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Extending the Dialogue:

Interactional and Multimodal Strategies in Synchronous Mobile Mathematics Tutoring on MXit

by

Bonita Robbins

(RBBBON002)



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for the award of the degree of Master of Education*

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Supervisor: Dr. Marion Walton
Co-supervisor: Dr. Adele Botha

COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature: _____ **Date:** _____

ABSTRACT

The aim of this study was to explore the interaction between learners and tutors in Dr Math, a mathematics tutoring project that uses instant messaging and the mobile application, MXit. There is currently little computer-mediated communication research available about the uses of mobile instant messaging for mathematics tutoring. This study utilizes the Exchange Structure Analysis model (ESA), adopted from Lim (2006) to explore tutoring interactions between Dr Math learners and tutors over a short period. A quantitative analysis of turn-taking in tutoring interactions during February is used to identify the characteristic roles of tutors and learners; their strategies for controlling and directing dialogue; and the kinds of pragmatic moves that are used during the scaffolding of mathematics learning, as revealed by the Dr Math log for the month of February, 2010. The log consisted of N= 6084 turns in interactions between 190 learners, who interacted with three different tutors.

Analysis revealed patterns which differ substantially from conventional classroom discourse, where teachers set the agenda, dominate participation, and regulate and assess learner's contributions. By contrast, on Dr Math, tutors were responsible for only slightly more turns (54%) than were learners (46%) and in fact learners initiated interaction slightly more often than tutors. Moreover, successful tutors were able to use Dr Math to engage in lengthy interactions and intricate meaning-construction, although not all learners or tutors did so to the same extent. Although the majority of turns were mathematics focused, social interaction accounted for just over a fifth of turns. The long-tailed distribution of participation (similar to that commonly found on social media sites) revealed that the majority of learners interacted only briefly with Dr Math tutors. Learners Initiated a median of three interactions with tutors, and these interactions were relatively short, adding up to a median of ten turns of dialogue for each learner in the month. A smaller number of learners were responsible for a large proportion of the extended tutoring interactions, with one learner initiating 54 interactions, and another contributing to learner-tutor interactions that produced over 200 turns of tutoring dialogue.

Distinctive interactional roles are adopted by Dr Math tutors and learners, and ESA reveals these roles. In particular, tutors contributed a dramatically higher number of Reinitiate (RI) turns to the dialogues than learners did. This reflects the tutor's important role in scaffolding learning, or the need for tutors to ask questions to clarify both the prior mathematical knowledge and the specific intentions and needs of learners. Thus ESA also shows which tutors focus on answering questions or providing solutions rather than extending dialogue or developing learners' understanding of mathematics.

Further qualitative analysis explores the ways tutors and learners responded to the constrained multimodal repertoires available to them on the text-based instant messaging platform. Many tutors and learners persevered despite the difficulties of 'texting' about mathematics, and they were able to interact meaningfully using the semiotic resources at hand, namely approximations of mathematical notation, transcoding of symbolic and visual languages, and also the textisms characteristic of MXit use among teens in South Africa.

While researchers have assumed that mobile phones offer converged media and a wide variety of multimodal options for interactions, the case of Dr Math highlights the way that projects targeting feature-phones on platforms such as MXit remain constrained by the requirement that they remain accessible and affordable to the widest range of mobile internet users.

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“To educate means to serve selflessly the originality and individuality of another, that is, to serve selflessly the great life which God has given to each person.”

Joseph Kentenich

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GLOSSARY OF TERMS

An emoticon, sometimes called a smiley, is a sequence of printable characters that is intended to represent a human facial expression and convey an emotion such as :) or ^_^ . Emoticons are used in internet forums, texting and instant messaging.

Discourse is a term widely used in a variety of ways. In this study discourse is used to both the linguistic forms and social practices which influence the written text and verbal communication.

Bots are "robot" programs which operate as agents for a user, another program or to simulate human activity. An online 'bot' usually refers to an automatic script. Typically, bots perform tasks that are both simple and structurally repetitive.

Conversational move is a unit within an individual message, similar to a speech segment. In one turn there may be more than one conversational move.

Double coding - a turn may be double coded when interpreted as simultaneously reflecting more than one pragmatic intention. In Exchange Structure Analysis, this occurs at the Move level.

Exchanges are the minimal unit of interactive discourse and consist of initiating and responding turns in an interaction between at least two participants.

Exchange Structure Analysis (ESA) is a discourse analysis framework which has been used to analyse learning and teaching interactions in classrooms. In this study it is applied to synchronous mobile tutoring interactions.

Feedback turns are response moves which offer acknowledgement or evaluation of the previous turn. Feedback turns are usually coded as RC.

Genres are socially recognized and defined, often informally, by a particular culture or community. In discourse studies the roles of structure, organisation and function are important.

Initiate (I) turn is a preliminary turn in an exchange. It is not predicted from a previous turn and is a contribution that anticipates a response by another participant.

Instant messaging is a form of synchronous, text-based communication in push mode, between two or more people using personal computers or mobile devices. The user's text is delivered over a network, such as the Internet.

Interaction is used in this study to indicate the activity between tutors and learners. Learning interaction (sequence) can be viewed as a continuous sequence of turns between a specific tutor and learner on a particular day.

Learner - In South Africa 'learner' is conventionally used to refer to a school-going person usually between 6 and 19 years of age. On Dr Math, learners are those users seeking assistance or engaging in other forms of interaction with tutors.

Mode is used in two ways in this study 1) To express the statistical value which appears most frequently in a data set. 2) Refers to a set of socially and culturally shaped resources for making meaning. Mode used in this study indicates the choice of representation such as written, visual, verbal modes of communication.

Multimodality - Communication in and across a range of semiotic modes – e.g. verbal, visual, and aural – gives rise to multimodality, or semiosis which utilises more than one mode.

Outliers are defined as observations that appear to be inconsistent with other observations in the data set.

Pragmatic is used to denote the meaning behind the words. This indicates not only what is written, but also the interpreted purpose of the text.

Reinitiate (RI) turn is a turn that is not 'initial' in the exchange, but continues a current exchange and anticipates a response from another participant. A Reinitiate turn is not predicted from an earlier turn. A Reinitiate turn indicates the intention to continue with a related topic in a sub-exchange.

Respond (R) turn is a turn that is not 'initial' in the exchange, usually does not anticipate a turn and commonly completes an exchange.

Response-Complement (RC) turn is a turn used to indicate feedback which can be either a form of acknowledgement or evaluation. An RC turn is never an initial contribution and although it often signals intention to close the exchange, it can also be followed by a new exchange.

Scaffolding is an instructional strategy that involves supporting novice learners by simplifying a task and applying support specific to their needs. As the learners gain the knowledge and confidence to competently apply these skills, the supports are gradually removed until they can work independently.

Semiotic resource in this study refers to the system of signs used to create meaning in mathematics (A combination of language, mathematical images geometry and mathematical symbolism) for meaning-making. A semiotic resource is always at the same time a material, social, and cultural resource.

Semiotic transcoding - Transcoding takes place when a message in one semiotic mode is expressed in another mode (e.g. expressing a mathematical equation (symbolic mode) as a graph (visual mode) or as a teacher's sentence (verbal mode)).

Semiotics is the study of signs and sign processes. It is the study of the relationship between signs, symbols and language

Speech Acts are how we do things with words and can be defined as the action performed by a speaker with an utterance. The term speech act is used to describe actions such as 'requesting,' 'commanding,' 'questioning,' or 'informing.'

Standard deviation is used as a measure of statistical dispersion. The elementary idea of standard deviation is that you're measuring variations around the mean value.

Synchronous (speech or text) indicates participants are present at the same time, even if not at the same location.

Transcoding in the context of this study is the adaption from one semiotic representation to another

Turns are defined by Sinclair and Coulthard as everything said by one speaker before another begins to speak. In this study a single texted message sent via Dr Math is viewed as a conversational turn and turns are delimited by a carriage return in the Instant Messaging chat log.

Tutoring Sequence has been defined for the purposes of this study as the full learning interaction between a specific tutor and learner on a given day (see also interaction)

Zone of Proximal development (ZPD) is a term used in sociocultural theory indicating the developmental juncture where the learner can perform certain tasks with assistance, but not yet independently. The concept originated from Vygotsky (1978) but has subsequently been expanded and adapted. In the educational context it is an important tent of the pedagogical strategy of scaffolding.

