing it. You need at least to write it down. Hopefully those who are more verbally orientated, because you are saying what you are writing all the time, is enough for them. Traditional mathematics lecture is overwhelming visually orientated.

INTERVIEWER: Students participation, specifically in the class: do you give them a lot of opportunities to participate?

PROF. C: I certainly try to encourage participation as much as possible by asking questions; firstly. Or giving them opportunities/time to work on something themselves. So by asking questions, class discussions and giving them opportunity to work on something. For example “We have done this together up to here, now you do this.” This are the ways I encourage participation. I need to constrain discussion in the class, because there is not enough time to have long discussions. We certainly do not have enough time, really in class. But to have short discussions along things. I am thinking of my course, certain parts of what I teach is very applied. So “Here is the problem” and then well have a discussion on how what you suggest the solution. You suggest this thing. Do you guys agree or do you see something wrong with this?” And have a sort of guided facilitated discussion to keep it on track. You cannot let the discussion runs its course, the chances are that you will get nowhere and you have not covered what you needed to in the lecture.

INTERVIEWER: Do you believe when you give them time to discuss and you facilitate – do you see the benefit?

I definitely think so. It encourages active learning. If the lecturer just stands up and gives a performance – it is extremely easy for students to dose off. The discussion certainly breaks the monotony of them just listening to you. And it encourages them to think for themselves- to be active in this process. It also brings out the competitive side of the competitive learners. “Now I
want to show that I have the right solution." So it engages the competitive students quite well.

Hopefully even the more passive/ dependent people - who are somehow engaged by that. To see that well, there can be discussion about this and people can have different opinions and you can grapple with this thing. It is not just that I have to know the answer immediately or I don't know it. I think class discussion and group discussions have immense benefit. I wish we had time to do more of it; but certainly the little that we do I certainly see benefits. You also get to know each other a bit and encourage again working together.

**INTERVIEWER**: Active and reflective – If there is a lot of opportunity to participate, is good for active students. Do you think reflective students can also benefit? Do the more reflective inclined students also benefit from class discussions?

**PROF. C**: I certainly think so. It gives them food for thought as it were. Being reflective is extremely important to be a successful mathematics student. But you can also be too much in your own head. Just hearing what other students think about things is certainly beneficial. Other people might also have other interesting approaches or other people might suggests approaches that are not right and being able to think why these things aren’t right; that is certainly also beneficial. I definitely think it is beneficial for both sides.

**INTERVIEWER**: Sequential and global- Double with the sequential preference. Though many students think they are global learners, according to other lecturers they are not, they are in fact sequential. Do you agree?

**PROF. C**: I agree, with your suggestion there that…We would hopefully like to progress from sequential approach to mathematics to a global approach. But most of our students are sequential. That comes from the way things are approach at school all the way through. Because a lot of the way mathematics are taught, and unfortunately even at university you may pass your mathematics is by learning recipes, which are sequences of performing steps. Part of the problem our students have with abstraction as they progress to third year and honors, is moving away from doing things sequentially to getting a global understanding of this. I certainly think somebody who only works sequentially would not really have a good understanding of what is going on. Because you can apply a recipe. Whereas you don’t necessarily have a picture of what is it you are doing. “What is this in the bigger picture?” With the sequential emphasis – a lot of our students that think they like mathematics actually like...
accountancy. Because they can apply protocols and procedures; they are very good with it.

Then you can do very well in high school mathematics and in first and second year, by simply applying procedures and working sequentially step by step. But increasingly, as you progress that is not going to get you very far. It will get you up to certain point and not further. I hope and try and encourage people to look beyond the sequential step by step and see the global sense of being a problem solver (innovating) the problems that you have to model and confront you in the real world don’t come with a little list of steps you need to follow. You need to be able to contextualize them and then come up with a little list. I concur, the curriculum and even the exam does not require students to think globally. As longs as they can follow step by step they will pass. But as you said in the long term – must reach a certain level. I think it is very interesting that your statistics confirms this.

INTERVIEWER: How do you help students in the classroom to think globally?

By contextualizing what you do all the time. A lot of the actual time that you spend lecturing, is spent on step by step things. But to help students, in a sense, zoom out to the global picture. To remind them where are we going and that this is part of a bigger setting. Also asking challenging questions, that requires students to go beyond the step by step. We present you something that isn’t part of the standard step by step things. Now your step by step breaks down. If you want to go further you are now being forced to do something else. The only way to do that is to think in a more conceptual global level of what you are doing. That is what I do; by emphasising the bigger picture and how the pieces and concepts fits together. And by challenging students with questions that cannot be done with the standard procedures. Not necessarily incredibly difficult things but things that challenge the standard step by step thing. Somewhere, where you would have to adapt the step by step which you can only do by having an understanding of the material that is little bit beyond the step by step.

INTERVIEWER: Relationship between teaching and learning style in general and then particularly?

PROF. C: There are certain learning styles that are not the best for mathematics and others much more conducive to good mathematics learning. I certainly think that the teacher should nudge students in the direction of the better learning styles, by the ways that you teach. But on the other hand, things like - the sensing versus the intuitive and visual versus verbal – by presenting things from different angles. Because you are going to sit with a class with people
with different learning styles – you can’t just teach to one learning style. Just approach things from multiple angles, is probably the best way to accommodate students. So even though we talk about the same concept or problem, by approaching it from different angles the light goes up for different people.

INTERVIEWER: What do you expect from students, in the classroom or generally?

PROF. C: From my ideal student I expect you to come to class prepared; look at the material beforehand. To participate in class, and this does not mean you need to ask questions or make remarks necessarily, just actively follow the work (silently participating). I also would expect independent work away from the classroom; solitary work or with a study group. Because the real learning does not happen in the classroom – it happens when you actually sit and engage problems that are just a little difficult for you. And then come and engage me based on the work you do independently- “this is where I am struggling. These were my approaches.” To sum it up – I expect active participation in these various ways rather than a passive receptiveness and hoping that somehow you will be illuminated by being in this environment.

INTERVIEWER: Do you expect students to make notes in the class?

Not necessarily. I put my slides up on edulink. Ideally would be for them to download them before the lecture. So they can print it out, because not everything is on the slides, or they can download them on their tablets and make notes where they want to. But I am perfectly happy for students not to sit and write anything in class. I think it might be better if you don’t hysterically busy to copy down everything from the blackboard. Many times, I would tell the students “Stop copy this down, it is in your textbook and listen to what we are doing.” Some students think that if they hysterically write down everything that happens that it will benefit them. Make some notes is good, but actually I am happier if they make less notes and participate more in the class. Because, ultimately most that we are doing in class and write down on the board is available in the textbook or the slides that is made available to them. Some of them have an absolute faith that you have to write everything down and you cannot persuade them to do otherwise. They are the dependent students. Probably.

INTERVIEWER: What is the ideal classroom?

PROF. C: 10-20 students in a class. There is a difference. A lecture type environment can have a larger class. But in a tutorial environment, the smaller the better. If I can sit with 5-10 students around the table in a tutorial, that would be ideal. In a class – I would say up to 50 students in a
lecture type environment. I also want space to be able to write. UJ has now very cleverly ripped
out the blackboards and replaced them with other forms of electronic technology that does not
always work very well. The best mathematics lectures that I have ever seen were those who
used ‘chalk and talk’. (For instance) top and well renowned people in my field, they arrive there
(at the conference) with nothing and they write everything they want to say on the black board.
It forces you not to go to fast. With slides it is too easy to go to fast and nobody has time to
absorb what's going on. So small classes and in terms of technology in the class, something that
is suitable to the class. A backboard is a piece of technology. Some have the idea that only
electronics constitutes technology. We want technology that is most appropriate for what you
want to do. For mathematics you need a lot of space to write. Whether that is multiple
document cameras or blackboards or overhead projectors. But the thing that UJ has to provide
one little screen with a projector on it is completely unsuited to teaching mathematics. Also
enough time. We are hysterically rushing from one class to the other. Periods have been
shortened – so it is certainly far from ideal. Especially 3rd year. Yes, it is complex things you
grapple with, you need time discuss these things. But with the time available “you have half a
minute to think about this and then I am going to give you the answer so we can move on to the
next thing.” That is absolutely the opposite of the ideal. But given the constraints we are
working with, well that is what you need to do. The majority of students struggle to follow. Yes,
you need more time. One way to absolve the system is to move more stuff online. Move some of
the actual lecture online, so people can go and watch that on their own time and the actual face
time, spend that working on problems together; make it more of a tutorial. I have experimented
by putting some extra examples on Youtube which seems to work alright for students. You
record yourself. Just with the document camera. So they only see the actual page while writing
and talking. So it is not a production. But I would like to experiment more with that, because of
the time constraints.

INTERVIEWER: What can be done to reach out to students whose learning styles are not
addressed by institutionalized approach to mathematics?

PROF. C: Diversifying the offering, more online content. Use the actual face to face contact time
for what you can’t do in an online environment- the one on one work, the discussions, that type
of thing. If you put your lectures with videos online, people can follow that on their own pace.
So just diversify what you are doing. Offer things with different angles. Material that does give you slightly a different exposition. So every year students differ. So do you change your approach, or do things differently per year? Certainly you get weaker years and stronger years. The level of examples you do and the pace of things – you can adjust. If you have a particularly strong group, you can do more challenging things. If you have a weaker group you focus more on the foundational things. So you can adjust the level of what you are doing. In terms of class participation – if you have a very participative class, you can spend more time on participation. It does not help if you force participation. It is like pulling teeth. The vibe in the class will guide the level of participation and interaction that you have. I take my queue from the students to a certain extent. I always try and get participation in there but if the groups participates nicely, well we can go a bit further than usual. Also in terms of the mix of students in the class. You might want to do examples or ask questions that relates to applications which students have particular interests in. If you have a lot of engineers in class this year, then we might do more engineering examples which they find interesting. In that way I also adapt a little bit.

III. Mr. A

INTERVIEWER: UJ students are dependent style rather than independent style.

MR. A: I can see UJ students are ‘dependent’ because most of them are not practicing. For me the difference between ‘independent’ students and ‘dependent’ students is ‘thinking by themselves. For example, if I ask questions, they think by themselves ‘what the answer would be’. And yet, dependent students are waiting for me to do everything. I would say those who frequently visit me during the consultation time can be ‘independent’ students. It is because they work on their own and find something to ask. They come to me and ask questions but actually they prepared for themselves. I don’t think I can see dependent student much so I would say dependent student don’t really interact with me, keeping the distance with me.

INTERVIEWER: Another result is they are more participant style.

MR. A: I would say ‘dependent’ students are closer to ‘avoidant’ student and ‘independent’ students and ‘participant’ students go together. According to the result, UJ students are
I don't know what to say about the correlation between 'dependent' and 'participant'. Because in order for them to participate, they need to practice on their own (they have to do homework, and to sit down for practicing. Without that, they cannot really participate though they want. If we think about 'dependent' student, they cannot participate because they wait for me to do it. If a student who frequently visit you and email you with many questions, then I would say he or she is independent student though he or she is weak in mathematics. Then how would you help 'dependent' student and 'avoidant' student? They should be able to have a good class notes because they are not going to make something else at home. It means they need to make sure that class time is sufficient.

**INTERVIEWER:** Collaborative style

MR. A: I would say they like to work together. It is because it would help one another all along. The problem is there is always grey area which means students who don’t want to work, and just want to copy of others. Therefore I would say working together would be good because those who are willing to participate will talk to one another, communicate each other and figure it out together. And yet it would be also bad because those who are not willing to participate won’t learn anything. They will never think. For helping those who are not willing, my suggest is, students need to find them and they should kick them out. I cannot do much with that, but I could advise students in class to include everyone for the good, asking questions to one another etc.

**INTERVIEWER:** Male students are more independent.

MR. A: One of reasons I can think is that mathematics are not their main subject, they are doing mathematics only in the first year. So they just want to get this year over and their main focus is passing. In other word, they don’t really care too much. I don’t think generally female students are more dependent. If you go for third year students or student in honor course, you would find something different. Hopefully they are only independent.

**INTERVIEWER:** How long have you been a mathematics lecturer?

MR. A: Since 2011 (4 years)
**INTERVIEWER:** How do you cater for the difference in your students learning or understanding of concepts?

**MR. A:** Since I have a large group, it is very difficult to cater for everyone. If I try to answer that, I cater for the majority, for example, those who are sitting in front. It is because I can see them and I can interact with them. I try to cater for everyone, but I would say it is difficult.

**INTERVIEWER:** What types of information do you emphasise?

**MR. A:** If I teach the students in the main stream, such as students in the third year or in honor course, it would be easy. But now I am teaching the first year students whose major is not mathematics, so I cannot be really theoretical. I don't go further, 'where these concepts come from'. It is going to be all over their head. Maybe I start to give them conceptual information and then tell them where they can use these concepts.

**INTERVIEWER:** What mode of presentation in your class?

**MR. A:** I am explaining something with diagrams and graphs because I can see myself as a visual person. Also if I read and discuss something, then they don't really pay attention. I guess it would be helpful to the verbal learners because when I teach some concepts, there are visual presentations with a lot of explanation. In mathematics class, not everything is available to teach the students with pictures and drawings. As you know, lecturing itself is verbal presentation.

**INTERVIEWER:** What mode of student participation is facilitated by the presentation?

**MR. A:** The content is too much for me to allow them to participate a lot in class. Therefore, I would say ‘Passive’. I guess ‘passive’ facilitation would be good for independent students because they watch and listen to the lecture (covering more contents) and go home and work on alone.

**INTERVIEWER:** What type of perspective is provided on the information presented?

**MR. A:** Most of case, we can find step-by-step learning from the text books. To be a global student, they need to be a very good student. Seeing a bigger picture and find the relevance are not applicable to all students. Since we have a lot of weak students in mathematics, we need to teach them step-by-step (baby
Without understanding concepts and theory, how can students apply and find the relevance? They have to firstly learn step-by-step. Later, hopefully they can be global student but not at the moment. Many students believe they are global learners but I think that cannot be true. They have a perception and they give themselves more credit than what they deserve. I try to link sequential and global teaching. Once I am done step by step and once they have sorts of understandings, then I might show where students would use the concepts and practices when you leave the university and start to work. That is why you need to know this. (I believe) Our aim is like that Sequential Thinking → Global Developing ways of their thinking

INTERVIEWER: what do you think about the relationship between the teaching style and the students’ learning style in general? And your teaching style and the learning style of your students?