CHAPTER ONE: INTRODUCTION TO THE RESEARCH

The legacy of apartheid in South African education has not yet been eradicated and there are still visible inequalities and distinctions in the quality of education provision (Chisholm, 1992; Soudien, 1994; Fiske and Ladd, 2004; Christie 2008). While prospects for learners from disadvantaged backgrounds have greatly improved since democracy in 1994 (UNICEF, 2009), access to resources for poor learners is still disturbingly lacking. Despite expanded access to mobile communication, many learners struggle to gain access to the internet and computers that might assist them with homework and studying after school (Walton & Donner, 2012).

The daily reality for impoverished learners is over-crowded classrooms and minimal learning support -- many schools are understaffed. Furthermore, HIV/Aids, poverty and violence have resulted in child-headed households where older siblings take on parental roles and bear tremendous responsibility in caring for younger siblings (Van Wyk & Lemmer, 2009; Meintjies et al., 2010). The lack of assistance at home leaves many school-going youth struggling to complete their daily homework tasks. These difficulties are particularly pertinent in relation to mathematics and languages which are fundamental to success in other school subjects. Growing concerns over declining performance in literacy and numeracy have been expressed in policy forums and highlighted in a range of studies (Fleisch, 2008; Sasman, 2011; Mouton, 2012).

In particular, South African teachers and students are not achieving satisfactory results in mathematics (Reddy, 2006a & b). For example, the Trends in International Mathematics and Science Study (TIMSS) 2011 revealed that South African learners had amongst the lowest scores of the forty two countries participating in the study (Reddy et al., 2012). These shortcomings were also evident from the Annual National Assessments results for 2011 released by the Minister of Basic Education, on 28 June 2011. In addition, statements on the draft report of the universities' National Benchmark Test (NBT) have drawn attention to the far-reaching implications of poor foundations in mathematical education. Only "7.5% of the 9771 university students who did the mathematics test were categorised as proficient in the tests" (Yeld, Bohlmann & Cliff, 2009) while 2.3% of Grade 9's achieved a 50% pass (Yeld, 2012).

Poor foundations in mathematics influences further learning and when these rudimentary building-blocks are weak, learners lag behind. Knowledge of basic mathematics pervades all aspects of daily life and is vital for many occupations, yet many young people complete schooling without the necessary mathematical skills to meet demands of an increasingly technologically-dependent economy (Vital, Adler & Keitel, 2005).

Fleisch (2008) raises concerns about the 'bimodal' pattern of educational achievement in South Africa, which means that a small number of privileged, mostly former private or model C schools produce excellent results, while others produce very poor results. A major obstacle is that there are not enough competent educators in South Africa to teach mathematics (Fleisch, 2008). Fleisch provides a comprehensive assessment of under-performance in mathematics and explains how deficiencies in mastering language, poverty and associated ills, lack of resources, and inadequate teaching contribute to learners from disadvantaged schools acquiring only 'a very rudimentary knowledge and understanding of mathematics' (Fleisch, 2008:v).

Fleisch (2008:121) maintains that among the many shortcomings of South African schooling, the classroom 'is the major source of the crisis in primary education'. Educator absence, ineffective teaching methods and unsatisfactory knowledge of learning areas or subject content, all contribute to a diminished quality of teaching (Fleisch, 2008). Traditional out-of-school interventions (extra lessons, mathematics clubs, etc.) are costly and, perhaps predictably, less well-resourced schools in rural areas benefit least from such intervention (Reddy, Lebani & Davidson, 2003). Reddy, Lebani & Davidson (2003) describe strategies such as extra lessons, and one-to-one tutoring for mathematics learning beyond the domain of the classroom. The Dr Math project is one such initiative which utilises technology already adopted by a large number of South African youth, to extend mathematics support beyond the reach of the classroom.

Background to the Dr Math project

The Meraka Institute's Dr Math project provides a free tutoring service to anyone who has an instant messaging service on a computer or mobile phone. Participation in this tutoring is voluntary, individual and anonymous. The project, initiated in 2007, provides the opportunity for primary and secondary learners to access tutors (mainly volunteer university students) who can assist them with their mathematics homework

(Butgereit, 2007a&b). Since 2007, Dr Math has attracted 28 000 registered users (Botha & Butgereit, 2012). A typical session would involve about thirty to fifty mobile users interacting with a tutor (Butgereit, 2010).

Learners communicate via MXit with online tutors who access the portal via the internet from computer workstations. MXit, a freeware Mobile Instant Messaging (IM) application developed in South Africa, runs on entry level feature phones with Java support and WAP connectivity as well as smartphones such as Blackberries and iPhones. MXit sends instant messages via GPRS/3G, rather than via standard SMS technology and allows the user to send and receive synchronous text and multimedia messages of up to a thousand characters in one message on a mobile phone.

The application is accessible internationally but the bulk of its user base is in South Africa. According to a 2011 survey by consultancy World Wide Worx, and subsequent reports (Muller, 2012), MXit is currently the largest mobile instant messaging service in Africa with approximately 10 million active users. The cost of person-to-person messages is minimal (approximately one cent [ZAR] per message compared to normal SMS rates of approximately 30 - 80 cents [ZAR]). MXit users can also exchange messages with users using other online chat protocols such as Yahoo, Windows Live Messenger, ICQ and Google Talk (MXit Forum).

How Dr Math Works

Dr Math is added as a contact on MXit or any other IM service which can be used to access the Dr Math portal. When tutors are available during the stipulated hours, the Dr Math Icon indicates a green light and when a message is sent to Dr Math an automated bot replies that a tutor is available to assist. Bulk messages such as jokes or tutoring schedule changes can be distributed to anyone who has Dr Math as a contact.

Butgereit uses the following illustration (**Figure 1**) to explain how a tutoring interaction is viewed from the Dr Math portal and describes a typical Dr Math tutoring session.

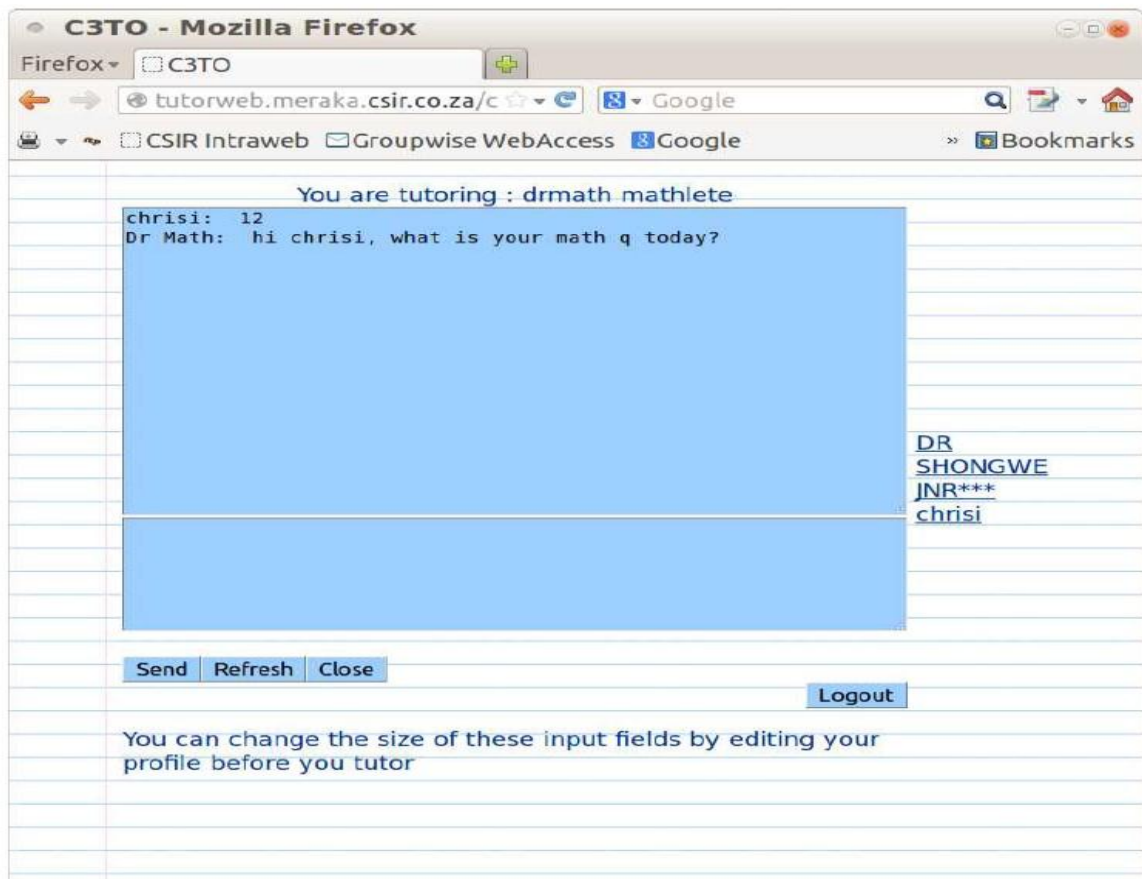


Figure 1: Typical Dr Math screen as seen from Tutors perspective (Butgereit, 2013: 16)

The illustration depicts the screen as viewed by a specific tutor and the Dr Math learner with whom s/he is engaging (the name appears on the left of the screen as part of the conversation). The names, generally pseudonyms, of all non-tutoring participants who have interacted with this specific tutor during the session are listed on the right. Participants who have unanswered questions are flagged with three asterisks as denoted by “JNR” in **Figure 1** above.