MR. A: We want them to be independent, but I don’t think it will happen soon. I believe there is a relationship between TS and LS. With this regards, lecturers have to accommodate them. For example, we have adapt our teaching styles to students with dependent learning style. Of course I agree I need modify my teaching styles for students because they are not going to change, we have to change.

INTERVIEWER: What do you expect from students? What is the ideal classroom in terms of how the class operate or students numbers?

MR. A: I want them to be independent. In my opinion being independent student includes many things, such as participating in the class, doing their homework etc. Hopefully they become global learner.

What my ideal classroom is The smaller class (40 students in a university level) – more interaction with students. In a big class, I just guess whether or not they really understand the content as I see their faces. More class time

For catering many students who come from different backgrounds, there is an extended
program. It does work, but the students who are in the extended program are quite weak in
mathematics.

INTERVIEWER: What can be done to reach out students whose learning styles are not address
the common institutional approaches in mathematics classes?

MR. A: Firstly, I have to accommodate the majority of student. If they are dependent, I need to
help in the way they prefer.

For the poor outlier, they have to come and see me during the consultation time. If they don’t
understand, they need to ask. If they don’t come, how would I know they don’t understand the
content or they don’t like my style?

They firstly have to reach out to me. Once they reach out, I can give them extra exercises and
explain in a different way. I can explain one concept in 10 different ways.

I have got 4 hours per week, but I cannot say they frequently visit me with many questions.

Normally I am busy the day before their semester test, there is a long queue.

Except that one or two students come and see me.

In my opinion, the domain of learning style in independent and dependent can include other
domains. So lecturers can try to accommodate both learning styles

IV. Mrs. D

INTERVIEWER: UJ students are dependent style rather than independent style.

MRS. D: Most of students are not that good at mathematics and consequently they are not
really interested in studying mathematics itself.

They came from high school where they just did what the teachers told them and got used to
follow the way of teachers’ teaching.

They are lovely students but I can see nobody ever pushed them harder until now…so they
learned just how to manage to get over it. Therefore it is hard for them to think beyond.

For example, when I give them an extra example after explaining how to solve it, independent
students are already done with the example by the time when I am written it on the board.

They jumped into the problem and do it. However dependent students start to copy the
questions of example. It seems that they do what they can do…at least I can write.
In my opinion, teachers didn’t set an example for students. For example, I told students that I have never been late for a class and never looked at the cell phone in the class. It means I expect you to do the same things. For me, as a teacher, being a good example is really important to students. Anywhere you are, whatever you are doing, you should remember ‘what if my students are around here and see you? What kind of example will you give them?’

It is hard life but it should be. That is what the life of a teacher should be.

Back to ‘independent’ and ‘dependent’ students, I think ‘independent student’ are hard working students. That is why they become strong in mathematics. With regards to students from rural area, I think the way teachers teach is not right. They put everything into the pattern.

The reason why I am saying this is many students asked me “Ma’am, what is that formula?” when I asked them to find out the surface area. Even engineering students did. It means they don’t think. They just want to get the formula and put into it without thinking.

They don’t think! I used to tell them, “look at the picture and make sense out of it”

INTERVIEWER: many students are participant style.

MRS. D: Usually I walk around among students and look at what they are doing. If they don’t do something by themselves, I push them to do it by themselves. I can see they are willing to participate; somehow they are forced to do that.

When they are given the questions, around 10 % of students answered. In a sense most of students belong to ‘dependent’ and ‘avoidant’ students. Since I don’t have a big class, I try to literally go to everyone and ask to work on their own.

When I give them an exercise, they work together in a group, but usually 2-3 students are working together. There are a lot of group-tasks in class. One thing is we don’t really have time to do all of that. Maybe in a tutorial time, they can have opportunities to work together because we allow them to do assignments together. Then they work very well together.

I think I can bring this idea into teachers’ class and give them time to work together. But what I am concerned is those who are lazy will just get bonus if they work together all the time.

Due to the background of students, I think, many students are not strong enough at UJ.
INTERVIEWER: many students are collaborative style.

MRS. D: When I give them examples to do in class then they work together. But it is not always formal way. Two or three students do it together.

One thing is we don’t really time to do it all together.

I found students working together in the tutorial time especially with assignments. Then they work very well together.

Therefore I am wondering if I bring that idea into the class next year. Maybe from next year I will give some assignments to work together, which is to encourage students to participate.

On the other hand, what I am concerned is some students become so lazy if I give them a lot to work together.

Since their learning style is collaborative, giving them a lot of opportunities would be helpful.

INTERVIEWER: Male students are more independent

MRS. D: I don’t believe that. It’s old-fashioned thinking.

Yet what I noticed is there are fewer females in pure mathematics class and contrarily there is a balanced ratio between male and female student in teachers’ class (from the faculty of education). Compared to both side, students in teachers’ class are relatively weaker than students in pure math. I hope students in teachers’ class will come and question. However, they are lazy to come and ask. They don’t frequently use the consultation time, though they have to do. I strongly believe that using the consultation time would be really a good opportunity for them to learn if they are weak in mathematics.

Regarding to the consultation time, I think it would be really good for them to come and ask.

It is one to one teaching and they would get the best intention. Yet unfortunately they are not diligent enough to use the consultation time.

I am tutoring at home, so if they can come and visit me like children who come for extra lesson, I think I would do great job for them even for free. I try to mention in my class ‘remember to come and see me’. I write ‘please come and see me’ for students who got particularly bad mark on their test paper, but they don’t always come.

INTERVIEWER: How long have you been a mathematics lecturer?

MRS. D: A junior lecturer (24years) - A big break – I started 3 years ago

INTERVIEWER: How do you cater for the difference in your students learning or
understanding of concepts?

How would you generally prepare mathematics lessons?

**MRS. D:** I do generally try to explain more than one way. Then when I go from a student to a student, I can help them. Looking at their eyes, we can easily see whether they understand or not. If they don’t understand, I explained again in other way. As hearing their question, it is easy to pick up what they don’t understand.

E.g. find out the surface area of cube box – 3 different colours of 6 sides / drawing a net of the box. (Approaching from students’ way of thinking)

**INTERVIEWER:** If you teach a big class?

I am not good person to teach a big group of students, but I remember in a large class, there are not a lot of questions. Usually for students in a large class, I use a tutorial time to cater for their differences. It is possible because, for example, if there are 4 classes then we have 8 different tutorial times, which means a group of students definitely become smaller. If there are still a lot of student, my way of doing it is putting a lot of questions on the board and let them work group to group. Then I can approach and explain group to group.

**INTERVIEWER:** What type of information do you emphasise?

**MRS. D:** It would be hard to separate fact and theory.

I used to talk to students in the class, “It took many years to figure out and prove it, so don’t try to prove on your own, you are not clever yet. Learn this and once you get this prove, you will be able to prove something else.”

Adapting principle!

In the tutorial time, I would check whether students understand concepts based on the theory or theorem that was taught. I used ‘word problem’ which make them to interpret, think and apply the theory and concepts.

Students don’t like ‘word problem’ because it require them to think independently. They always find the easier way. They just want to see the proceed and the answer.

**INTERVIEWER:** What mode of presentation is stressed in your class?

**MRS. D:** I would say mathematics needs a lot of visual. Yet of course it is based on lecturing.

I use ‘powerpoint’ and ‘document camera’ many times. In the beginning, I show them the pictures and diagrams and explain. In a way, I give them the outline of the class and start to
teach on the blank paper. In the class, I rewrite the note, but I didn’t show all of them because if
I do that it means nothing for them.

“Now let’s see this is the formula we can adopt for this problem, what do we know”

Write, write… In this way, it would help them understand what is going on.

“Remember? We did this example.”

**INTERVIEWER:** What mode of student participation is facilitated by the presentation?

**MRS. D:** Unfortunately there are not much movement. I would say mostly it is ‘passive’.

Though I realise it is important for students to actively participate, I couldn’t give them a lot.

This is university and mathematics doesn’t need a lot of movement!

Another thing is we don’t have time for students’ talking & discussing.

The participation of students I offer is giving them other examples and they can try to figure
out by themselves.

**INTERVIEWER:** What type of perspective is provided on the information presented?

**MRS. D:** Generally a lecturer is step-by-step.

**INTERVIEWER:** How will you help a global learner?

**MRS. D:** Give them ‘word problem of practical situation then they can find the relevance and
learn how to link their knowledge to the real situation.

Also I connect what they are going to learn to what they have already learned before.

And curriculum can help global learners. For example, in teachers’ curriculum the work of ‘geometry & trigonometry’ flows beautifully. We teach ‘geometry & trigonometry’ day by day.

However, for pure mathematics class it might be difficult. Those who are doing pure math get a piece of knowledge here and there, also they will do very different things in the following year.

**INTERVIEWER:** Regarding the mismatch in class?

**MRS. D:** We have to lift them up. It is easy to say that I am not an intuitive learner so I can learn something only in my preferred way. Then they can’t get anything. Therefore we should push them to force themselves.

Students study mathematics and get the degree and do something else with that degree.

For example, when I give them word problems, I didn’t ask them to just solve the problem.

Rather I told them this is actually what your work aims when you get 3rd or 4th year.

**INTERVIEWER:** What do you expect from students? What is the ideal classroom in terms of
1282 | Page 291 | **MRS. D:** How does the class operate or students number?

1283 | **MRS. D:** I want them to attend the class. After class, they have to work on their own. They work by themselves and come to the tutorial and ask what they couldn’t understand. They mustn’t expect me to teach everything of what I have already taught them.

1284 | They have to prepare in advance and come to the tutorial (e.g. doing their homework first)

1285 | **MRS. D:** Attentive attitude, making a note. The smaller class.

1286 | We have a class, a tutorial, consultation time and we prepare tutors to help students. What more can we do? I believe we are doing as much as we can. Now it’s time for them to grow up to work by themselves.

1287 | This is a university. You pay for being here and it’s up to you. I am not going to feed with a spoon. Sometimes we make a mistake to intervene too much so students become lazy.

1288 | **MRS. E:** They need to be responsible, which is part of our duty.

1289 | I have four jobs to pay for the education of my children. I am coping with my grey hairs then you can also do that. Don’t say you are tired.

1290 | **V. Mrs. E**

1291 | **INTERVIEWER:** Regarding facilitator teaching style (most of lecturers have low scores in facilitator teaching style domain)

1292 | **MRS. E:** I am telling the students I am not here to make sure that they will pass.

1293 | Whether pass or not is their responsibility, not mine.

1294 | They have to make it sure. They can use me to help them pass; asking questions, coming to the class, listening to lectures. “I am a tool. (Use me as a tool for them to pass)”

1295 | Usually students expect me to tell exactly what they have to do for the exam.

1296 | **MRS. E:** They get used to ‘spoon feeding’ process of teaching. For instance, one of articles says that the structure of text books require learners to just analyse.

1297 | You don’t have to understand any mathematics, you just have to able to analyse the text book.

1298 | **INTERVIEWER:** Because an example is explaining step by step and thereafter the questions based on the example are so similar to the example. In a sense learners can solve the problem if they can analyse them. There is no understanding in the textbook. They are required to follow the
example. The point is that students don’t want to understand mathematics.

Another observation is that most of 2nd year students are from the faculty of Science and Engineering so they are not really interested in understanding. What they want is to get over it because it is one of requirements.

Some of them started to ask many questions about what I was teaching because they tried to understand, other students just asked “Are you going to make questions for the exam?” I preferred questions “how can I understand better”. I didn’t answer if student asked “Are you going to make questions for the exam?”, because it would defeat the purpose of mathematics classroom.

INTERVIEWER: UJ students have more dependent style.

MRS. E: after they answered my question, if I asked why, usually they said “You said so.” though they have to describe ‘why’. It shows somehow they are dependent.

Can be classified in the class, for instance, they respond in a different way.

Independent students listen to explanations and ask questions, trying to go wider & deeper. They inquire of the connection (where this fit in?) and make an effort to find the common. On the other hand, dependent students say “I must step 1 – step 2 … etc.” Understandably most of students are never asked to think creatively or critically. They were asked to follow the instruction.

INTERVIEWER: Avoidant < Participant

MRS. E: It might be cultural thing. They have more confidence to ask and participant. It is not out of the interest in mathematics. In my opinion, very few students are interested in mathematics. Even among those whose major is mathematics, I could see their weak interest.

Of course they are struggling.

INTERVIEWER: Collaborative > Competitive

MRS. E: In a sense, it would be good if they are strong in collaborative learning. I give them an open test. They are allowed to discuss to find the answer. In doing so, they can learn from one another and have better understanding. Also it would be helpful to prepare for the exam.

It is because they don’t know enough to sit on their own and to write what they are supposed to know yet.

I agree that they will still compete one another even in a group. While working together, they can
say “I did this” “I was able to do this”, especially boys.

In my opinion, ‘collaborative & competitive’ learning styles are quite healthy.

One problem is that most students are not strong enough in math and they can be easily manipulated by one or two students who know well.

**INTERVIEWER:** Female students are more dependent

**MRS. E:** I would slightly agree, There are 10% of female students and 90% of male students in my class, and yet students are coming to me during the consultation time are 50% and 50%.

It means more female students come and see me.

**INTERVIEWER:** Independent students are higher marks than dependent students, & participant students are higher marks than avoidant student.

**MRS. E:** Independent students are strong in math. That’s why they can be independent and of course they can gain a higher mark.

Avoidant students usually are those who give up mathematics, saying “I can’t do this”

Also they don’t have enough knowledge to participant, consequently they don’t have confidence. They are behind in most of mathematics classes and later it’s too late for them to catch up. They keep on avoiding which put them in a vicious cycle.