Tutors are able to connect and log in with an internet connection from any location. In some locations the infrastructure might be less reliable, making connections to the Dr Math platform challenging. The majority of Dr Math tutors are university students from engineering or science faculties in various institutions. Most tutors access Dr Math via academic or research Institutions such as Meraka or universities in and around urban Cape Town and Pretoria (Butgereit, 2011a). Apart from special event initiatives, Dr Math characteristically runs on Mondays through Thursdays from 14:00 in the afternoon with a flexible closing time depending on tutor availability (Butgereit, 2011b).

The Dr Math software has an automatic timeout, which activates if there is no response to a learner from a tutor within a ten minute period. If this occurs then all the learners interacting with that particular tutor are swapped to another tutor. While this ensures that users are not left 'hanging' without receiving a response, it can be challenging for both tutors and users who have to negotiate such switches in the course of an existing interaction (Butgereit & Botha, 2010b).

A number of bots or software applications running automated tasks over the Internet are also included in the Dr Math platform (Butgereit 2010). These bots both include 'work' and 'play' (or social) bots. The "work bots" are primarily informative in nature and provide access to educational materials. Butgereit explains that, as of August 2010, the "work bots" could be categorized according to their four functions, namely: The "scientific calculator bot" enables calculations. The "static lookup bot" enables the administrator to generate dictionaries containing definitions or specific terminology. The "web scrape bot" supports access to information 'scraped' or copied from Wikipedia and a "feedback bot" elicits feedback from Dr Math users regarding their evaluation of the service (Butgereit, 2011:68). These bots are meant to automate replies on definitions and formulae in order to free up tutor resources, but they also make it possible for learners to access resources at any time (Butgereit & Botha, 2010b).

Online conversations with minors

The majority of learners who access the Dr Math portal are primarily school children who need support with homework. The service is accessed predominantly via MXit, an easily accessible free portal that can be used without parental consent. Consequently steps have been put in place to protect minors and regulate the interactions.

For ethical reasons all tutors are required to sign a code of conduct whereby they agree not to have private interactions with participants outside of the Dr Math tutoring program.¹ Tutors also consent to Meraka Institute recording and monitoring their conversations. Additionally, learners are made aware that all their conversations are recorded for quality, security and research purposes through the daily message which is distributed each time they access the portal or connect with a tutor.

¹ Ethics review board approval was granted for the Dr Math project by the Tshwane University of Technology

Butgereit (2011a) explains that Dr Math's functionality has evolved over the period of its existence and its most recent software platform, C³TO (Chatter Call Centre/Tutoring Online), links tutors and learners but also makes it possible to better protect the anonymity of all participants. The C³TO platform hides all cell phone numbers and all users are required to create a pseudonym. Initial string handling is implemented to ensure that these names do not contain the mobile phone numbers of the participants. Tutors are not allowed to ask or answer any personal questions or contact learners who access the Dr Math portal directly. Log files of each interaction are recorded. From the perspective of discourse analysis, these logs also constitute valuable records of the tutoring interactions, and a corpus of such logs has formed the basis of my research.

Research on Dr Math

Initial publications about Dr Math provided an understanding of the design of the system (Butgereit, 2007a & b), an overview of the project and the practical processes of tutoring (Butgereit, 2007b, Butgereit, 2008a & b). Further research and development have resulted in the introduction of games and challenges to entice learners to practise mathematics skills (Butgereit, 2009 a & b; Butgereit et al., 2010). Research into tutor engagement or activity load has been explored by applying a "busyness model" to the tutoring interactions (Butgereit & Botha, 2010a). The conclusions Butgereit & Botha (2010a) drew from this research have informed some of the assumptions of my own research, for example that the number of learners interacting with a tutor is not necessarily an indication of how engaged they are in tutoring. The complexity and length of each interaction varies and although two tutors may be engaged in dialogue with the same number of learners, one could be dealing with more intricate or complicated problems needing extensive assistance. While all tutors have a mathematics-related background, their diversity of disciplinary backgrounds means that some have a more current mathematical knowledge (e.g. students of mathematics or physics), whereas others (computer programmers for example) might not utilise mathematics regularly (Butgereit & Botha, 2010). More recent research by Butgereit and Botha (2012) on "topic spotting" in Dr Math describes the implementation of an automated topic spotter to process cryptic questions, determine general mathematical topics, and automatically provide supporting material to tutors. Their research was aimed not only at enhancing the technical capabilities of the system, but also at assisting tutors and enhancing the tutoring process.

Investigating tutoring discourse – a research study

In this study I investigate the dynamics of tutoring interactions by exploring the discursive roles of the tutors and learners as recorded in the logs of their exchanges. I apply Exchange Structure Analysis to identify interactional and multimodal strategies used to scaffold the tutoring interactions and extend the tutoring dialogue. While the technology affords possibilities for networked dialogue, the quality and experience of tutors and their ability to scaffold learning interactions so that the needs of the individual learner are met, play a significant role in the tutoring interactions (Botha & Butgereit, 2012).

A skilled tutor is able to scaffold learning interactions to elicit relevant information that will help in the meaning-making process (Dabbagh, 2003; Anghileri, 2006). Meaning-making requires not only a good grasp of mathematics concepts and procedures but also the ability to make meaning from mobile discourse via MXit, a distinctive form of texting which is highly abbreviated, and where many grammatical clues are absent. For tutors, knowledge of mathematics is not sufficient to guide learners. The ability to ask questions which help scaffold the learning interaction and reveal what the learner does not know is perhaps even more crucial when explaining the correct step in a problem (Botha & Butgereit, 2012). This study focuses on discursive strategies used by Dr Math tutors rather than their mathematical knowledge per se. The structure of the dialogues between tutors and learners are coded and explored quantitatively to identify patterns of interaction, particularly those related to scaffolding.

Computers and mobile phones offer the potential for multimodal interactions, but transferring media files via mobile networks entails data costs which may exclude learners from accessing Dr Math. By offering a predominantly text-based application, the costs of tutoring interactions are minimal and it becomes viable for learners who may not have access to much airtime. This nonetheless means that both tutors and learners need to adopt various transcoding strategies to overcome the limited visual resources of the platform when asking or answering questions and developing understanding of mathematics.

Purpose of the study and research questions

Learning interactions that take place in a classroom environment are traditionally more structured and formal (Sinclair and Coulthard, 1975) than those which occur outside the classroom, such as in a tutoring environment for example. How does learning take place in an online tutoring environment using mobile phone technology? This study explores the interactions between learners and tutors and examines meaning-making in the tutoring of mathematics via the mobile application MXit, in order to explore the opportunities and challenges of mobile technologies for teaching and learning.

The central research question is the following:

What interactional genres and discourse characterise learner-tutor interactions in an online mobile mathematics tutoring environment?

Sub-questions arising from this are the following:

- What characteristic exchange structures can be identified in the corpus of tutor-learner communication?
- What do these characteristic genres of exchange suggest about the roles of tutors and learners in MXit-based tutoring?
- How do limited modality and semiotic resources on Dr Math influence tutoring interactions?

In on-going debates about the roles of ICTs in Education, techno-centrists tend to overemphasise the value and importance of technology in providing access to more advanced forms of communication, while traditionalists negate the possibility of transformed interaction through the introduction of technology for learning. This study challenges assumptions by examining both the affordances and constraints of the technology, and the impact these have on the interactions between tutors and learners.

Structure of this thesis

Chapter One provides a brief synopsis of the context of education in South Africa, particularly some of the challenges with regard to mathematics teaching and learning. The Dr Math project, the MXit platform and the basic format of tutoring interactions that take place via Dr Math are introduced, and the focus areas of the research study are outlined together with a main research question and sub-questions. A central goal of

this study is to explore possibilities for meaning-making via mobile instant messaging in the mathematics learning process.

In **Chapter Two** a broad overview of the literature which has informed this research is provided. The literature spans four fields relevant to the tutoring interactions, namely education, information and communication technology (ICTs), mathematics and linguistics. As this study cuts across disciplines, only the scholarship which has a bearing on key aspects of the research project has been outlined, particularly research involving ICTs in education, discourse analysis relating to meaning-making in multimodal interactions, and Exchange Structure Analysis to examine the nature of tutor-learner interactions. This chapter also explains the analytical framework of Exchange Structure Analysis, the central framework for analysis of the Dr Math logs. Exchange Structure Analysis was originally used by Sinclair and Coulthard (1975) to analyse classroom interactions. An adapted framework, based on their original coding conventions has been applied to the discourse analysis utilised in this study. While ESA has been used to analyse learning and teaching interactions in classrooms it has seldom been applied to synchronous tutoring interactions, making this an important contribution of my study.

Chapter Three explains the research design and the methodology for sample selection, coding and analysis. Ethical concerns and issues of reliability and validity in the study are also addressed.

Chapter Four presents the research findings, both quantitative and qualitative. Overall patterns of participation are presented, and the dynamics of turn-taking are analysed in relation to what they reveal about shared responsibility for the learning interaction, and which strategies are used by tutors to extend the tutoring dialogues into more mathematically complex scaffolding interactions.

Extracts from specific tutoring interactions highlighting key findings regarding transcoding and multimodality are discussed in more detail in **Chapter Five**.

Finally, **Chapter Six** draws together the various theoretical and empirical strands and outlines the significance of the findings, implications for future research and outlines some recommendations for further development of the platform.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMING

My research into an online, mobile, mathematics tutoring support project spans at least four disciplinary fields which have contributed to this literature review: education, ICTs, mathematics and linguistics.

These interrelated areas of scholarship reveal critical elements of my study. Key concepts and theories of language, discourse analysis, socio-cultural learning theory, computer-mediated discourse, and the role of mode and multi-semiotic representation in the discourses of mathematics learning laid the foundation for the methodological and analytical choices in this study. In **Figure 2** I have illustrated how these different areas of research intersect.

Language, Mathematics and meaning- making

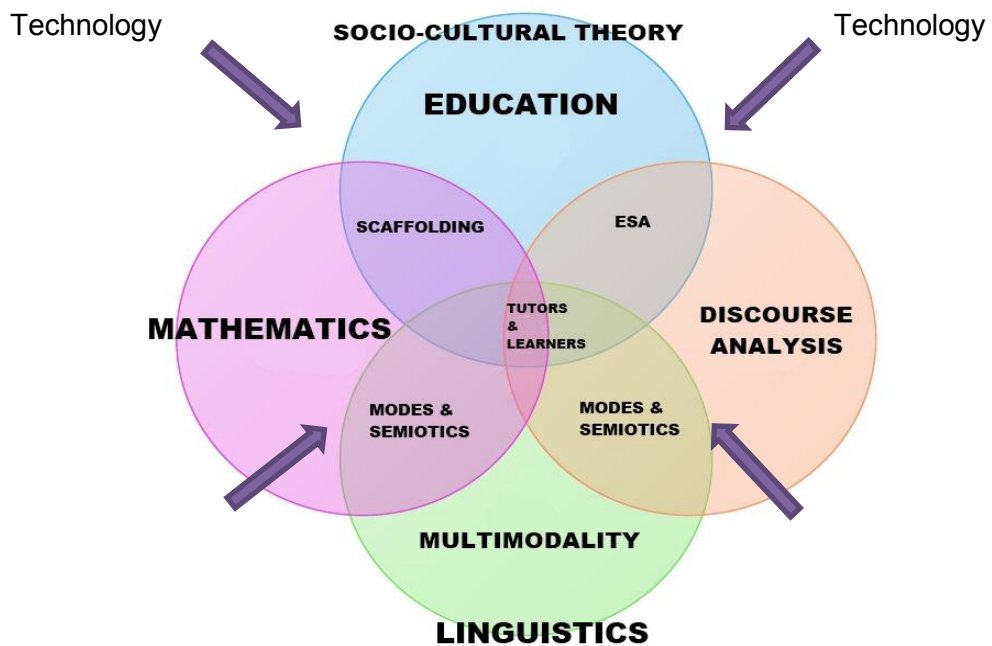


Figure 2: Cross disciplinary research areas which intersect for this study

The role of language in meaning-making has been researched extensively from different perspectives (Vygotskian, Bernsteinian, and Hallidayian) and applied to areas

of learning, which I am relating here to the learning of mathematics on a synchronous text-based mobile platform. O' Halloran (2005) explains that language is functional to human needs and this determines the way it is utilised. Halliday (1978:192) describes language as a semiotic system, "not in the sense of a system of signs, but a systemic resource for meaning". For Halliday, language is a "meaning potential" and in his theory of Systemic Functional Linguistics (SFL) he refers to language as "a network of systems, or interrelated sets of options for making meaning" (1994:15) or rephrased, language is a "resource for meaning through choice" (O'Halloran, 2005:61). Conventionally, interpersonal communication is established when meaning-making or shared understanding is achieved with the assistance of chosen codes or conventions. This can be done through various modes of representation such as gestures, text, illustrations or sound.

Mathematics, like grammar, consists of a network of systems for meaning-making. Semiotic resources such as signs and symbols are the fundamental elements of language and all systems of communication. O'Halloran (2005) proposes that we use sign systems or systems of meaning such as language, music, images and numbers, to order the world around us. Symbols and signs need therefore to be understood in relation to all the other choices available within the system networks. When conventional communicative resources are limited, as in the case of Dr Math, this presents the opportunity to investigate how tutors and learners adapt to the modal and semiotic resources available to negotiate meaning.

Vygotsky suggests that mental processes can only be understood when there is consideration of the tools and signs that mediate them. Vygotsky distinguished between technical and psychological tools. Technical tools refer to objects/instruments used primarily for regulating the environment, while psychological (intellectual) tools include "language; various systems for counting; mnemonic techniques ... all sorts of conventional signs" for effecting altered behaviour during social interaction (Vygotsky, 1981:137). In this study, technological objects, software applications and protocols (handsets, computers, connectivity) and psychological tools such as language and mathematical symbols influence the interaction and either enhance or limit the understanding of those involved in the process of learning or negotiating meaning. The MXit chat channel is a tool, but so are the multimodal semiotic resources of mathematics, and genres of interaction which relate to classroom and academic discourse. Various intellectual tools are available in a range of modes.

According to Halliday (1996:89), “language does not consist of sentences; it consists of text, or discourse – the exchange of meanings in interpersonal contexts of one kind or another”. Hicks (1996:51) claims that discourse ‘implies a dialectic of both linguistic form and social communicative practices’ and argues that discourse can be seen ‘in terms of oral and written texts that can be examined after the fact, and socially situated practices that are constructed in moment-to-moment interaction’. Therefore, discourse includes both textual products (both oral and written) and ‘constitutive discursive practices’ (Hicks, 1996:52).

Language acts as a vehicle for transmitting information, for asking questions to generate feedback, for the acquisition of knowledge and for directing behaviour. Vygotsky (1978) explains that language serves as a psychological tool that can lead to fundamental changes in mental functions. Furthermore language serves to mediate higher order thinking (Vygotsky, 1978; Wertsch, 1979) and therefore plays a critical role in the process of teaching and learning.

Learners accessing Dr Math are to a large extent involved in learning or acquiring knowledge. While it was not possible to investigate the actual process of learning in this study, the Dr Math tutoring logs constituted the textual trace of learning interactions. Lim (2006) employs a sociocultural, constructivist perspective to examine conversational interaction in online tutorial discussions, as guided by tutors and mediated by tools (technologies and language), and explains that this theoretical approach assumes that learning occurs and this leads to construction of shared knowledge. The negotiation of meaning propagates “the construction of shared knowledge”, culminating in “individual appropriations of shared understandings” (Lim, 2006:10). Furthermore, Lim (2006:24) avers that this “is assumed to be empirically observable through an examination of the chat discourse”. Lim’s assumptions manifest similarly in examples of tutoring interactions from Dr Math tutoring logs. Tutors and learners using Dr Math constantly negotiate meaning, not only through written mathematical representation, but also through choices of everyday language such as textisms and slang associated with mobile Instant Messaging. Since learners may experience challenges when using the limited semiotic resources available (e.g. emoticons, mathematical symbols) on mobile phones to interact with tutors and negotiate meaning, the onus lies heavily on tutors to clarify mathematical concepts to enable learning.

Scaffolding to assist learning

Scaffolding is a term that has become widely used in educational contexts to describe the precise help that enables a learner to achieve a specific goal that would not be possible without some kind of support. Wood, Bruner & Ross (1976) originally used this metaphor to describe the form and quality of intervention by a 'learned' person to assist the learning of another person (Wood, Bruner & Ross, 1976). Scaffolding is a teaching strategy which provides individualized support based on the learner's "zone of proximal development" (ZPD), namely the developmental juncture where the learner can perform certain tasks with assistance, but not yet independently (Vygotsky 1978). The notion of scaffolding is congruent with the essentially social nature of learning and affirms the importance of language in making meaning within this process. Dialogue is a central feature of scaffolding (Mercer, 1994; Gibbons, 2003; Sharpe, 2006).