**INTERVIEWER:** How long have you been a mathematics lecturer?

**MRS. E:** Since 2001 but I was in and out. Approximately 8-10 years.

**INTERVIEWER:** How do you cater for the difference in your students learning or understanding of concepts?

**MRS. E:** I try to get them interact. I encourage students to come and see me in the consultation time because I can help them in their level during the consultation time. I am willing to support them through emailing me,

**INTERVIEWER:** What type of information do you emphasise?

**MRS. E:** For me ‘sensing students’ are those who start to write whatever on the board. ‘Intuitive students’ are those who want to listen to first. They wouldn’t mind too much what a lecturer are writing, because for the ‘intuitive students’ what is written on the board is just recipe. They believe that they can make their own recipe. That’s why they want to know first ‘why & how’ Regarding mathematical subject, calculus is very concrete for me, because my mind is in those pictures. Algebra is much more abstract for me. Though many believe mathematics.
are abstract subject, there is possible to give students a very concrete recipe (Algorithms)

I want them to be able to deal with whatever I give them. Ideally I encourage them to do

mathematics with both concrete & abstract information. But that doesn’t always happen

INTERVIEWER: What mode of presentation is stressed in your class?

MRS. E: Students can be visual learners because they might be lazy to read paragraph by paragraph.

They can see more from the visual information which is able to show thousands of words.

INTERVIEWER: What mode of student participation is facilitated by the presentation?

MRS. E: Time is an issue. I want to give them many opportunities but it is not easy.

But I realise that some students told me they need more time to think about what they are

learning when they are asked to do it in class. I would say they are reflective learners. It

doesn’t mean they don’t understand but it is not comfortable for them to do it immediately, they would prefer going and sitting by themselves, trying to understand. Then I gave them a

chance to think and asked them to come back to me if they couldn’t completely understand.

The problem is that it is difficult to recognise whether they need more time or they are not

interested in. Students who respond in a very active way are ok, but those who usually keep

quiet, I don’t know what they want.

So I used homework or assignments to help them understand more. However, one thing about

homework, lecturers cannot really know whether they know or not because they can do

homework with the help of friends, even worse they can just copy.

One day, I gave them homework and all of students gave me the same answer which was

wrong, but only one student approached to the questions in a right way. It seemed that

students understood the concept.

INTERVIEWER: What type of perspective is provided on the information presented?

MRS. E: With regards to accommodate every kind of student, While I am giving them an

eexample, I talk a lot, trying to link to what they have already learned for sensing students.

I always talk about the bigger picture and point to the connection. I emphasise the bigger

structure for their understanding and show them the vision to where they are leading

When I was doing honor, I asked the question which was not supposed to generalise (I can’t

remember exactly what it was at the moment) and she couldn’t answer me. And yet when she

came back the next period and she did work not in the syllabus and at the end of lecture, she
gave me a solution at last. That was wonderful for me. It was because somebody came back and show me the beautiful mathematics. Visualisation of concept (Visual understanding – Global Learning)

They really struggle to understand what it is about. For most of students, mathematics is about solving the problem and the methods. If I give them a slight different content, they cannot figure out because they don’t have concept image or visual understanding.

They got a concept definition which comes from the book, but they don’t have image to provide them with the whole picture.

Those who understand the whole picture, they are able to grasp the definition, of course, and re-create the definition on their own. Abstract understanding of rigorous mathematics

For doing that, words are not enough. Therefore lecturers can ask ‘Can you draw picture of that?’ or ‘how does it link to other concept?’ In mathematics, all the solutions should be written rigorously with the right words & symbols.

Some students can write out step-by-step (Sequential learners), and others don’t know exactly what it means (learners who does not have ‘abstract understanding of rigorous mathematics – Global learners)

In mathematics, students need both skills (writing down step-by-step) and understanding overall.

INTERVIEWER: A problem for the global learner is that all curriculum and exam are step-by-step process which make them bored or indifferent.

MRS. E: In my opinion, everything in our mind has a harmony perfectly connected to each. I would love to impart that harmony to students. Unfortunately, I couldn’t deliver that harmony to students, even to those who are listening to me. Seemingly they don’t have that harmony that everything is connected with what are supposed to connect.

In my opinion, if they don’t understand and if many things are not connected to one another, they have to ask. Most of students are not global learners. To help global learners which I do in a way that I am learning (I believe I am a global learner). I always try to give them a bigger picture and to fit in, because that is the beauty of mathematics.
A bigger picture in which you can place knowledge! But they have to make an effort to listen carefully to what I say and to understand what it means.

One of problems for global learners is that every test and exam doesn’t require students to think globally or holistically. In order for students to pass the model, they are asked to think in order and answer sequentially.

**INTERVIEWER:** What do you expect from students? What is the ideal classroom in terms of how the class operate or students numbers?

**MRS. E:** It would be nice since time is a big issue. Preparing lecture tapes and giving that to students. They can watch at home and get the theory which they need and come to class. In the class, lecturers can help students with exercises that they do normally as their homework. In that process, students can be assisted with where they are weak. It would give students deeper understanding and assist them with critical thinking.

Then we can have extra time. Actually what the lecturers are doing in the class can be taught just from the textbook. My opinion is very ideal, but it would be more value for students to work on much deeper understanding.

My favorite class is the smaller class which make it possible to interact with students. Yet in the bigger class, I tried to interact with a group of students who are usually sitting in front.

Most of student who are sitting back started to move or react once I write something on the board, because they want to copy and keep that for their exam.

VI. Mrs. G

**INTERVIEWER:** UJ students have dependent learning style.

**MRS. G:** Independent students feel more comfortable with working on their own. Dependent students want some help from the lecturer or prefer working in a group (Female students prefer working together).

**INTERVIEWER:** Collaborative style

**MRS. G:** It might be because they can take less responsibility when they work together. They don’t have to be able to do it for themselves and they don’t need to everything on their own. It means they are not strong enough in studying mathematics and in doing so, they can
contribute each other. The fact that the dominant learning style is ‘Collaborative’ is because we have a lot of weak students in mathematics.

INTERVIEWER: Independent < Dependent

MRS. G: Because they are weak students, In high school, they were not very good and consequently they don’t have enough skills or knowledge to work independently.

Considering how often students come and see me during the consultation time, I guess, more dependent students visit me. Independent students can manage it by themselves.

In my opinion, dependent students frequently visit me and seek helps.

INTERVIEWER: Avoidant < Participant

MRS. G: Some of students have difficulties to get into the university, they were accepted by only UJ. So they really need to work hard to achieve the degree or qualification. Some of them are eager to participate to get a degree, which cause them to be active. Getting a degree is very serious issue for them (Out of their personal desire). They might be weak but they really want to have a degree.

The example of participant students, they are asking questions, and they answers when I asked them. A group of students are answering me back. They are very responsive

INTERVIEWER: Collaborative > Competitive

MRS. G: It is also because they are weak. They need to work together. Since they don’t have good backgrounds in terms of mathematics, we have very low pass rate (40%). The majority of them failed.

In conclusion, they are dependent, participant and collaborative learning styles (attitudes) out of their personal background.

INTERVIEWER: Independent & participant students have higher than dependent & avoidant students in terms of mark.

MRS. G: It makes sense because they are strong in mathematics. Participant students have higher marks. It indicates their attitudes. Those who are willing to participate in class work hard with the right attitude.

INTERVIEWER: How long have you been a mathematics lecturer?

MRS. G: 8 years

INTERVIEWER: How do you cater for the difference in your students learning or understanding of concepts?
MRS. G: It is very difficult to cater for everyone in a big group. I would say being available if students come and see me personally. Weak students come with a lot of questions and strong students come with insight questions, so I can help them based on their needs during the consultation time.

The best way for me to cater students is the consulting time because I can meet them on their personal level.

In the class, I start with the basic example for the weaker students and build up to more complex examples for the stronger students.

INTERVIEWER: What type of information do you emphasise?

MRS. G: I explain concepts and methods. I would say ‘Abstract’, but depends on the definition of factual. It’s about the subject. Mathematics is about the concept & methods.

INTERVIEWER: Most of students are sensing learner and Several studies show that most professors are themselves intuitors. On the other hand, the majority of students are sensors, suggesting a serious learning/teaching style mismatch. Is there any solution for this?

MRS. G: Students need to learn the skill of how to do and approach mathematics because in mathematics, they need to understand concepts, there are not sorts of fact that they can memorise.

Students should first understand the concept and need to develop the skills to apply the understood concept. That’s how the ‘intuitive’ comes in.

In other word, mathematics is how to solve problems intuitively.

It comes from, I think, experiences (they need to practice for themselves).

INTERVIEWER: What mode of presentation is stressed in your class?

MRS. G: When I lecture, I explain a lot, but I write down all the process with sketches and diagram. Therefore I would say my presentation is more ‘Verbal’ and yet I try to corporate with lots of drawings & pictures, hoping it would help students understand more.

For helping both visual & verbal learners, we have weekly tutorials. During the tutorials, they are given assignments and allowed to work together.

We don’t ask them to work together, but they start to talk to and explain to each other.

INTERVIEWER: What mode of student participation is facilitated by the presentation?
MRS. G: I would say my lesson is closer to ‘Passive’, as a part of a lesson; they are required to sit and listen to me. And yet there is time to give them exercises that they need to practice. During two third of class, they listen to and one third of class they can do activities. Since active students need an opportunity to do something by themselves and reflective students need an opportunity to think, one third of practicing time might be good for both.

INTERVIEWER: What type of perspective is provided on the information presented?

MRS. G: Probably it is sequential, because the methods we are teaching are step-by-step techniques. A lot of mathematics techniques require step-by-step approaches. Perhaps we can explain how and where the knowledge they have or they are learning fit in with other subject (physics or applied mathematics), so they will get a global picture. Even in mathematics, they can connect to other topics we are recently done.

INTERVIEWER: What do you think about the relationship between the teaching style and the students’ learning style in general? And your teaching style and the learning style of your students?

MRS. G: In general, we have different teaching styles from the learning style of students, partly because of the past experience which has always been done. When I was a student, I had been taught in a certain way in which I am teaching now. In other word, I am teaching students in a way familiar to me. We might not be aware of the way students are learning. we, as a lecturer, are just aware of our own teaching style. It is because we feel it worked as we were students and the style I am insisting worked for me. That is why we are continuing in the same way. For me, I was independent student and learned in a sequential process. The way I learned can be related to more ‘expert’ & ‘formal authority’ To give students many opportunities to participate as a facilitator and a delegator, we need a small group of students. It is so difficult if we have a big group of students. If we teach a small group of students, like 40-50, we can give them more opportunity to work on their own, and to collaborate. At the same time, a lecturer can control the class better. With a big group of students, we don’t know how to do it. that is why we avoid the way of teaching as a facilitator or delegator.

INTERVIEWER: What do you expect from students? What is the ideal classroom in terms of
<table>
<thead>
<tr>
<th>Line</th>
<th>Text</th>
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<tbody>
<tr>
<td>1546</td>
<td>how the class operate or students numbers?</td>
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<tr>
<td>1547</td>
<td>MRS. G: The smaller group of class (between 50-100) Then I can have more room to focus on</td>
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<tr>
<td>1548</td>
<td>my own teaching styles and to consider the learning styles of students.</td>
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<tr>
<td>1549</td>
<td>It would be helpful for lecturers to teach as a facilitator and delegator.</td>
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<tr>
<td>1550</td>
<td>With a small group of students, there will be a lot of opportunities for students to work on his</td>
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<tr>
<td>1551</td>
<td>or her own which is very important to study mathematics</td>
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<tr>
<td>1552</td>
<td>There is only way to be a good mathematics is doing mathematics. (they need to do it!!)</td>
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<tr>
<td>1553</td>
<td>In the light of that, a small group will be very effective.</td>
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<td>1554</td>
<td>I can see them more frequently, from 3 hours per week to maybe 5 hours per week and more</td>
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<td>1555</td>
<td>contact time with students,</td>
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<td>1556</td>
<td>The curriculum - There need to be a bigger part of linking between high school and university.</td>
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<td>1557</td>
<td>There is a extended program.</td>
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Appendix E: Students’ interview transcripts

I. **K (201306914 / Science / 2nd year)**

<table>
<thead>
<tr>
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because I had a module I read through the textbook but I just get some piece of information without full understanding. Only in class, we pick up what the information is about in class. Sometimes we just attend in case.

INTERVIEWER: I heard students have lectures, tutorials, tutoring and consultation time. Do you think they are all effective?

K: Yes, they are all effective. If we don’t understand something in class, we can go to tutors. If they understand, they can explain. In the descriptive class we don’t have tutors so we go to lecturers. So consultation time actually become a good play.

INTERVIEWER: what happens in the tutorial time?

K: In tutorial time, if we have a problem, we exercise together. If there is tutors, they can help us with problems. Sometimes they explain to us and sometimes we will get messages back. They will consult us with the problem we found.

INTERVIEWER: Do you visit lecturers during the consultation time?

K: Yes. I visit lecturers frequently and it was very helpful.

INTERVIEWER: What type of information is emphasised by the lecturer (concrete/abstract)? (Explained the difference between Sensing learner – concrete information & Intuitive learner – abstract information)

K: Mathematics, I do have two subjects one is abstract, even it is called abstract. It is more theoretical, and my other subject is linear algebra which is more concepts. The information there is more practical. They give us theorem but they show us how to apply. Actually I experienced both. Even descript math has both information – both concrete and abstract.

INTERVIEWER: Which class do you feel more comfortable?

K: I actually enjoy both modules because they work hands in hands. And it was very different. I have never seen mathematics in that form.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?

K: lecturers gave us verbal lectures. They drew diagrams and pictures. They show us what is happening in the matrix or space, what happens to the group because we were working with space and vectors. That’s how expect concepts to us

INTERVIEWER: you mean they use both. Are you comfortable with that?

K: it is better if they show us something visual when we are looking at. If they just give us
verbal explanation, then we don’t really see what’s happening, we don’t see how theories apply, what steps we need to, by showing us pictures, something then now we see examples.

INTERVIEWER: What mode of student participation is facilitated by the presentation (Active / Passive)? Before going there, do you think it is important for students to participate?

K: yes, then actually lecturers know what we do understand, or what is going on, if we give him more answers he can give us theorem again or examples again so by telling them to repeat for us .. it actually tells lecturers what it is going on within us (students).

INTERVIEWER: What kinds of participation are in mathematics class?

K: Mrs. E, when it comes to prove at the end, she asks us ‘what is the next step?’ then we need to go and prove theorem. Dr. B, I am in his tutorial, he give us questions and ask us the root, what step should we do? ‘What answers can we get?’

INTERVIEWER: simply there are two kinds; active or passive.

K: I would say there are more passive students. I think just scare or lazy but there are students who are very active and talking a lot and keeping answering. They are always sitting in front and always interact with lecturers. But ones who are sitting toward back side are more passive. They want to listen to.