It is within the ZPD that "teachers", (also tutors or more capable peers) actively enhance learning through assisted performance, namely learners are able to learn more effectively when aided (Tharp & Gallimore, 1991). Assisted performance is the underlying principle of most individualised tutoring programs where support is offered according to the specific needs of the learner.

Anghileri (2006) explains how scaffolding practices can enhance mathematics learning. Although Anghileri's research emphasises scaffolding teaching interactions in classroom mathematics, her research is a valuable point of reference as it relates to scaffolding in a mathematics learning environment. Her framework depicts levels of scaffolding that can be specifically applied for the support of mathematics learning. Botha and Butgereit (2012) apply this framework to the environment of Dr Math, indicating how scaffolding is an essential component in meaning-making. Two key elements of the meaning-making process evident in the framework are those of reviewing and restructuring. These practices indicate the supportive role of tutors when scaffolding the learning interaction around the specific needs of the learner. Tutors negotiate meaning by simplifying the problems, prompting, probing and rephrasing until the learner gains the cognitive clarity and confidence to proceed.

A further aspect of socio-cultural learning theory is appropriation, in which a person takes a tool, makes it her/his own, and transforms it by using it in a way unique to her/himself (Rogoff, 2008). Newman, Griffin & Cole (1989) apply appropriation to explain the pedagogic function of a specific discourse event whereby one takes up the

other person's comment interprets it and offers it back in a modified form. In Chapter Five I discuss how tutors re-contextualised students' questions through paraphrasing and recapping to obtain clarity.

Barnard & Campbell (2005) indicated how scaffolding can be realized by teachers and students applying six principles of scaffolding (Van Lier, 1996) to the practice of writing at undergraduate level. They suggest that with effective scaffolding, understanding is co-constructed during the verbal dialogue within the ZPD. Furthermore Barnard & Campbell (2005) maintain that learning only follows when this understanding is appropriated, that is, when the meaning and use of the concept is internalised by the individual. Thus, learning is mutually created by the participants in a structured dialogue in which the more capable partner promotes learning by scaffolding steps which enable the learner to progress to a higher level of ability. The eventual aim of scaffolding is autonomy so that what the learner currently can only do with assistance, s/he will do independently in the future (Vygotsky, 1978). In the tutoring process, learning within the ZPD is not exclusive to learners, as tutors rely on the assistance of the learner and written materials to appropriate strategies in order to become more proficient in tutoring.

The limitations placed on both tutors and learners when using only the written visual mode to interact on Dr Math are specifically challenging when discussing mathematics which has its own conventions and semiotic resources. Ensuring that learners understood the conventions for textual discussion of mathematics required a great deal of assistance and scaffolding, as will be discussed in detail in Chapter 6. Participants adopted various strategies to adapt to these constraints. The following section investigates literature on multimodality in mathematics learning, a relevant aspect to consider in this research.

Multimodality and learning

Multimodality as a field of study is concerned with different modes of human communication, such as images, written words and symbols, gesture, action, music and sound as used to represent or make meaning in the world (Stein, 2008; O'Halloran, 2009). Multimodality recognises that in any communicative act or artefact there is interconnectedness between various semiotic modes (Archer, 2006).

Michael Halliday's (1978, 1994) Systemic Functional (SF) Theory lays the foundation for conceptualising the multifaceted variety of semiotic resources used to create meaning.

Although language is considered one of the key modes of communication, especially in the field of education, multimodal theorists show that most communication draws on a variety of modes simultaneously (Jewitt et al., 2001). A central tenet of multimodal theory is that modes have been shaped through cultural, historical and social uses to realise social functions and are therefore embedded in a specific context for a specific purpose (Jewitt, 2008). This is congruent with socio-cultural learning theory which posits that “different modes can enable different kinds of being and knowing” (Archer in Stein and Newfield, 2006:11). The choice to use a specific mode can impact on learning and while language plays a key role in learning other modes support different aspects of knowledge construction.

Jewitt explains that, in many contexts, spoken and written language tends to be a more socially valued form of communication. She states that language is “embedded in an ensemble of modes, and all modes play a central part in meaning-making” (Jewitt, 2007:280). Stein & Newfield (2006:2) concur, indicating that an amalgamation of modes interacts “in different ways with different effects, to create multi-layered, communicational ensembles”. Furthermore, “A complex of modes including talk, visual communication, action, gesture, gaze, posture and movement contribute to teaching and learning” (Jewitt, 2003:1). In the educational context, if different resources challenge, extend or constrain thinking, it is important to consider how the choice of mode contributes to or hinders the meaning-making process. Stein & Newfield (2006:8) maintain that teachers and students are “designers of meaning” and are therefore involved in making particular choices about how and what to communicate. Still, they may be limited by the semiotic resources available in the choices they make to represent meaning (Stein & Newfield, 2006).

As this research involved the analysis of the discourse of mathematics tutoring logs, where the written visual mode was the only mode of representation of mathematical knowledge, an understanding of the nature of mathematical notation is central to the tutoring discourse. This draws heavily on O’ Halloran (1999, 2004, 2009), whose work includes a descriptive account of the evolution of the semiotics of mathematical discourse, multimodality in mathematics teaching and learning and multimodal analysis and digital technology.

Multimodality and the construction of mathematics knowledge

O' Halloran (2005) explains that mathematics is considered to be primarily a written discourse. Nonetheless the teaching of mathematics is strongly multimodal given the role of lectures, visual and verbal interactions, complementing the written word. Classroom discourse offers the option to use cross-modal communication and affords teachers more choices when introducing or explaining intricate concepts. "Mathematical discourse succeeds through the interwoven grammars of language, mathematical symbolism and visual images, which means that shifts may be made seamlessly across these resources. However, each semiotic resource has a particular contribution or function within mathematical discourse" (O' Halloran, 2004:94).

Furthermore, O'Halloran (2005) explains that the grammatical strategies for organizing meaning in symbolic statements differ from those found in language. While members of a culture are capable of using language as a functional resource in various ways, the use of mathematical symbolism is typically restricted to those who understand how mathematical meaning is organized. Mathematics has unique grammatical strategies specifically developed in mathematical symbolism and the use of these conventions enables the solution of mathematics problems. Mathematics is considered a 'multisemiotic construction' as language, mathematical symbolism and visual representation all form the discourse of mathematics (O'Halloran, 2005:10). Spoken language is normally used when introducing, contextualizing and describing mathematics problems. Typically thereafter, visualisations (graphical or diagrammatic) of the problem are utilised. Then mathematical symbolism is used in conjunction with various representations to solve the problem (O'Halloran, 2005).

While the discourse is often presented in the written mode, mathematics is not confined to these forms of semiotic activity. O'Halloran (2009:2) defines the concept of semiotic transcoding, namely "the conversion of symbolic data into visual images and vice versa". Substituting one semiotic representation for another, transcoding is comparable to translation where the intention is to retain the full meaning to the extent possible, but enable a broader understanding.

Written mathematics texts only involve one mode namely 'visual modality' (O'Halloran, 2004:2). One of the unique features of the tutoring examined on the Dr Math's platform is that only the textual record of tutoring interactions are visible in the data logs. It is possible that learners or tutors made use of other modal representations while grappling

with mathematical problems (e.g. by verbalising their problems or by sketching graphs or equations on paper), in their interactions with one another (as mediated by Dr Math and MXit interfaces) they are restricted to basic alphanumeric keystrokes.

While language can be adapted and used in various ways by various cultural groups, O' Halloran (2004) asserts that mathematical symbolism is restricted to those who understand how mathematical meaning is organized. Different semiotic resources render unique affordances and constraints so choices in representation can impact the negotiation of meaning. In Dr Math the semiotic resources are limited not only because there are no graphics, gestures or sound involved in the tutoring process, but also because the use of mathematical notation is limited to those characters available on a mobile phone.

O' Halloran explains that as mathematics evolved, the grammar of mathematical symbolism developed and specific symbolic conventions were implemented. Elements such as "punctuation symbols, brackets, iconic representations, abbreviations and the invention of new symbols" all contribute to the recognised mathematical convention (O Halloran, 2005:111). This abbreviated notation enables the representation of complex interactions in a single semiotic resource. In a single line of mathematical notation, numerous procedural instructions and information can be denoted. O'Halloran (2005) clarifies how the grammar of mathematical symbolism is based on a range of compression strategies which facilitate the rearrangement of relations and the order of the operational procedures. These strategies include, for example, the use of spatial and positional notation, specific mathematical symbols and the Rule of Order for operations (O'Halloran, 2005:131).

As technology evolves and is utilised extensively, it is sometimes assumed that all digital devices are equally well-equipped to represent and manipulate data, produce dynamic visual representations and facilitate complex interactions. There is little argument that the capabilities of technologies (e.g. cameras, touch surfaces, audio and video options) proliferate potential opportunities for multimodal interactions, yet it cannot be inferred that they will be used in this way. This study serves to highlight that the latent potential of technology in no way reflects the actual application of this potential. Context-driven technologies, especially in developing countries where cost, access to networks and user-friendliness all affect choices when designing programs or applications, and the way users choose to engage with the technology, is often

incongruent with the intended design purpose (Ali & Bailur, 2007). The reality is that despite the potential applications of technologies for educational purposes, the impact they have in actual teaching and learning is influenced by numerous factors, and understanding their contribution is complex.

Technologies in learning

The topics of computers in education and computer mediated communication have generated a substantial body of literature (Willis & Raines, 2001; Herring, 2007; Garrison, 2011), however the use of computer and mobile communication for synchronous tutoring is not well documented.

The introduction of technology in human interactions modifies the way people act, interact and react. This raises questions about the impact technologies have on educational practices and whether they facilitate or hinder learning experiences. Advocates and opponents of the use of technology in education continue to defend their respective positions. Martinovic's work (2004, 2005b, 2009) on mathematics' tutoring online raises a number of important questions about the role of computers in the teaching and learning process. She suggests that although schools try to keep up with some of these advances, for various reasons (cost, logistics, teacher training) they lag behind, which further increases the 'disconnect' between in-school and after-school activities (Martinovic, 2004). In cases where schools incorporate modern technologies, it is evident that they require new pedagogies, which Balacheff and Kaput (1996:495) underline by saying that, "for teachers, traditional professional knowledge is not sufficient to deal with the deep changes in learning, teaching, and epistemological phenomena that are emerging". Martinovic's (2004, 2005a) research contributes to understanding the role of expert and peer tutors in asynchronous mathematics' tutoring. Balacheff and Kaput (1996) suggest that further research is needed to investigate the complexity of the tutoring task in the online context and to specify the tools needed by the online tutor.

Mariotti (2002) gives an overview of the use of computers for the learning of mathematics and discusses various approaches to the meaning-making in mathematics' learning when computers are introduced (in Lynn, 2008). She explains that the use of technological devices such as computers for teaching and learning remains complex.

The use of technologies for mediating knowledge can also impact on interpersonal relationships and meaning-making processes. Sproull & Kiesler (1986) advise that where technology-mediated exchanges are exclusively textual, users may experience a greater freedom of expression and more spontaneity as they do not have the social pressures resulting from face to face interactions. Nonetheless text-based communication such as email, sms or forum interactions offer limited modal resources (e.g., inflection, gesture, facial expression), particularly when compared to classroom interaction. In such interactions, both parties rely solely on text messages. The contextual clues which assist in deciphering the message are to a large extent absent.

Kress & Pachler (2007) suggest that portable technologies enable easier access and greater reach which could bring some degree of the democratisation and transformation in the field of education. Taylor (1995:5) cautions, though, that while the trend towards "technology-mediated flexible learning" is perhaps inevitable, it is important to realize that merely using technology to mediate learning does not automatically enhance the quality of teaching and learning.

Mobile learning (Mlearning) is evolving rapidly. Initially all technology mediated learning activities were carefully designed by educators, but now learners are increasingly motivated by their personal needs to use portable devices to enhance their personal learning experiences (Kukulska-Hulme & Shield, 2007; Butgereit, 2007a & b). Growing access to, and ownership of mobile and wireless devices, means that learners are increasingly in a position to take the initiative in their own learning and intellectual growth (Kukulska-Hulme, Traxler & Pettit, 2007). Traxler (2005:262) delineates mobile learning as: "any educational provision where the sole or dominant technologies are handheld or palmtop devices". Previously mobile learning was frequently defined in terms of the mobile technologies used; more recent thinking has foregrounded the mobility of the learner (Sharples, 2006, Botha et al., 2008). Fleischman (2001) suggests that mobile technology offers an educational environment which can assist learning activities both inside and beyond the classroom.

The key aspect of mobile learning for this study is not so much the mobility of the handset but ubiquitous learning mediated via handheld devices which may be in the formal context of schools or beyond the walls of the classroom. Attewell (2005) points out that there are several advantages intrinsic to mobile learning interactions, such as

the possibility of independent and collaborative learning experiences, of which Dr Math tutoring is an example.

The following section takes a closer look at computer-mediated communication (CMC) discourse.

Technology and Discourse

Herring (2007:1) defines computer-mediated communication (CMC) predominantly “text-based human-human interaction mediated by networked computers” or portable devices such as mobile phones. Herring (2007) explains that while linguists have made numerous attempts to classify the discourse of CMC, based on the modalities of language, speech and writing, early attempts at classification tended to over-generalize all CMC language as if it were a homogeneous genre.

Furthermore, Herring explains that conventions of discourse analysis classify discourse into types according to various criteria such as modality, quantity of participants, text type, and genre or register. Instant messaging is an example of CMC where the discourse displays features of “written speech” such as rapid message exchange, informality, and even depictions of prosody (Herring, 2007:2).

Baron (2010) suggests that CMC can be defined by considering two basic parameters. The first being synchronicity where communication is either synchronous or asynchronous. In synchronous CMC, for example, the message transmission is instantaneous and interlocutors are assumed to be present to read and respond to messages. The second parameter is whether the communication is one-to-one (dyadic communication) or many-to-many (multiple participants broadcasting to multiple potential interlocutors). According to this classification, the discourse of Dr Math tutoring interactions can be identified as dyadic and synchronous.

Lim (2006:26) proposes that “chat discourse is a hybrid of both speech and writing that evolved from the limitations of the CMC medium or demands of communicative context”. Thurlow and Poff concur and state that most new media discourse has this hybrid quality in terms of the “speech writing blend” as well as the “mixing of old and new linguistic varieties” (2011: 12). Furthermore they acknowledge that, as technologies evolve, the generic distinctiveness of various genres of CMC become somewhat blurred, but what remains unchanged is people’s “determination and capacity to rework technologies” (Thurlow & Poff, 2011:13). In understanding mediated discourse,

Exchange Structure Analysis provides a useful framework for examining patterns of tutor-learner interactions.

Exchange Structure Analysis

Sinclair and Coulthard (1975) identified distinctive patterns of exchange characterising teacher-learner interactions by applying Exchange Structure Analysis to records of classroom discourse. While there is substantial literature on the application of ESA to classroom discourse (Renne, 1996; Atkins.2001; Cullen, 2002) the literature on the structure and patterns of interaction found in online learning environments is sparse, particularly when discussing dyadic synchronous tutoring.

According to Sinclair and Coulthard (1975), classroom “transactions” have structure expressed in terms of “exchanges” (**Figure 3**). The boundaries of such transactions are typically marked by “frames”. In lessons, frames are limited to words such as “OK, well, right now or good” indicating the beginning of a transaction with a meta-statement about the transactions referred to as a focus (Coulthard, 1977:123). Transactions frequently end with another focus summarizing the content of the transaction.

Transactional analysis and ESA coding

Exchanges are the minimal unit of interactive discourse and consist of Initiate and Respond turns in an interaction between at least two participants. Coulthard and Brazil (1992:62) define exchanges that consist “minimally of contributions by two participants” comprising moves with speech act functions. The theoretical basis of ESA is informed by Sinclair and Coulthard’s (1975) transactional analysis and modifications to it, as suggested in Stubbs (1981).

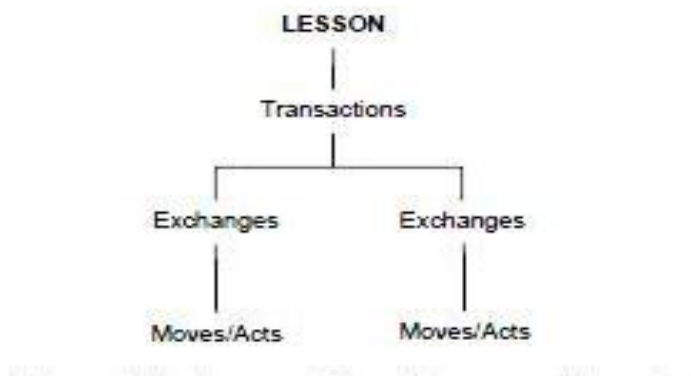


Figure 3: The units of ESA in classroom discourse (Sinclair and Coulthard 1975)

Pilkington (1999) and Kneser et al. (2001) build on Sinclair and Coulthard's conventions and define chat *exchanges* as consisting of Initiate and Respond turns. In chat discourse a *turn* is defined as a sequence of text delimited by a carriage return: "a carriage return effectively sends a message and automatically delimits a turn" (Kneser et al., 2001, 67).