INTERVIEWER: so then lecturers wants student to participate, but it depends on students’ attitude.

K: Yes. My lecturers try a lot to get us to be active.

One of my lecturers does his best to make students active, giving us some materials to improve our knowledge and answering whatever we ask. Another lecturer gave us activities, she knows everybody since it is a small class. her consultation time for one student to get to know (like one-to-one).

INTERVIEWER: What type of perspective is provided on the information presented? (sequential / global)

K: I would say it happens in both ways. Lecturers try to connect what we are doing not to what we have already done before.

INTERVIEWER: Have you ever tried to connect what you learned in mathematics class to what you learned in other subjects?

K: I spent a lot of time to study mathematics. We IT technology student cannot simply design
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or create things without calculation. We have to take in terms of space, as well as memory
and concepts. Because that is what we are dealing with. For me mathematics basically is
something for everyone. (like a foundation to study other subjects)

INTERVIEWER: How would you like to be helped to learn mathematics more effectively
and efficiently?

K: What I would love to come about is not for the university. Lecturers and curriculum, I
believe are all good; they are excellent. I cannot find any flow in the system of university.
Yet the problem is that many concepts, especially abstract concepts are so unfamiliar to
students. It is really new to us. So when we start to study, it is quite hard to catch up.
If we are prompted to what mathematics is from high school, I guess it would be helpful to
students, our struggles would become less and more students would enjoy studying

INTERVIEWER: were you good at mathematics in your high school?

K: Personally, I was brilliant in mathematics in my high school, but when I came here, all of
sudden I felt ‘I am stuck’. Catching up and getting ‘A’ are pretty hard. This is my last year of
mathematics, and I wish I would have done better, if I was taught earlier.

INTERVIEWER: how about university system?

K: it is brilliant. So far I cannot find any flaw. As I told you just before, we students should be
ready when we get into the university beforehand.

INTERVIEWER: How about students’ self-study? Students in high school, no one is really
study by themselves. Even they don’t think it is necessary. Could you hand the situation when
you entered university?

K: I was ok since I took extra mathematics lessons and studied in advance.

II. A1 (201177007 / Science / 3rd year)

INTERVIEWER: you completed the questionnaire in…whose class, do you remember?

Do you remember?

A1: Professor C.
The theme of my research is comparing the teaching styles of lecturers and the learning styles of students. It is like how they can understand each other or how differently they view. Look at this. This is 5 teaching styles: Expert, Formal authority, Personal model, Facilitator, Delegator. If I simply explain … (explained teaching styles)

Most of UJ mathematics lecturers are teacher-centered teaching style.

What do you think about this?

A1: I prefer when lecturers give us information. Mathematics is not something you can teach. Students have to sit and do by himself, getting over and over. That is how I get it. Because in class like I don’t really understand something … I don’t think … if you don’t prepare before the lecture, go for it then you don’t know what’s going on.

I would like lecturers to tell us ‘this is what we have to do, then you can go and if you are interested in then you can go further. Something like that..

INTERVIEWER: Your expectation from lecturers is to give you information. Somehow What you want is to get the frame of what you are supposed to do. Am I right?

A1: These days we are doing ‘Abstract Algebra’ which is about group theory. There is no way to … if I go to class and the lecturer go through on the board, I won’t understand what is about unless I go home and read it 5 times on my own and think for myself. Maybe Lecturers can highlight important tips and emphasise something more important. Or they can show us the new way of solving problem (this is what I expect).

INTERVIEWER: Since your major is mathematics and physics. I guess you are interested in mathematics. A lot of students here are struggling with studying mathematics.

A1: In my high school, I get 13 % in grade 10. I hate mathematics and I couldn’t get anything when I looked at the formula and symbols…etc. I used to think mathematics was useless. This was my attitude toward mathematics.

My parents introduced my tutors and started to learn mathematics from him in my matrix. He told me if I wanted to succeed, you need to do mathematics, by practice and practice.

Somehow I took it into consideration and I went back to the grade 10 text book and did every single problem. And then my algebra skills began to build up.

I think all about the attitude of students for studying not only mathematics but also all other subjects. Changing attitude and working hard!
My current module is ‘group theories’. For the first time, I didn’t like it. It seemed boring, but I tried to put an effort to know it. As when we see new persons, we don’t know them and we don’t feel familiar with them. And yet once getting to know them, we feel comfortable and better. I think studying mathematics can be like that. Anyone can study mathematics as long as they change their attitude and make an effort. Anyone can do mathematics. Just it takes more dedication for students to do better.

INTERVIEWER: In your opinion, students’ achievement quite rely on their attitude toward mathematics. Right?

A1: no one is born genius. Like what I did. Struggling a lot to get it. In the same way any one can do better in mathematics. It won’t come naturally.

INTERVIEWER: what is your favorite type of lecturing style?

A1: I would love those who have confidence in what they are saying and what they are doing. Convincing and persuasive lecturing. My current mathematics lecturer explains so basic principle very confidently. For the first time I thought it was stupid thing we should know, but later he completely persuade me to believe ‘it is important to know.’ Some lecturers don’t teach in details. It seems that their work is the secondary, which I don’t mind. Actually sometimes it motivates me. Since they provide basic things, it encourages me more to do self-study. Therefore I can say I like both style. Or let me say that I am not really affected by lecturers., maybe 20%? I would like to be independent and figure out something on my own.

INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?

A1: There are two modules I am currently attending; ‘Group theory’ and ‘Complex Analysis’.

In ‘Group theory’ I would say we usually learn only abstract information. On the other hands, in ‘Complex analysis’ there are more concrete information and a lot of exercises.

I think it depends on the subjects.

INTERVIEWER: which one do you prefer?

A1: Since I don’t have a lot of time to think about group theory, I prefer ‘complex analysis at the moment. Yet I do enjoy studying group theory and it satisfies me when I grasp that. For me to understand abstract information it takes much longer, but I prefer abstract information.

It is because abstract information, I believe, develops students’ thinking and analysing for
example the world situation. It encourages me to do research and gives me time to think over
‘what it is about?’ I believe interpreting and analysing abstract information will help me
develop my way of thinking and viewpoint. I experienced that my solving problem skills in
physics were improved after studying ‘Group theory’.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?
A1: I think it is visual. There are a lot of diagrams, graphs which help students including me
understand more.

INTERVIEWER: What kinds of participation are happening in mathematics class?
In other words, do you have a lot of opportunities to participate or usually are you asked to
sit and listen to lecturers?
A1: There are opportunities to participate for students.
We can stop lecturers and ask him or her to explain more. Yet most students do not do that.
The problem is unprepared students. If we don’t prepare in advance, we don’t have any idea of
what is going on in class. Without preparation, no one can participate.

INTERVIEWER: do you actively participate?
A1: No. usually I study by myself. If I find something I cannot understand, then I visit lecturers
after class or during consultation time.

INTERVIEWER: Do you believe that it is important to participate in studying mathematics?
A1: No. I believe studying by ourselves is more important.

INTERVIEWER: What type of perspective is provided on the information presented?
(sequential / global)
A1: Mostly, it is sequential way which is really boring. If we learn ‘calculus’ and ‘integration’
sequentially, we repeat the same things over and over If we study theories and some proof, it is
necessary to learn sequential way. Looking at what happened and how it worked, then we can
understand they way of those whom developed theories and proof. It would be very helpful.
I can say it also depends on module. My preferred way is depending on the module.
Theoretical part I want to learn in a sequential way and non-theoretical part in a global way.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively
and efficiently?
A1: I would say they are doing great job. As I told you before there is no way for lecturers to do
more to help students to improve their mathematics knowledge and skills. Students need to work. Nothing to fix! Especially lecturers in mathematics department, they are all confidently teaching and leading the class.

Since many students are not willing to sacrifice their time for studying, if I were a lecturer, I would motivate them. Once they change their attitude and get the basic knowledge, then it won’t be that difficult for them to understand mathematics. They just lift themselves little bit.

### III. A2 (201328740 / Education / 2nd year)

**INTERVIEWER**: My theme of research is about whether there is a match between the teaching styles of lecturers and the learning styles of students.

The questionnaire you completed before is about learning styles, for instance independent style or dependent style. Do you remember I emailed you regarding your results. There are 5 teaching styles; Expert, Formal authority, Personal model, Facilitator, Delegator. I distributed questionnaires to 31 lecturers. All of them got higher score in expert style.

Look at this diagram. As this shows, most of mathematics lecturers’ style is more Teacher-centered teaching style. In other words, they are focusing on conveying their knowledge to students and the rest parts belong to students. According to teacher-centered teaching style, students need to study by themselves. What do you think about this fact?

Firstly, which way do you prefer, teacher-centered or student-centered?

**A2**: I prefer student-centered. Because if it is teacher-centered, most of learners in my filed (education faculty) most of students left out or behind. If it is student-centered style, then teachers like getting to know how learners learn and have more knowledge of learning styles, like he will know how to enhance learning in order fit or accommodate all different kinds of learning style.

**INTERVIEWER**: among lecturers whom you met so far, what kinds of lecturing or character did impress you?

**A2**: The kinds of teaching impress me is the one who involves everyone, (for example) when having discussions he won’t give us answers (rather) he expects answers from us… like participations in class, forms of debates, like we gives us an answer and someone opposes it.
that is what I like classroom environment.

INTERVIEWER: do you think it is possible when we study mathematics?

A2: well.. I would say some of concepts need to be done verbally (facts – data) but if we study theory such as abstract information, it should use another teaching method.

INTERVIEWER: Do you like studying mathematics? And are you going to be a mathematics teacher?

A2: Yes I do, because mathematics doesn't change. It is quite concrete.

INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?

A2: I would say we have both information but it is more concrete because it doesn't change.

INTERVIEWER: then personally do you prefer concrete information or abstract information?

Do you enjoy interpret and analysing symbols?

A2: I do enjoy. Analysing, interpreting symbols and solving problems.. These are all about.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?

A2: the lecturer uses both. I think as a teacher needs to use both. For visual learners, there should be visual presentation and for verbal learners, there should be verbal explanation.

In that way, every student can be accommodated.

INTERVIEWER: What kinds of participation are happening in mathematics class?

A2: I think it is important 'being active' in class. For me, the meaning of 'being active' is reflecting what we heard and what we see in class and practice over and over.

Everything and every happening in our lives can be connected to mathematics. We just need to think mathematically.

INTERVIEWER: How do you study mathematics?

A2: I would like to say practice mathematics rather than studying. When I cross the road, looking at the car coming toward me and I estimate the distance etc.

Thinking mathematically and actively is also important to mathematics teachers.

For instance, while teaching in class, setting an practical example or calling students to the front and getting them involved as many as possible.

Though active participation is important, we university students don’t have a lot of active participation. Some of the lecturers expect us to know certain things that we don’t really
INTERVIEWER: What type of perspective is provided on the information presented?

A2: it is usually sequential but some information are provided in a global way.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

A2: In my opinion, students need more exercise and activities. Of course I must say students need to practice over and over with the materials from lecturers. When we practice more, we can be exposed by many types of questions and I believe it would be very helpful for the exams.

IV. A3 (201405424 / Science / 1st year)

INTERVIEWER: Before staring, I want to explain shortly. I did survey with lecturers of mathematics regarding their teaching styles.

There are 5 teaching styles; Expert, Formal authority, Personal model, Facilitator, Delegator.

This is the mean score of lecturers. Out of 31 lecturers, most of them are Expert in their Teaching. Expert, Formal authority are more teacher-centered teaching style and Facilitator, Delegator are more student-centered.

A3: This is true. Especially the lecturer I am attending, she is more expert level. She used to pick up the point and makes sure everyone understands what she says. She stays on the topic until everybody comprehends what she says. So I agree with that (everyone is Expert)

INTERVIEWER: are you comfortable with that? Not only with your current lecturer but also with other lecturers?

A3: Yes I am. I also experience other styles. They are more student-centered style like facilitator or delegator. But I prefer her style (teacher-centered teaching style) because I understand math more since it is new & different from high school. She makes it more simply. In a way we can understand what she is talking about.
whereas other lecturers give us information but we need to sit down and kinds of figuring out what they said in the class.

**INTERVIEWER:** you said the information of what she delivered is clear. Then you can see what you should do, right?

**A3:** when I go back and study, it is easy for me to remember. ‘oh, she mentioned this and that, it is easier when you go back to text book because I remember what she was talking about.

**INTERVIEWER:** so you prefer teacher-centered teaching style.

What type of information is emphasised by the instructor (concrete/abstract)?

**A3:** let me say it is more concrete information because it is very clear.

There are theories but she picks up what we have to know, saying ‘this is what we have done’, ‘this is what we are going to do’. I am very comfortable with that.

**INTERVIEWER:** are you studying ‘Calculus’?

**A3:** Yes, I do.

**INTERVIEWER:** then there are formulas rather than theories. Let me ask in a different way. Studying mathematics includes analysing symbols and comprehending theories. Are you excited about it and looking forward to doing that?