With the unit of analysis set at the *turn* in chat discourse, coding chat transcripts using the Exchange Structure categories produces a relatively straightforward quantitative count of the frequency and types of turns contributed during discussions.

A more detailed analysis of chat exchange patterns could be obtained by an examination of the nature of the *speech acts* (Austin, 1962; Searle, 1969) in the interactions, or by identifying the pragmatic intention of turns using *move* categories, and further associating turns already coded at Exchange and Move levels with anticipated argument and Exchange Structure roles. Kneser et al., (2001) extend the model of Sinclair and Coulthard (1975) and present a hierarchical model made up of four components. They are, in hierarchical order: acts, moves, exchanges and transactions. In their original model, Sinclair and Coulthard (1975) included the fifth element of a lesson which encompassed all the other elements.

A seminal study by Kneser, Pilkington, & Treasure-Jones, (2001) applied a refined ESA coding instrument to transcripts of chat interaction and investigated symmetry in exchange roles. Kneser et al's research sought a quick and reliable method of analysis that would allow one to comment on the inclusiveness of the dialogue by examining the distribution of exchange roles amongst participants in online learning environments. Differences in the roles of student and tutor were identified, indicating the degree of participation by both parties in chat discussions. Results from the quantitative discourse analysis indicated a pattern of tutor-domination, which suggested a need for improvement in online tutor facilitation strategies (Kneser et al., 2001).

Several other studies have been published which focus on participation in online tutorial groups. Cox, Carr, Eden & Loopuyt (2002) investigated the impact of online synchronous chat interaction in virtual tutorials and their findings highlight the potential of synchronous collaborative learning activities. Carr, Cox, Eden & Hanslo (2004) investigated the potential of synchronous technologies in supporting students in the development of learning communities, and a comparative study conducted by Cox, Carr, & Hall (2004) applied a modified version of ESA to transcripts from group chat

sessions to identify participant roles adopted, inclusiveness of participation, and characteristics of chat discourse.

Lim (2006) further modified, refined and applied Kneser et al's (2001) Exchange Structure Analysis scheme to gain greater insight into the impact of online synchronous (chat) interaction on the learning process from a sociocultural constructivist perspective. Lim (2006) applied ESA to online chat in two tutorial groups and examined the impact of chat interaction in facilitating participation, knowledge construction, and quality of online learning experience and the effectiveness of chat interaction in supporting knowledge construction processes. By combining ESA and Social Network analysis Lim was able to demonstrate that while the literature characterizes chat interaction as "fragmented and characterized by interactional incoherence that disrupts the dialogic knowledge construction process" (Lim,2006: iv), it is in fact more structured and complex than this. In fact, chat interaction enabled valuable participation opportunities in tutorial discussions, while variations in levels of participation within and between groups suggest a pattern of active and peripheral participation which is not necessarily detrimental to learning. Chat interaction was also found to facilitate collaborative sharing of individual understandings and critical negotiation of meaning which are characteristic of the knowledge construction process.

Van de Sande (2009) posits that what distinguishes tutoring sessions from other means of instruction is the pattern of dialogue between participants. The pattern of Initiation (question or claim articulated by the teacher), Response (an answer or comment from the student), and Evaluation (teacher evaluation of student's contribution), abbreviated as IRE and identified by Sinclair and Coulthard (1975) is adapted by Graesser, Person, & Magliano (1995) who suggest a five-step dialogue process in tutoring: First the tutor asks a question or presents a problem. The learner then answers the question or begins to solve the problem to which the tutor gives short immediate feedback on the quality of the answer or solution. Both the tutor and learner collaboratively improve the quality of the answer through on-going interaction and finally the tutor assesses the learner's understanding of the answer.

This five-step dialogue frame in tutoring is a significant expansion of more typical classroom discourse structure. Graesser, D'Mello & Cade (2009) identify step four, which is typically a lengthy multi-turn dialogue in which the tutor and student contribute to the explanation that answers the question or solves the problem as a feature of

tutoring which goes beyond the IRE sequence. Graesser, D'Mello and Person (2009) suggest that experienced tutors assume that students understand very little of what they say and verify the students' understanding by asking follow-up questions or setting follow-up problems.

Conclusion

This literature review was limited by the scope of what could be accommodated in a thesis of this nature, and could therefore only skim the surface of research contributions from the fields of linguistics, ICT, and educational technology for mathematics learning. Nonetheless, major trends and learnings have been identified and serve as critical underpinnings for my study which focuses on the affordances and challenges of online tutoring within a synchronous text-based platform. Whilst a few studies examine one-to-many or many-to-many chat interactions in synchronous online chat, there is a gap in the knowledge of dyadic chat in synchronous interactions, particularly in mobile chat applications, which my study attempts to address.

The ESA model and its subsequent iterations, together with the range of findings arising from applications of the model, have been particularly useful to my research, as the next chapter sets out in greater detail. My data analysis details how I have used Lim's (2006) Exchange Structure Analysis framework. The structural description of discourse used for online learning has been labelled 'Initiation, Response, and Feedback' (IRF) (Kneser et al., 2001), and I will use an adapted version of this to assist in determining the characteristics of the interaction between learners and tutors in the Dr Math tutoring project.

CHAPTER THREE: RESEARCH METHODOLOGY

What interactional genres and discourse characterise learner-tutor interactions in an online mobile mathematics tutoring environment? This chapter describes the methodological assumptions underlying this research project, as well as the procedures and instruments chosen to examine learner-tutor interaction in synchronous mobile mathematics tutoring.

Three specific aspects of the tutoring interaction will be investigated. First, I will identify the characteristic Exchange Structures in the corpus of tutor-learner communication in line with the ESA model. Second, I will explore what these suggest about the roles that tutors and learners take on in online mathematics tutoring. Third, I will address discursive characteristics of the interactions such as register, orthography and in particular the multimodal resources associated with this mode of tutoring. In the following chapter the method for analysing interactional discourse during mathematics tutoring sessions, including coding procedures and analysis of the data, are outlined.

Research Design

The study focuses on logs of the Dr Math tutoring sessions conducted during February 2010. These sessions are automatically logged in text files and provided the data for the study. These logs record one-to-one synchronous discussions between a number of learners who are anonymous and three volunteer tutors. The identity of both tutors and learners is protected and numbered logging codes are allocated to each user by the system (Butgereit, 2011).

This inquiry aims to gain deeper understanding of the interactions between learners and tutors by analysing the structure and meaning-making processes from the data logs of actual tutoring sessions. While analysis of a single month of tutoring logs from Dr Math does not yield generalizable knowledge, as Patton (2002:584) explains, the findings may be extrapolated as “modest speculations on the likely applicability of findings to other situations under similar, but not identical, conditions”.

Purposive Sampling

Engaging in purposive sampling signifies a series of strategic choices about the study site and methodological process. The sample is tied closely to the objectives of the study and context of the research. The central criterion for a purposive sample concerns

what the researcher wishes to accomplish and how a specific sample can assist them to achieve this. According to Palys (2008) there are a variety of purposive alternatives, two of which include typical case sampling, where a case is of interest simply because it is not unusual in any way, and paradigmatic case when it is considered the exemplar for a certain class. Purposive sampling of a single month of tutor learner interactions in Dr Math was based on the following rationale:

- This sample was chosen because it exemplifies a typical month of educational chat interaction, albeit one which took place relatively early in the year (the academic year begins in January in South Africa). The sample is a typical case sample.
- February was chosen as a purposive sample because the number of tutors accessing the site was manageable and thus an overview of the various tutoring interactions was possible.
- Accessibility for research purposes, namely the availability of site access and cooperation from CSIR Meraka Institute which co-ordinates and regulates the tutoring interactions for Dr Math.
- Dr Math is one of the first and most well-known mobile mathematics tutoring projects in South Africa and could also be considered a model of online tutoring interactions.

Significance of the Study

This study intended to contribute better understanding of the pioneering work of mathematics' tutoring via the mobile phone application MXit. As MXit is already widely used by teenagers in South Africa the availability of the tutoring logs suggested an opportunity to develop better understanding of the opportunities and constraints of teaching via this application. Furthermore the study contributes a model for investigating tutoring interactions in mediated online learning environments which can be applied in similar situations. Further research could extend the validity of the data by investigating another period of Dr Math use, such as for example exam time.