**A3:** If I have to, I will. Yet I prefer more concrete information such as fact.

The information from other lecturers is more theoretical. Reading the whole theory, explaining what is about, and doing activities later. And yet in my current mathematics class, she explains theorem while doing calculations and gives us time to do exercises on our own and thereafter she corrects us. In other class, we do it at the same time with lecturers. We don’t have opportunities to do it on our own. After doing exercises by ourselves, she corrects what we are doing wrong. Saying again that other lecturers are focusing on the electrical slides

**INTERVIEWER:** if you make a conclusion, what is your favorite teaching style?

**A3:** first explaining what are going to do, showing us how to do and giving us time to do by Ourselves.

**INTERVIEWER:** What mode of presentation is stressed (visual / verbal)?

**A3:** I would say it is more visual presentation with verbal explanation.

I am comfortable with visual material. Our current content includes a lot of graph and diagrams that is easier for me to grasp.
317  INTERVIEWER: when you study something and if you have an opportunity to explain the
            same concepts, would it make clear to you?
318  **A3:** It is the same to me. I tried to explain after reading a certain concepts, I put that concepts
319  with my own words and prospects without changing the real meaning. Then it helps me get.
320  clearer.
321  
322  INTERVIEWER: do you frequently visit lecturers?
323  **A3:** No I don’t.
324  
325  INTERVIEWER: what if you find something you cannot understand?
326  If I find something I cannot understand, I usually ask friends. Visiting lecturers has never come
327  cross in my mind. It is because there are many friends available around me
328  
329  INTERVIEWER: which way do you prefer; studying in a group or by yourself?
330  **A3:** I study by myself and I like to do things on my own unless I find myself not figuring out
331  something alone.
332  
333  INTERVIEWER: What kinds of participation are happening in mathematics class?
334  **A3:** There are participations in math class. If we don’t understand something then we can ask
335  to explain more.
336  
337  INTERVIEWER: Do you believe active participation is important in studying math?
338  **A3:** I believe that active participation is important to study mathematics. We can find what we
339  don’t know and then we can get clear information in class. If we are just sitting and listening,
340  we cannot realise how much we are learning and understanding.
341  
342  INTERVIEWER: Do you ask many questions?
343  **A3:** I don’t do that. 😊 I don’t have confidence and I am shy.
344  
345  INTERVIEWER: What type of perspective is provided on the information presented?
346  (sequential / global)
347  **A3:** It usually step-by-step. A lecturer teaches us in a sequential way, but sometimes he or she
348  reminds us of how what we have taught connect what we are doing now. They try to give us a
349  bigger picture. In a sense we can learn in a global way. Lecturers sometimes said something like
350  this “Remember? What we are doing now is related to what we have learned last week.”
351  They try to let us think the relevance. Yet most of time we learn in a sequential way.
352  (I am studying environment chemistry, but I will study chemical engineer next year)
INTERVIEWER: what if a lecturer gives us several information at once and ask you to figure out by yourself, how would feel, in a very global way?

A3: I would feel pressure, but I will try because I like to figure out something on my own.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

A3: So far how we learn is good. I would like to have on-line test like trial examination before exam. So I can test myself to know which part I don’t understand. Studying by myself and practicing at home are not the same as writing exam (time pressure and being in strain)

V. C (201201173 / Science / 2nd year)

INTERVIEWER: This is about lecturers’ teaching style. I distributed the questionnaire to 31 lecturers from UJ, WITS and UP. Most of them were UJ lecturers. Here is the name of teaching styles; Expert, Formal authority, Personal model, Facilitator, Delegator. (explained more..) Do you agree they have more teacher-centered teaching style?

C: I go to a class to understand the basic knowledge. My academic performance comes more from my works, like 70% and 30% from teaching. I like teachers give me basic works, what it is about, then I go back and study. I prefer kinds of teaching style which is more interactive, give me little bit of freedom

INTERVIEWER: means you prefer student-centered teaching style. What is your major? Do you enjoy studying mathematics?

C: IT. I do enjoy but I am more interested in IT or computer science.

Yet I am currently teaching mathematics to university students as a tutor.

INTERVIEWER: do you regularly attend class?

C: I do. I have never been absent unless I am sick.

INTERVIEWER: since you are teaching mathematics, I guess you can think the situation from both sides.

C: let me say lecturers give us assignments sometimes you understand more from your peers
because of interactions. Teachers come to class, just speaking. Sometimes students come in with
the problems they have in class, then having one & one interaction. Sometimes I understand in
the way students understand it and pass it to them. Then it becomes easier. Teachers teach right
theorem, but students cannot understand. If I teach them in the way I would like to understand
them (the concepts), then it would be understandable for them.

INTERVIEWER: UJ students’ learning styles are Dependent rather than Independent,
Participant and Collaborative. What do you think about this?

C: Personally I can do better when I study by myself. First I try to understand and figure out.
My concern is whether increasing the pace or not. If I don’t understand then I would cut the pace
of cognitive understanding. If I understand faster than others, I would slow down myself. That is
my major concern and this is why I prefer studying by myself.

INTERVIEWER: do you visit lecturers or use the consultation time?

C: something I couldn’t do on my own, then I can visit peers or lecturers.
I don’t frequently visit a lecturer. Usually when tests or exams are coming.

INTERVIEWER: do you usually go to lecturers or peers?

C: Depending on the modules I choose whether I asked a lecturer or a friend. If I can identify who
know well some contents I would go to him. The thing is the consultation time is limited which
means lecturers are not always available. That was why I go to peers.
Also depends on the characteristics of lecturers. But in terms of mathematics, I prefer asking to
lecturers.
Last semester I attended the module of ‘descriptive mathematics (abstraction of normal
mathematics) ’. We all struggle because it was totally new concept to us. Therefore I tried to get
the recipe, what is the best way to know the concepts and to pass. I visited one lecturer but I
couldn’t get it. I read a book and tried to find ‘who else can explains what this book about?’ and
then visited another lecturer. He explained very well and helped me inhabit the concepts. In the
end my mark went from 60 to 80. Meeting lecturers are very good especially for studying
mathematics.

INTERVIEWER: do you think lecturers’ way of explaining affect students’ understanding?

C: It depends on a lecturer of course. Sometimes they explain concepts in a very higher level.
They don’t come down to students’ level.
This is where the problem of students come from. I had the same experience. The lecturer
whom I visited first time, she explained on that level and I couldn’t get it. The second lecturer started from the basic then I could understand the higher level later. If a lecturer starts to explain the basic knowledge then it would be easier to grasp the complicated concepts (this was what he did to me last semester. At that time I could even teach to my classmates.).

INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?
C: I think they use both but more abstract.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?
C: Verbal explanation is dominant but they also use visual presentation. For me especially in math classes, it is preferred way if a lecturer write with verbal communication.

If the module is for instance business management then visual presentation would be helpful.

INTERVIEWER: What kinds of participation are happening in mathematics class?
C: I have a lot of opportunities. In the module of ‘linear algebra’ before he introduce scenario or theorem, he gives us questions. This is what is ahead of us, how do we solve? We tried to solve first and once we are done, then he starts to explain. In this way it becomes easier for students to grasp.

In our first year, we had two different classes with the same module.
I found many students went to one class that students could rarely find the seats
That class had more students ‘participations. She encouraged students to participate more instead of just coming and telling us ‘this is how you approach, this is how you solve and this is answer’, then we don’t really learn. We can sit silently but hardly understand. We don't have a chance to test ourselves.

Participation is not only helpful for students to learn but also it keeps our class alive.

INTERVIEWER: What type of perspective is provided on the information presented?
(sequential / global)
C: I would like to learn step by step and most lecturers are doing as well.
It is normally sequential; from one to the next like building blocks.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?
C: In a ‘Linear Algebra’ module, I had struggled and got 57%. After the first test before the second,
he gave us time to revise. During the revision, there was ‘question and answer section’ which students bring any unsolved concept and we talk about it with one another. It helps me a lot. Afterwards I realised that session was really good. Maybe the tutorial time which could be similar would be very useful. In a sense sometime tutorial times are more helpful than lectures. I would like to have more practical application of questions. Just gaining theorem never tells us how to figure out and to solve problems. If lecturers tell us ‘this is theorem number 6 and this is theorem number 7, something like this’

**INTERVIEWER:** can you tell me more about tutor time?

**C:** Those whose mark was good were chosen as tutors. We can wait for students to come with questions. It is an excellent system. Before becoming a tutor, I frequently visit tutor room and even I had my favorite tutor. I prefer time that includes more interaction.

For example, in the time of lecturing, lecturers need to finish certain amount of contents within 45 minutes, like pushing & pushing and then finishing.

### VI. **D** (201218555 / Education / 2nd year)

I have a sort of negative attitude toward mathematics, probably it was because I have never understood math from when I was very young. I have never thought I would study mathematics at the university. Studying mathematics was really a challenge for me. I struggled but I have friends who are better than me in mathematics, so I could manage to pass with their helps. Actually my goal is just to pass and I made it.

Last semester I got 69 which was a dream for me and encouraged me a lot. (She is willing to make an effort to do better in math.)

**INTERVIEWER:** what did make it different?

**D:** I studied by myself at home and next day I came here to see peers or tutors with unsolved questions. Then they helped me understand afterwards I learned again in class. Working with Peers and Friday tutoring time is helping me a lot. I prefer studying together to alone especially when it comes to mathematics.

**INTERVIEWER:** According to the questionnaires I distributed last semester, UJ students’ learning styles are Dependent, Collaborative and Participant.
D: with weak background in mathematics, I guess, I prefer studying in a group.

INTERVIEWER: what kinds of direction are you heading for?

D: I would like to be a dedicated teacher but I won’t be a teacher forever. I want to study further and I don’t want to be stuck in a class for the rest of my life.

INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?

D: My lecturer doesn’t come to class with fancy stuffs like a laptop or a projector. He uses a blank paper and a pencil only. Then we work together with him. For me this is why I understand mathematics better. If a lecturer come with many slides or a ready-made presentation and show us, saying ‘this is how we should do, work it out’, then I cannot follow. A lecturer comes with a paper and a pencil and a lecturer and students work together, that is the best way for me. So far he is the best mathematics teacher I have ever met from primary until now. We are allowed to stop him and ask him to explain more.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?

D: He usually uses verbal explanation but shows his procedures (visual presentation).

For me it is very suitable to study math. It is because I remember what someone said very well and what I saw help me to understand more.

If I talk about my style – visual or verbal, I would say I have both styles, because I always remember what someone said and through seeing I understand better.

INTERVIEWER: What kinds of participation are happening in mathematics class?

We have a lot of opportunities to participate. He asked us come to the front and worked it out on the board. If we did get the wrong answers then he corrected us.

He is very patient. Even he says we can come and see him whenever we can’t understand how to work it out. Even we are allowed to work out on the board in his class. After some students do, he does again, which helps us understand better.

If we go to his office, he first asks us to do on our own, after that he corrects us and explains why we went wrong.

INTERVIEWER: What type of perspective is provided on the information presented?

D: it is sequential way.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively
D: I am very satisfied with his teaching style and classroom environment, but if I say something I wish, it would be good if students have more exercise for self-study and more discussions with peers in class.

VII. G (201404655 / Engineering / 1st year)

INTERVIEWER: my research is about teaching styles of lecturers and …

INTERVIEWER: What is your major subjects?

G: it has to be mathematics, physics and applied mathematics?

INTERVIEWER: are you planning to study mathematics? Are you going to choose mathematics as your major?

G: I don't understand some of what lecturers in engineering are doing, I don't understand the whole major things. I didn't decide that yet, I just chose modules.

INTERVIEWER: Are you interested in studying mathematics?

G: I have been really enjoying studying mathematics from my high school. Only mathematics, I feel it is just continuing.

INTERVIEWER: My research is about the teaching styles of lecturers and the learning styles of students. Unlike you, many students are struggling to study mathematics. Do you know that?

First of all, they are not really interested in mathematics; second of all they don't have enough knowledge to cope with university mathematics. So (my research is about) how can we make it better? Even though students’ major is not mathematics, they can enjoy studying mathematics and also lecturers can do their best to help students. (explained teaching styles)

Most of UJ lecturers’ teaching style is quite teacher-centered teaching style. What do you think about this?

G: it would make it hard students in a way like they just give information then expect (students) to study. Although it is good because they give us information feel like they put more pressure. I feel the one with more opportunities is better.

INTERVIEWER: then can I say that you prefer student-centered teaching style? Why do you think if a lecturer has a teacher-centered teaching style, students feel more pressure?
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<th>Line</th>
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<tr>
<td>518</td>
<td>G: let say they just give you information, teach you and leave you. That is not the only module you have. You have all other modules. You have to go and try to understand information. On your study you don’t want to get just information.</td>
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<td>520</td>
<td>We students want to understand and make it practical so the knowledge can stain within us. In our study, we need to understand well and apply it. In doing so we need a lot of time. My point is if lecturers give us practical examples then it would help students understand the concepts and theories. It will encourage us to reflect what we are learning. Or I can say if a lecturer explain some concepts from the origin, showing us where it comes from and how it derives, it can help students understand more and remember longer.</td>
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<td>528</td>
<td>INTERVIEWER: what kinds of teaching styles impress you so far?</td>
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<td>529</td>
<td>G: Some lecturers gave us information and do exercise and the lecturing is done. Others give us information of course; afterward give us time to do it on our own, like 4-5 activities. We students try to solve the problems and lecturers go back to the program and show us which mistakes students can possibly make. It is essential to make it sure that we really understand what we are learning on our own. Without an opportunity, though we listened to what lecturers taught us, we need to start over when we study by ourselves. The lecturer I would like is those who is not only delivering information but also giving us chance to practice on our own. I want to practice in the classroom. If I find something I cannot understand in my room, then I got frustrated and I won’t be able to carry on.</td>
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<td>539</td>
<td>INTERVIEWER: do you frequently visit lecturers and ask questions?</td>
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<td>540</td>
<td>G: I don’t visit them. Frankly speaking, I might be wrong, I feel like it takes time. Since peers are always available, I usually ask classmates.</td>
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<td>542</td>
<td>INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?</td>
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<td>543</td>
<td>G: I think lecturers provide concrete information but I am confused with concrete and abstract information. Yet I prefer abstract information.</td>
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<td>545</td>
<td>If a lecturer gives us a formula or equations, then I would feel just concrete information and I can hardly remember that.</td>
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<td>547</td>
<td>In other word, if a lecturer explain some formula or theory in a way ‘how this theory derives, what is the origin of the formula’, then it would be very helpful for me.</td>
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</table>
If a lecturer starts ‘who brought this idea, how it proved, and how it is applied’, which make me easier to understand.

**INTERVIEWER**: What mode of presentation is stressed (visual / verbal)?

The presentations are provided in both ways. We don’t have a lot of discussion in class. Usually a lecturer explains and asks us to answer the questions. In a class, I ask many questions if I don’t understand.

**INTERVIEWER**: What kinds of participation are happening in mathematics class?

G: We get a chance to participate but we are usually sitting and listening to though I want to participate. In a sense I can say it is passive. I expect the class would be active.

**INTERVIEWER**: how do you want to change it?

G: To increase the participation, firstly students should be active. If students keep quite, then lecturers would carry on. Lecturers are going to think we understand. I know they are very helpful and willingly explain more. So in my opinion, it depends on students’ attitude. The more students are willing to join the class, the more there will be more benefits for students.

**INTERVIEWER**: how about tutorial time?

G: Tutorial time is perfect for me. A lecturer provides many exercises without lecturing and we can work on our own. If we have questions, we are allowed to questions constantly. I am so happy with tutorial time and there are a lot of opportunities to work together.

**INTERVIEWER**: you believe participating is important to study mathematics. Is there any preparation for students to participate?

G: Students need to study in advance & prepare for the lectures. I don’t see how we can participate without preparation. That is why we can have consultation time and tutors. If students just go to class and listen to very new concepts then it doesn’t make sense to participate in class. Without studying in advance it is almost impossible to participate. I also try to study in advance.

**INTERVIEWER**: What type of perspective is provided on the information presented?

(sequential / global)

G: It happens normally in a sequential way.

Step-by-step means we understand one thing and move to the second thing. Right?

I would say I am comfortable with sequential way of teaching since I have never experienced a
INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

G: I can't find any problem in our current system though I didn't get the distinction. 😊

VIII. I (201136294 / Science / 3rd year)

INTERVIEWER: This is from lecturers. (explained teaching styles…)

most of UJ lecturers’ teaching style is quite teacher-centered teaching style and 2 of UJ lecturers are student-centered. What do you think about this? Are you first year?

I: 3rd year.

INTERVIEWER: so your major is mathematics, right?

I: mathematics and computer science.

INTERVIEWER: do you like studying mathematics?

I: I do enjoy.. though getting some challenges. Yet I wouldn’t want to continue to study mathematics. I would continue to study computer science.

INTERVIEWER: Generally are you satisfied with mathematics lecturers’ teaching?

I: No… there are couples of very good lecturers, but sometimes I feel lectures are really useless, I mean attending lectures. I just go but I didn’t get enough what I need. Actually sitting down and studying, looking at the textbook by myself.

Only the time when I feel I get enough was free reading, theory course. But math course that I like is ‘descriptive mathematics’. That was what I did last year, Dr. C. It was much organised and I could guess what the class test would be and how I should prepare. At that time I didn’t have to make a note. I could just sit and listen to what he said. Yet this semester, the module I am attending requires a good note. Honestly I am not good at making notes in an organised way. While attending the class, I realise I would be able to get something only when I read the text book by myself. Attending the class, I feel, it confused me more.

INTERVIEWER: what is an organised lecture?

I: It shows what the important things are beforehand. If I go to class, it is easy to understand
323 | P a g e

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<th>Line</th>
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<tr>
<td>606</td>
<td>examples. I don’t mind they use a lot of slides or extra information. As long as I can follow without making notes, I would be ok. For instance, lecturers in computer science use diagrams and some visual presentation. It helps me understand what it is going on in class.</td>
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<td>609</td>
<td>INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?</td>
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<td>610</td>
<td>I: It is more abstract. I follow and grasp the abstract information but if there is a relation with the real life then it might be easier for me. Actually I got the message that it would be the students' job to understand the concept with the connection of the practical example. It is because we, students have a different background and interests. Yet if a lecturer give us a couple of examples, then it would make it easier for students to know what it is about and to remember.</td>
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<td>616</td>
<td>INTERVIEWER: What mode of presentation is stressed (visual / verbal)?</td>
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<td>617</td>
<td>I: I would say 'verbal'. Lecturers are lecturing and students are making notes. Since I am not good at making notes, if a lecturer use diagrams and pictures of graphs, it is helpful. It makes it easy to catch what's going on. What I wish from lecturers is to help us understand. For example with couples of points we have to know, not so much writings, or with notes we can understand during the lecture. (perfectly prepared lecturing) if I understand well during the lectures it always make my self-study easier. One more thing I wish is getting more exercises during the class though it is not always possible. Apart from marking if we have many exercises, it would get us know where we are and I guess it could encourage students to have desire to study more. For me when it comes to tests, my attitude quickly changed. I studied not because I want to be knowledgeable but because I want to just pass. If I think about myself sitting in the library, I have more intent to understand.</td>
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<td>630</td>
<td>INTERVIEWER: What kinds of participation are happening in mathematics class?</td>
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<td>631</td>
<td>I: We usually are asked to sit and listen to what they say. I believe it is important to participate in the class. The more we do by ourselves the more we understand and remember. Just sitting and listening to make us sometimes wonder. If I have opportunities, I would concentrate more.</td>
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<td>634</td>
<td>INTERVIEWER: how does tutorial time work?</td>
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| 635  | I: We don’t have a lot of tutorial time. It is for 1st and 2nd year students in most cases. The 3rd year students are asked to study by ourselves (we have it couple of times but we don’t have
There is a tutorial time that has less interactive. While sitting there, though I found something I don’t understand, I don’t ask, thinking maybe we are in behind work.

### INTERVIEWER: do you frequently visit lecturers and ask them?

I: I don’t go to the lecturers. It is because I usually work behind the schedule so when I have something I couldn’t understand; I figure it out by myself with textbooks or the internet.

I think lecturers also expect students to work hard, so I am wondering if I ask them, they might be disappointed. If I study in advance then I am more willing to go and ask them.

### INTERVIEWER: What type of perspective is provided on the information presented?

(sequential / global)

I: Most of time, it happens sequential perspective. I don’t say I am not comfortable with that, but if a lecturer show the big frame and explain what we are going to do in the whole session and go to details, then it would help me understand more. Without knowing the whole story, I feel like being lost or not interested in that.

### INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

I would like to have more exercise in the class. I know it is not always possible because lecturers need to cover the works. Apart from marking, if there are more practices it would be helpful because when it comes to marks I change my attitude due to pressure. I realise that when it comes to marks, I am no longer interested in understanding, but I just want to get the points and try to memorise something in order for me to pass. If I remember correctly, when I sit in the library and do self-study, I intend to more understanding and enjoyed it without pressure. Another thing is that I would like lecturers to make use of quiz on line. With the quizzes on line we can manage our time and arrange our schedule for self-study.

### IX. J (201464428 / Science / 1st year)

INTERVIEWER: are you the first year? this is (interview) questions I am going to ask. Shortly my theme of research is.. (explained) what do you think about teacher-centered teaching style?

J: just for math specifically. I found, I studies engineering last year so I tasted a bit of differences of lectures last year and this year. Well, last year they just delivered information
to you, you sort of fell along with them. Whereas this year I learned Mrs. J’s class, she has a lot of hands-on, wailing on class, helping people, getting students’ problem to solve and moving on. There is more interactive, people are impressed and expect to take Information.

**INTERVIEWER:** Do you enjoy studying mathematics?

J: Sort of. I enjoy this year than last year, I enjoyed math more at high school than this year.

**INTERVIEWER:** You don’t feel uncomfortable lecturer’s style. What type of information is emphasised by the instructor (concrete/abstract)?

J: They bring the basic concept down first and do any sort of problems. Also we learn theorem and theories in most of time. Let me say the whole information is quite abstract.

**INTERVIEWER:** What mode of presentation is stressed (visual / verbal)?

J: I would say there is much more visual aspects. We used to write down everything, drawing the diagram and looking at what is written on the board. Lecturers need to explain verbally, but it would be very hard to understand verbal explanation without visual presentation (diagram or the whole procedure). If a lecturer explains without writing down and showing us what is going on, it would be harder for students to get information.

**INTERVIEWER:** Do you prepare mathematics class in advance?

J: I have never studied in advance because I learned most of concepts in mathematics class in my high school. And I can quickly understand the new concepts.

**INTERVIEWER:** Do you believe it is important for student to participate?

J: I think it is important, because if a student just write down whatever a lecturer writes on the board without thinking and questioning, it would be harder to take in information. I think sitting and watching what the lecturer is doing would help us very little. It is like the more you practice the more your brain gets to know. Thinking and questioning by ourselves make us find our own problems. Like my lecturer, giving us time to exercise on our own and allowing us to ask if we cannot do by ourselves, it is very helpful. Everybody can participate in her class. Without practices, there is no benefit, I believe. Going back to my mathematic class, students eagerly want to sit in front and we are very active in the class; raising hands, questioning and discussing.

**INTERVIEWER:** Is there enough time for students to participate as much as they want in her
Generally there is a lot of work that should be done in class but as I told you, I have never been with lecturers or tutors outside of the class. I think we do have enough time to handle problems. Of course it is not major problems. She can come and quickly help us out. For some students who are struggling with math it is not enough time in class, but mostly it works.

INTERVIEWER: do you think the reason you are not struggling with studying mathematics is because you learned well in high school?

J: I was in the top class of mathematics and what I learned in high school especially from AP class covered 1st year mathematics. I was before coming to the university the basic concepts.

INTERVIEWER: What type of perspective is provided on the information presented? (sequential / global)

J: More sequential! We never see the big picture, how everything will link up together. For instance, when we learn ‘the definite integral to solve volumes of solids of revolution’, we don’t really know what it means, we just learned how to solve individual problems and get to know the process. We don’t really know what ‘integration’ requires, but we know how to solve exercises.

I think everything we are learning takes place in a sequential way.

Nothing wrong with that! It is nice to just focus on one thing, get it done before we move to the complicated version.

INTERVIEWER: Have you ever tried to connect what you learn in mathematics class to other subjects?

J: In computer science, we had to sketch graph randomly generate them. So I used graph techniques which were from mathematics class, but it is not necessary to include something complicated from mathematics. Maybe later it would be necessary when I have to do a big project, but at the moment I don’t see the needs.

INTERVIEWER: Do you see yourself as a sequential learner or global learner?

J: I think I am a sequential learner.

It is depends on subjects, especially computer science, I believe we need to know how to fit in together and what would be like as a big picture. Yet in mathematics, I don’t know it is necessary to look at the information in a global way. Just at the beginning stage, if students can see the bigger picture, it would be helpful for us.
INTERVIEWER: Have you ever learned mathematics in a global way?

J: Maybe in my high school. It might be because there were less students but more motivated students. We tried to see what would happen later and how it could be connected to other subjects. I remember we sometimes talked that.

Now we don't have much time to find the relevance. We only put an effort to get the works done as soon as possible.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

J: So far what I am doing is quite fine. I don't really see how to be taught any better.

What happens in the class is wonderful especially regarding to the participation of the whole class. We sit in a group and work together for 3-4 persons. If someone has problems, 3 of us have a solution. In doing so, we teach others and when we teach other, it can also help us to understand more; explaining the concepts.

Generally to improve my mathematics, I need to spend more time to practice. There is not something to fix or improve in the mathematics classroom.

INTERVIEWER: apart from lecturing, is there anything to fix to improve situations regarding mathematics?

J: I think learning mathematics more effectively and efficiently requires students’ dedication. After understanding concepts, we need to sit and repeat practicing until we won’t forget.

If a student try to find other way except dedicating themselves in studying.

X. M1 (201405301 / Science / 1st year)

INTERVIEWER: This is my doctorate research. The purpose is to survey those who teaching mathematics and explore their teaching style. At the same time students’ learning style as well. The point is how we can make it better, though students’ main major is not mathematics, they can enjoy studying mathematics. Here is the score of teaching styles of mathematics lecturers. As you can see the score of Expert & Formal authority is higher than Facilitator & Delegator. In other words, most of UJ lecturers’ teaching style is quite teacher-centered teaching style. Do you enjoy studying mathematics?
M1: When they teach as if they think we understand what they are saying. It happens at most of
time. Nevertheless we don’t usually raise hands and ask questions. It is because what a lecturer
says is quite complicated and what they write on the board is long, then we don’t know what
and how to ask. I guess student-centered teaching would be helpful, because in student-centered
style teaching, I can study on my own and come to class and ask.

Since I have a lot of modules, I don’t have enough time to study in advance so when I attended a
class, I couldn’t understand enough. Afterward, I go to library and sit and study by myself.

INTERVIEWER: do you frequently visit lecturers and ask questions?

M1: I don’t come to them.

INTERVIEWER: then how do you solve the problems that you don’t really understand?

M1: usually if I have something that I don’t understand I go to Youtube. I learned the video
from other universities. There are many different videos and different teaching styles. If I find
something different from my lecturer and sometimes I understand better.

INTERVIEWER: I interviewed 4 lecturers who want students to come and ask questions but
students don’t visit them. Not only you but also other students don’t do that. Why do you think
many students visit lecturers?

M1: If we don’t understand in class, maybe we won’t get them as well though we visit lecturers,
maybe they confused us more. I had the same experience. The other day, I visited one lecturer
to ask questions. I didn’t get what I wanted and in the end, I was
confused more.

INTERVIEWER: what cause you confused at that time?

M1: I think it happened because I didn’t have enough basic knowledge. When they explained,
they didn’t start from the beginning (of course I didn’t ask them to explain from the beginning
since it is time-consuming).

At the same time we, students don’t help ourselves like looking forward to gaining more
knowledge or asking though lecturers try to help us.

Since that time, if there is something I couldn’t understand I find the video on the ‘Youtube’ and
watch them. What I observed from the various video, there are diverse types of teaching, so I
can find something more suitable to my understanding.

What I do for studying mathematics is teaching myself until I understand that. If I can’t figure
INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?

M1: I am not sure about the difference between concrete and abstract information, but I struggle to understand theories and complicated concepts in ‘calculus’ class. I need to first go through on my own if I can understand that. Today what we learned was quite new for many students. Our lecturer noticed that we didn’t understand and he said he would explain more at the tutorial time.

INTERVIEWER: How do you help yourself understand abstract information?

M1: When I study by myself, I usually write down what we learned in the class and highlight key word. I believe it is important to understand the meaning of words so keeping on reading through and memorizing certain formulas or symbols help me.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?

M1: it is usually visual. Lecturers show us diagrams and graphs. Visual presentation is more helpful for me than discussion or verbal explanation. Visual information makes me more comfortable.

INTERVIEWER: What kinds of participation are happening in mathematics class?

M1: Our lecturer wants us to participate and answer him. Yet we don’t respond him. Usually we keep quite. I think the reason we keep quite is we are shy, thinking if I ask this question, then someone might judge me or think ‘that is the stupid question.’ We don’t have confidence. Another reason is the language we are using is different from the one lecturers use. Though we have something to ask, it is difficult to put them together properly.

INTERVIEWER: How about the tutorial time?

M1: There is not that difference. Some students raise their hands and ask but many students are quite. We are asked to do activities but we don’t work in a group in many occasions. Therefore we work silently. Yet, there is a difference in ‘statistics’ time. The activities are printed out before the tutorial time so we can work on in advance. When we attend the tutorial time, we discuss everything together with the lecturer. It is very helpful. Compared to ‘calculus’, we performed better in the statistics.

INTERVIEWER: Let’s talk about why your achievement were better in ‘statistics’ than ‘calculus’

M1: Firstly, my interest, Secondly, study materials which were given to us, extra activities which
is very helpful. Thirdly, the characteristics of the subject. Regarding the teaching styles of 
lecturers, a lecturer who is teaching ‘statistics’ is a good lecturer and he always try to 
interact with students. Nevertheless we are quite. I guess the reason we are always quite is 
because we are concerning too much other students and we don’t know how to pose 
a question properly. We are really not sure of whether lecturers will accept 
our questions or not. In high school we were in a small class. It wasn’t difficult to ask questions.

**INTERVIEWER:** What type of perspective is provided on the information presented?

**(sequential / global)**

*M1:* It happens ‘Step-by-step’. I am comfortable with that. At least I can follow (though I don’t 
understand concepts completely).

**INTERVIEWER:** How would you like to be helped to learn mathematics more effectively 
and efficiently?

*M1:* As I said before, the study materials provided for us in advance are helpful. Yet I think we 
are the problem because we don’t study hard or prepare in advance though we are struggling 
with mathematics. I can see lecturers make an effort to improve our knowledge and skills. It is 
impossible for them to help individual student. We need to study hard. without putting an effort, 
we, students, are complaining ‘mathematics is difficult, something I cannot understand’ … etc.

For example, we don’t go to ask lecturers, we don’t really participate in the classroom.

### XI.

**M2 (201139984 / Science / 3rd year)**

**INTERVIEWER:** This one is more in depth about the questionnaire you completed. It is more 
about how to process information (explained the difference between ‘sensing’ & ‘intuitior’).

What type of information is emphasised by the instructor (concrete/abstract)?

*M2:* It is more abstract. She doesn’t go into in very depth. She wrote something on the board and 
asks questions to students. Let me say she doesn’t teach deeper concepts unless someone asks 
questions. It is very basic information.

**INTERVIEWER:** What mode of presentation is stressed (visual / verbal)?

*M2:* It is more verbal. My preferred way is first a lecturer explains what we have to learn and 
then show us visual presentation. I think I need both ways.
I have to see examples first and understand the concepts. If I try to explain the concept to others, I think I would grasp more.

When a lecturer provides more visual presentation, I can get more information, I feel.

And also when I work in a group, if I have a chance to give explanation to others, it would always help me understand concepts.

**INTERVIEWER**: What kinds of participation are happening in mathematics class?

**M2**: Learning mathematics in my opinion, students should participate more than sit and listen. It is because mathematics is logic-based subject. If you don’t understand a certain concept, when they actively participate, they could get more.

Active attitude in mathematics class, for example, is to answer the questions when lecturers ask. If there is something they don’t understand, ask lecturers to provide more examples.

In real class, we have much time to think and participate, with which I am satisfied.

**INTERVIEWER**: What type of perspective is provided on the information presented? (sequential / global)

**M2**: I firstly see myself as a sequential learner. I am comfortable with the current system that is sequential way. I think lecturers are teaching students as they are teaching themselves.

For example, when we start to learn new sections, we need a lot of explanation. However, some of lecturers teach as if students have already learned before.

Consequently, some students cannot follow the contents; it causes them to feel frustration and discourage to study. In many occasions, I expect a lecturer to start from the basic things (I usually teach myself if I don’t know the basic things).

**INTERVIEWER**: What is the most difficult thing for you in math class?

**M2**: Going back to sequential-global, if a lecturer teaches in his or her preferred way, then I quickly lost interest because I can’t follow. In a sense, I believe it is important the match between learning styles of students and teaching style of a lecturer.

**INTERVIEWER**: How would you like to be helped to learn mathematics more effectively and efficiently?

**M2**: More examples and explanation in a class!

As I told you before, I expect a lecturer to explain from the basic to the top in a step-by-step way.
| INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)? |
| M3: I would say abstract. Most of concepts they involved (in class). Most of time, it was 'abstract'. They describe 'concept' and it is related to 'theoretical part'. I can say I am comfortable with that. It is because the more I understand the concept the easier I can see what I should do next. |
| INTERVIEWER: so is what lecturers explains theorem and concepts easier for you to understand? |
| M3: yes it is. |
| INTERVIEWER: What mode of presentation is stressed (visual / verbal)? |
| M3: I would say it is 'verbal'. The presentation is not showed in a visual way. Of course the lecture use pictures for instance when we study graph, but there are a lot of explanation with regards to the graph. About myself, I can see myself as a visual learner. It is a sort of challenge because firstly I need to adapt myself to new environment of which I am not really familiar. When I was in high school, I learned in a visual way. There used to be a lot of pictures, diagrams.. etc. Yet I am getting used to that. |
| INTERVIEWER: How did learn mathematics visually in high school? |
| M3: During the holidays, teachers gave us mathematics CD with which we could do self-study. When I study by myself, if I couldn't understand some part, then I could stop playing and going back, listening to and watching again. |
| INTERVIEWER: What if all lectures are recorded and that CDs are available to students? |
| M3: I think it would be very helpful. I need to time to think and to try to understand while attending the classes. If I have an opportunity to listen to what lecturers said, definitely it would help me study at home. |
| INTERVIEWER: What kinds of participation are happening in mathematics class? |
| (active/passive) |
| M3: Students should be active. Mathematics, you cannot just watch. Learning mathematics requires active participation. If we just sit and watch and wait for lecturers to do everything, we would get very little and quickly forget what we learned. We need to listen to what they are saying and write it down, do some problems and take notes. Though our curriculum is quite tight, |
if we attend the class and go home and remind ourselves of what we studied, then it becomes easier. I don’t think it will take long for students to participate in class. As I told you before, the CDs might be helpful, but without that kind of instrument, as long as students recall what happened in the classroom and diligently make an effort to understand the content, we won’t have a problem.

**INTERVIEWER:** What do you think about the fact that UJ students are willing to participate though they are little bit weak in mathematics?

**M3:** I don’t know what to say, students need to participate actively as I told you. If they are passive, I don’t think they can make it.

**INTERVIEWER:** What type of perspective is provided on the information presented?

**(sequential / global)**

**M3:** I would say it is ‘sequential’. Mathematics problems in most of case involves step-by-step. If you miss some part, you won’t get the right answer. Since the class I attend proceed in a sequential way, I am very comfortable with that.

**INTERVIEWER:** How would you like to be helped to learn mathematics more effectively and efficiently?

**M3:** According to me, for example, during the holiday I would like to have more work; assignments, projects, more activities. So I can practice more. Once I finish practicing, lecturers or tutors can check and feed me back. In that way, I can find what I couldn’t understand and improve my knowledge.

I believe the more I do, the more I will enjoy and be motivated.

The university life is quite different from high school. I felt there was a big gap between them.

Firstly, there is huge amount of workloads. Secondly it requires self-discipline. No one really tells me what I need to do. It took time for me to accommodate myself.

**XIII. M4 (201457790 / Education / 1st year)**

**INTERVIEWER:** What type of information is emphasised by the instructor (concrete/abstract)?
| 925 | **M4:** Abstract side she does emphasises but she also uses concrete. |
| 926 | **INTERVIEWER:** can you give me an example, what kinds of concrete information? |
| 927 | **M4:** for example, those problems that you can learn theoretical way of calculation so the |
| 928 | question which is more realistic like “where is the building?” we have to calculate, we have to |
| 929 | actually look at the things, |
| 930 | **INTERVIEWER:** there are two kinds of learners – Sensing & Intuitor (explained more…) how |
| 931 | do you see yourself? Sensing or Intuitor? |
| 932 | **M4:** I am not sure about myself; I would love to analyse and break down and put them together. |
| 933 | It helps me to understand the origin ‘where does it come from?’ |
| 934 | **INTERVIEWER:** What mode of presentation is stressed (visual / verbal)? |
| 935 | **M4:** There are a lot of explanations but it includes diagrams and pictures. |
| 936 | For me to get more information, I need both presentations (visual & verbal). |
| 937 | In class, I usually read the textbook and try to figure it out while thinking. |
| 938 | If I find something difficult to understand then I write down. I don’t make a lot of notes because |
| 939 | writing something can interrupt my thinking. |
| 940 | **INTERVIEWER:** What kinds of participation are happening in mathematics class? |
| 941 | **M4:** I don’t know whether it can be said ‘passive’ or ‘active’, but what she did in class, first she |
| 942 | explains something and gives us a lot of exercise to solve. After that, she walks around us and |
| 943 | helps us if we don’t understand. It might be the time to be active. |
| 944 | **INTERVIEWER:** is it easy for you to stop her while she is teaching? |
| 945 | **M4:** She is approachable. She tries to answer all means and encourage us to come to ask her |
| 946 | again. After class, we can come to her and ask. |
| 947 | During the tutorial time, we have a group discussion. In a way it is an opportunity of active |
| 948 | participation. I think it is quite good time for students. |
| 949 | **INTERVIEWER:** do you feel a gap between the university and high school? |
| 950 | **M4:** I am studying mathematics and physics at the moment. And it is not difficult for me to catch up |
| 952 | what I am studying. With the knowledge from my high school, I can cope. |
| 953 | **INTERVIEWER:** What type of perspective is provided on the information presented? |
| 954 | (sequential / global) |
| 955 | **M4:** It is sequential. I am comfortable with that. Yet I try to think in a global way since I study |
mathematics and physics. I prefer thinking how it does work, connecting to what I have already learned.

**INTERVIEWER:** What can it be a good way to help global learners learn effectively and efficiently?

M4: I think when lecturers are done with the basic things and when students understand the concepts, then lecturers bring many problems from other subject which can be related to the concept students are newly learning. For instance, ‘Distance = Speed * Time’. Looking at this formula, it doesn’t give us a lot of information. Yet if it is placed on some practical problems from physics, then it become easily understandable and encourages students to think. In that way, students can see the usefulness of what we are learning and it somehow motivate us.

**INTERVIEWER:** How would you like to be helped to learn mathematics more effectively and efficiently?

M4: What I prefer is to learn where it derives from. If I understand the origin, it becomes a good sense to me and I can easily connect one another to have deeper understanding. Without knowing where it comes from, we are not studying. We are forced to memorise and then it would be boring for many students. Many people say when we study mathematics, we need to practice a lot, but for me thinking is more important. Digesting (reading the textbook and thinking how it works by myself) is crucial in mathematics. That is why I expect lecturers to give me original information.

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**XIV.** N (201402967 / Science / 1st year)

**INTERVIEWER:** this is lecturers’ teaching styles..(explained more)

N: this is true. Some of lectures are more like delegator, wanting to interact more, but majority are more like experts. They just come and do what they have to do with us. That’s it.

**INTERVIEWER:** are you comfortable with that?

N: I can’t say I am comfortable but I think I got used to that. , accepting this is the university Works.

**INTERVIEWER:** is it different from high school teachers?

N: Teachers in high school, they put more efforts to make sure that students understood. Even
to students who didn’t want to study teachers in high school put an effort. But here if
students cannot understand, they have to figure out by themselves. They say that there are
lecturers, tutorials and consultation time, whether you sue or not is up to you.
I expected more in the beginning, but I am aware of how works at the university.
**INTERVIEWER:** commonly lecturers treat university students as adults.

**N:** first I expected more like more friendly .. now I accept this as reality. Lecturers are friendly if
you take time to go for consulting.. but they don’t do outside of the reach ‘this is my lecturing
time, this is my consultation time’, out of this time, it’s your own business.

**INTERVIEWER:** do you visit lecturers frequently?

**N:** Usually I ask friends who understand something I couldn’t. The reason I prefer asking to
peers is that they explain in a way how they grasp the new information. Then it would help me
understand better. They use certain words which is easier, much more fun and understandable.
Especially in a class of calculus, I don’t know exactly why, but I am not comfortable to approach
to him. It is little bit intimidating 😞

Last semester, I got a good mark of calculus with the help of one of my housemate. After that I
couraged more to study. However, if I know much in a certain module, like ‘statistics’ most of
contents I understand in class so it is not difficult to do self-study. If there is something I
couldn’t, I asked them in a class.

**INTERVIEWER:** What type of information is emphasised by the instructor (concrete/abstract)?

**N:** I think it is concrete. We read the textbook and work out examples from the text book.
I think I could understand better if there is more abstract information but what I am focusing on
now is what to do in order for me to pass, not getting information. Frankly I don’t really think about
why I am doing it, what is the whole point of what I am learning or how I could do better.
Also I don’t have good background regarding mathematics to digest mathematics and to have
deeper understanding.

**INTERVIEWER:** What mode of presentation is stressed (visual / verbal)?

**N:** Very verbal explanation with little bit of visual presentation

**INTERVIEWER:** What kinds of participation are happening in mathematics class?

**N:** The whole atmosphere is really passive. Though my lecturer tries to make it active, few
respond.

In most classes we just sit and try to take in what he says.
INTERVIEWER: Why do you think students become so passive?

N: Even with his jocks we feel being intimidating. For example, he jocks about how we wrote answers on the paper... etc. Also it was quite shorts.

Since we don’t know how to involve him and prefer asking each other, no one doesn’t pick up the hands and speak out though we don’t understand the concept.

It happens again and again. I can see he just ignores that.

I know we are so passive but it is not easy to talk to person.

Most of us are getting used to an active lecturer, like ‘statistics’ so when we go to his class, we are somehow discouraged. We naturally compared to each other 😞

INTERVIEWER: What type of perspective is provided on the information presented?

(sequential / global)

N: Mostly it is sequential way.

Step-by-step teaching is helpful and help us understand more.

It might be a problem if we try to apply to more complex exercises, but I am comfortable with the sequential teaching.

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

N: The ideal teaching style for me is more interactive, more demonstrative.

Instead of just teaching and saying ‘you have to do it because it is part of your course. Rather if a lecturer shows why I am doing and how it is to apply later and what benefits I would have, it would make me interested and encourage me do self-study. If I cannot find any practical reason, I cannot motivate myself. I am very happy when I understand something which looks difficult.

For instance, when I prepared the previous test, I wasn’t really interested in passing. I enjoyed studying and found myself very satisfied because I understood what I was doing for the exam.

Eventually I could get a good mark by understanding.

I am willing to put an effort to develop myself once I am motivated.

If students learn in that way it would be more valuable than just passing.

Putting a lot of efforts from students’ side is important I know.

Yet another aspect personally, once I put an effort I want to see a good result.

If I gain a good result then it encouraged me study more, but
If I don’t get a good result then it discouraged me more.

**XV. T1 (201227818 / Education / 2nd year)**

The theme of my research is whether the teaching style of lecturers and the learning styles of students math or not. The point is lecturers need to teach students in a various way. Because lectures have their own not only teaching style but also learning style. So usually they teach according to their own experience since their experiences made their own teaching styles. Yet they have to change their teaching style to accommodate many students. This is the results of lecturers’ teaching style. (explained more)

I would like a lecture give me an opportunity to do things by myself. Yet he or she needs to offer a bit of information first. Of course he needs to give us foundation, From there we can go and figure out on our own. I don’t know exactly teacher-centered teaching style, but if I say based on my experience, if a lecturer talk in a overconfident way 😕, it would intimidate students who cannot understand the content well. He or she has to consider the students who have weak background in mathematics. Sometimes lecturers expect us to know math and be like him or her.

**INTERVIEWER:** do you enjoy studying mathematics?

I hate mathematics but now I enjoy studying mathematics here at university.

**INTERVIEWER:** What happened? How?

I guess I was motivated by a group of people (my peers and tutors). Group studying really helps me to gain confidence. My mark went up and even peers come and ask me to help them.

**INTERVIEWER:** it means that group studying helped you?

yes it helped me a lot. Sometimes when I try to explain to them, then they corrected me.

Sometimes we are arguing then we come to Dr. L then he tells us to write something on the board. I think that was how I gained my confidence.

**INTERVIEWER:** UJ students’ learning styles is collaborative.. quite strongly..

believe me. We cannot learn mathematics by ourselves.

**INTERVIEWER:** what is the most impressive lecture?

Come to class, explain what we are going to study, first and allow us to work in a group and encourage us to figure out on our own in class (maybe for 10 min.). If we cannot grasp though we
work together, after that, a lecturer explains more and help us understand some certain complicated concepts.

It is because I don’t have confidence to study by myself. Also when I try to study alone, I am less motivated than in a group. Only time when I study by myself is the day before exams since I know I need time to think what I have done in a group.

INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?

T1: Abstract information which is difficult for me to grasp!

It might happen because I am not familiar abstract information. After a lecture, I go to a tutor and ask questions then the explanation of tutors is understandable.

INTERVIEWER: What mode of presentation is stressed (visual / verbal)?

T1: A bit of both, but most of time he speaks and I write down everything he said. Otherwise I would be lost when I study by myself. Actually we are asked to make a lot of class notes. With class notes I can recall whatever a lecturer said in the class and it is always helpful, though I can see myself as a visual learner.

INTERVIEWER: What kinds of participation are happening in mathematics class?

T1: I don’t think we have a lot of opportunities unless we tell a lecturer we don’t understand. Yet we usually keep quite because he or she would ask us to try out by ourselves first if we say we don’t know.

For me it is easy to ask tutors, so though I don’t understand what is going on in class, I am waiting for visiting tutors.

INTERVIEWER: What type of perspective is provided on the information presented?

(sequential / global)

Step-by-step process

T1: I am very happy with the sequential explanation. It is easier for me to understand anything comes with step-by-step

INTERVIEWER: How would you like to be helped to learn mathematics more effectively and efficiently?

Studying in a group is important for me. If we have group works in class or do assignment in a group, it would be good. Anything in a group motivates me. (Active participation)

INTERVIEWER: If many things are done in a group, what is the best way to help students who
1191 are not willing to participate?
1192 T1: In my opinion, the best way is to separate those who are working hard from those who don’t
1193 and let them take a responsibility. It should happen among students.

XVI. T2 (201212107 / Science / 3rd year)

1194 INTERVIEWER: my research is about teaching styles of lecturers and learning styles of
1195 students. I would like to whether they match or to see lecturers’ view and students’ view
1196 Which year are you in? what is your major?
1197 T2: I am third year and my major is mathematics and statistics.
1198 INTERVIEWER: do you like studying mathematics?
1199 T2: yes, I do.
1200 INTERVIEWER: let me explain this. This is the teaching styles of lecturers. (continue to
1201 explain…) what do you expect when you attend the class?
1202 T2: I expect lecturers to briefly break down what I am going to do. What I expect from lecturers
1203 in the class is to explain what I should do to learn more by introducing the topics and by
1204 directing me. Then I will go through in detail by myself.
1205 Maybe if I have a problem I can go for the consultation. Maybe they introduce topics that I
1206 have not seen before. Afterwards I can do more details.
1207 INTERVIEWER: can I say then as long as they deliver the information (that you should know)
1208 you would be happy?
1209 T2: if they can show me diagrams and pictures, it would be helpful. I can go and read through and
1210 understand.
1211 INTERVIEWER: what if lecturers tell the main theme and ask what you want to study (“the title
1212 of today is like that, how would you like to study?) then you don’t feel really comfortable, right?
1213 T2: I wouldn’t have that confidence. First I need to read through then I would have confidence.
1214 INTERVIEWER: do you see yourself as an independent student or a dependent student?
1215 T2: first I thought I was a dependent student but later I realised that I am more an independent
1216 student.
1217 INTERVIEWER: What type of information is emphasised by the instructor (concrete/abstract)?
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<tr>
<th>Line</th>
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<tr>
<td>1218</td>
<td><strong>T2</strong>: It is more abstract information because mathematics includes more abstract information.</td>
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<td>1219</td>
<td><strong>INTERVIEWER</strong>: is it easier to understand abstract information?</td>
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<td>1220</td>
<td><strong>T2</strong>: I cannot say that I can understand fully abstract information, just here and there I can get a piece of information. After the class, I go to the library and read through the text book, then it become clear to me.</td>
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<td>1223</td>
<td><strong>INTERVIEWER</strong>: What mode of presentation is stressed (visual / verbal)?</td>
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<td>1224</td>
<td><strong>T2</strong>: It is more verbal...there are a few diagrams but mostly a lot of verbal explanation. I tend to remember more if I see visual presentations, but I am getting used to verbal presentation. For instance, if a lecturer draws a curve and explain what is going on the graph, breaking down details, I would get it quickly.</td>
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<td>1228</td>
<td><strong>INTERVIEWER</strong>: What kinds of participation are happening in mathematics class?</td>
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<td>1229</td>
<td><strong>T2</strong>: It depends on lecturers. Not every lecturer gives students a lot of opportunities to participate in the class. Some lecturers go through explaining everything and ask us 'do you understand?' then we can hardly say 'yes' or 'no'. Also not every student is eager to participate though they are given time to participate.</td>
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<td>1233</td>
<td><strong>INTERVIEWER</strong>: why do you think students are not active in participation?</td>
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<td>1234</td>
<td><strong>T2</strong>: I might be not correct, but what I noticed we tend to be proud. We think we know a lot. I guess it is because people outside (those who don’t study mathematics) expect us to know many things and to be very good at mathematics. It has been making us proud 😊. In the class, though we don’t understand, we don’t want to reveal ourselves, just holding back. This is what I observed and my story. When I have something that I don’t understand, I remember that and try to figure out by myself. I prefer asking a lecturer during consultation time rather than during the class.</td>
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<td>1241</td>
<td><strong>INTERVIEWER</strong>: Do you think participation is important to learn mathematics?</td>
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<td>1242</td>
<td><strong>T2</strong>: Yes, it is important. Sharing what we know and what we struggle to understand would encourage us to study more and give us benefits, such as studying guide or making clear notes. And yet we don’t share much in the class. Everyone is quite independent students; we don’t work in a group and we don’t do projects together.</td>
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<td>1247</td>
<td><strong>INTERVIEWER</strong>: What type of perspective is provided on the information presented? (sequential / global)</td>
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<td>1248</td>
<td><strong>T2:</strong> It is more sequential and I am comfortable with the. I think I get used to the sequential teaching.</td>
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<td>1249</td>
<td><strong>INTERVIEWER:</strong> How would you like to be helped to learn mathematics more effectively and efficiently?</td>
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<td>1250</td>
<td><strong>T2:</strong> I would like to have more application examples. Application examples mean ‘to where we can apply what we are studying’. We heard many times that mathematics is useful in various fields but we don’t have any idea of how it applies.</td>
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<tr>
<td>1252</td>
<td>Demonstration in both ways (visual and verbal) would be helpful. It can give me clear concepts since I am currently learning a lot of theories.</td>
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Appendix F: Coding Matrix

Participant Identifier:
Date:
Time:

Code List
Factual Information:

Analysis and Interpretation:

Open Code

<table>
<thead>
<tr>
<th>Interviewee K</th>
<th>Active participation (actpar)</th>
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<tbody>
<tr>
<td></td>
<td>Discrepancy of understanding (dispcundr)</td>
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<td>Absolute attendance (absatt)</td>
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<td>Teaching around the cycle (tcycle)</td>
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<td>Visual presentation (vispre)</td>
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<td>Practical problem-solving (pracpsol)</td>
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<th>Interviewee A1</th>
<th>Absolute attendance (absatt)</th>
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<td></td>
<td>Global learning (globlear)</td>
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<td>Independent study (indstu)</td>
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<td>Motivating students (motstu)</td>
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<td>Students’ dedication (studedi)</td>
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<th>Interviewee A2</th>
<th>Practical problem-solving (pracpsol)</th>
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<td>Low self-esteem (lowestee)</td>
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<th>Interviewee A3</th>
<th>Time to practice in the class (tmipra)</th>
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<td></td>
<td>Setting goals and leading (setgold)</td>
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<td>Providing intervals (prointva)</td>
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<th>Interviewee C</th>
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<th>Interviewee D</th>
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<td>Group work and study (growor)</td>
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<td>Interviewee</td>
<td>Materials for self-study (matselstu)</td>
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| Interviewee M3 | Materials for self-study (matselstu)  
Active participation (actpar)  
Dependency on lecturers (deplec) |
|----------------|----------------------------------------------------------------------------------|
| Interviewee M4 | Time to practice in the class (tmipra)  
Small group discussion (smgrdisc)  
Practical problem-solving (pracpsol)  
Global learning (globlear)  
Derivative teaching (drvtea)  
Motivating students (motstu)  
Hard to ask (Hardask)  
Comfortable with sequential (sequen) |
| Interviewee N | Many opportunities in the class (Mnopp)  
Low self-efficacy (loseeff)  
Group work and study (growor)  
Motivating students (motstu)  
Low self-esteem (lowestee)  
Discrepancy of understanding (dispcundr)  
Hard to ask (Hardask) |
| Interviewee T1 | Time to practice in the class (tmipra)  
Small group discussion (smgrdisc)  
Making notes (maknot)  
Low self-efficacy (loseeff)  
Group work and study (growor)  
Motivating students (motstu)  
Dependency on lecturers (deplec)  
Active participation (actpar)  
Low self-esteem (lowestee)  
Comfortable with sequential (sequen)  
Visual presentation |
| Interviewee T2 | Time to practice in the class (tmipra)  
Setting goals and leading (setgold)  
Small group discussion (smgrdisc)  
Many opportunities in the class (Mnopp)  
Students’ dedication (studedi)  
Practical problem-solving (pracpsol)  
Comfortable with sequential (sequen) |
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<tr>
<th>Interviewee</th>
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<th>Low confidence (lowconf)</th>
<th>Preferred collaborative atmosphere (collatmos)</th>
<th>Teaching around the cycle</th>
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Independent learning (indep)  
Global learning (globlear)  
Students’ focus on passing (focupass)  
Students’ dedication (studei)  
Alternatives from students (alterstu)  
Motivating students (motstu)  

| Interviewee Mrs. G | Unprepared student (unprestu)  
| | Preferred collaborative atmosphere (collatmos)  
| | Low confidence (lowconf)  
| | Small-size class  
| | Students’ focus on passing (focupass)  
| | Consultation time (consul)  

Axial Code

<table>
<thead>
<tr>
<th>Categories</th>
<th>Subcategories</th>
<th>Axial Coding</th>
</tr>
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</table>
| **Expertising**     | How to share knowledge         | Students  
|                     |                                | Professional development  
|                     |                                | Gradual explanations with visual presentations  
|                     | Lecturers                      | Elevating students’ academic level  
|                     |                                | Preparing students for further studies  
|                     | Both                           | Visual presentation  
|                     |                                | Cautious use of technology  
| Clear guideline     | Students                       | Directed instruction  
|                     |                                | Providing more academic resources  
|                     | Lecturers                      | Guidelines ultimately for independent study  
|                     |                                | Lack of students’ pre-knowledge  
|                     | Both                           | Well-structured instruction  
|                     |                                | Importance of class attendance  
| **Motivating**      | Collaborative settings         | Students  
| Students’ Learning  |                                | Mutual works  
|                     |                                | Tutors and peer assistance  
|                     | Lecturers                      | Manipulative teaching  
|                     | Both                           | Peer assistance  
|                     |                                | Useful tutorial time  
| Embracing ‘Sensing’  | Students                       | Explanations related to real-life experiences  
| students            |                                | Starting with concrete information  
|                     | Lecturers                      |  

| Climate Building | Adjustment to students' understanding | Students | Considering students' weak conceptual knowledge  
Lecturers | Many unprepared students for collegiate mathematics  
Active engagement both in an extrovert and introvert  
Both | Monitored disparity between lecturers and students  
Various ways of explaining |
|---|---|---|---|---|---|
| Active classroom environment | Students | No straightforward lecturing  
Practice exercises in class  
Lecturers | Difficulty to make students active  
Studying in advance  
Both | Approachable atmosphere  
Providing intervals |
| Participation in the learning process | Interactions | Students | Availability for assistance  
Low self-efficacy  
Low self-esteem  
Lecturers | Small-size classroom  
Students attitude  
Both | Small group discussions  
Use of consultation time |
| Options & alternatives | Students | Revisions, hand-on materials  
Lecturers | Time pressure  
Both | Diverse lesson activities |
| Flexibility for individual development | Visual understanding of abstract information | Students | Support of bigger pictures as introduction  
Lecturers | Making global (holistic) learning as an ultimate goal  
Students’ commitment to think critically  
Both | From sequential to global  
Context & relevant-tied up |
| | Both | Students’ dedication  
Effective & efficient lecturing time |