Parameters of the study

The one month sample consists of 6084 logged lines of conversation from the Dr Math files for February 2010, amounting to 134 A4 pages. Four hundred and thirty eight dyadic conversations (Episodes) between learners and tutors were methodically analysed.

The most productive tutor (Tutor Lawrence) is the project leader.² The other two tutors, Tutor Bosch and Tutor Parker, are volunteer tutors who assist on Dr Math. Tutoring sessions took place between 13h50 and 19h00 throughout the month of February.

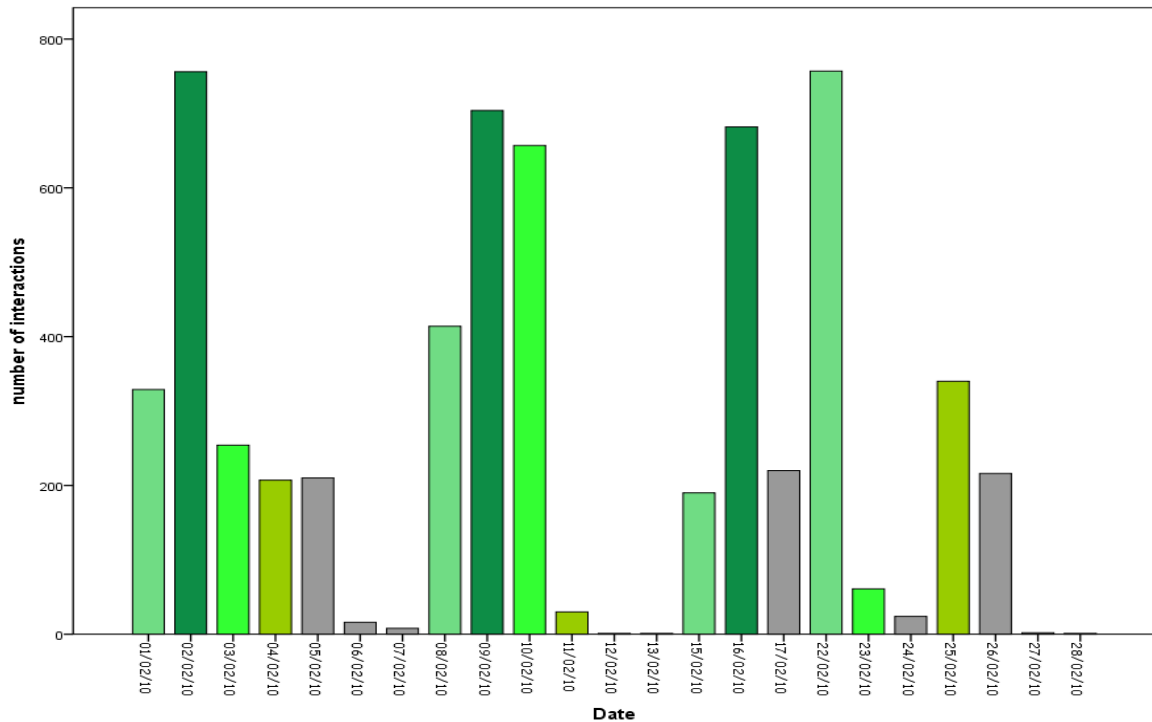


Figure 4: Levels of interaction on Dr Math during February 2010

Figure 4 indicates the dates and extent of interaction for the sample chosen. What is noticeable from the graph is the patterns of higher and low volume activity on the platform during specific periods throughout the month. Supply and demand patterns according to days of most intense homework activity and availability of tutors shows trends for mid-week intense activity.

Data Collection

Data was derived from the logs of Dr Math tutoring interactions between volunteer tutors and learners. Learners and tutors interacted anonymously either by using pseudonyms or their assigned portal user identity numbers. This enabled researchers to

² Pseudonyms are used throughout to protect tutor anonymity.

protect the individuals' identities. Any information in the log files which could indicate the identity of a learner or tutor was removed or disguised and then indicated in the transcript.

Logs of Dr Math chat tutoring interactions are archived by CSIR Meraka. Logs were stamped chronologically and according to the tutors and learners involved, with the tutor identifier, the learner identifier, and the date. In total, 226 learners accessed the portal, while 190 had learning interactions with tutors on the Dr Math portal during the month of February 2010 and a total of 6084 messages were sent.

Cleaning and presentation of the data

The data in the form of log files for February 2010 are presented in one of two formats. Dr Math log files primarily store individual messages, not necessarily conversations. The logging system changed substantially during 2010 when the system was completely rewritten to cater for scalability concerns.³ After the change, the logs were stored in a database table searchable by specific tutor and specific mobile user. Butgereit explains that the sorting algorithm is different either according to tutor or learner (personal communication via email 1/4/2011, 18/1/2011).

The central challenge for this analysis was that the logged interactions were not necessarily stored in chronological order. When the decision was made to look at the tutoring interactions of the three tutors who accessed the portal during February 2010, I initially requested a chronological ordering of the logs but found that when a tutor talked to multiple learners at the same time, the date sort caused the logical conversations to be broken up into pieces. Hence the logs were ordered first by date and then according to the tutor-learner sequence.

Whilst this was one of the challenges of ordering the log files, it was still necessary for a conversational analysis to sequence the chronological order of conversations. One of the features of synchronous interactions via MXit is that there can be long delays in the conversations.

The log files were formatted in CSV format (comma-separated values), which allowed for data to be viewed and analysed in MS Excel. The columns were reorganised to allow full conversations by either tutors or learner to be viewed together. This also

³ Prior to this the logs were operating system logs written to text files.

raised some difficulties as not every line in the logs had time-stamps. In total 12.16% of the logs did not have time-stamps. In most cases the time-stamps had not been logged because of the use of the /r carriage return in a transmitted message consisting of multiple lines. This left certain lines of data without a time stamp Time-stamps were also missing in log files where the /r preceded bot interactions (automated descriptions from the Dr Math wiki, encyclopaedia or use of the scientific calculator).

A manual time stamping was performed on those logs which had not been time-stamped. These lines were manually stamped with the same time as the previous line. An example of a reconstructed, manually time-stamped sequence follows.

Transcript 1 The Dr Math wiki

Tutoring sequence	Date	Time stamp	time taken	Participant	Message
Tut1Seq112Ln5	15/02/10	15:54:27	0:01:14	TUTOR	That is known as the natural logaratihm. it's a bit much to explain but you can read all about\r
Tut1Seq112Ln6	15/02/10	15:54:27	0:00:00	TUTOR	it by typing in\r
Tut1Seq112Ln7	15/02/10	15:54:27	0:00:00	TUTOR	\r
Tut1Seq112Ln8	15/02/10	15:54:27	0:00:00	TUTOR	.w natural logarithm\r
Tut1Seq112Ln9	15/02/10	15:54:27	0:00:00	TUTOR	\r
Tut1Seq112Ln10	15/02/10	15:54:27	0:00:00	TUTOR	for the wiki entry
Tut1Seq112Ln11	15/02/10	15:55:29	0:01:01	LEARNER	When do u use it and what for?

Rationale for ESA

To assist in the analysis of the discourse in the transcripts, the Exchange Structure Analysis (ESA) framework was used. Cox, Carr and Hall (2004) explain reasons for using this method of coding and analysis coding as it is relatively simple to use and can be performed by a researcher who is not a content specialist or a seasoned qualitative researcher. It is a development of an established approach to discourse analysis and can be applied in several disciplines (Mason 1992).

Exchange structural analysis (ESA) was employed in my research since it offered the possibility of a simple coding method for the analysis of the chat protocols between the learners and tutors. It also offers insights into the conversational roles and relationship dynamics during the tutoring interaction. Kneser et al. (2001) utilised ESA to examine characteristics of chat discourse and to evaluate the effectiveness of online tutors in

transferring discussion skills to postgraduate students in a distance learning program (Lim, 2006). The different roles of the tutor and learner were indicated in the analysis of the transcripts and patterns of exchange roles adopted by the students and tutors indicated the extent of participation of both parties in the discussions.

Lim (2006) adapted and extended the ESA of Kneser et al. (2001) and Cox et al. (2002, 2004) and applied this to case studies of two tutorial groups. Lim's study indicates that chat interaction is more structured and complex than the literature suggests. Lim's research supplements the body of literature on ESA as a method for analysing online synchronous chat interactions and extends previous studies regarding the pedagogical impact of synchronous CMC technology from a socio-cultural constructivist perspective.

Whilst the afore mentioned studies focus on group collaborative learning and have as their main focus the individual interactions within groups, the Dr Math project utilised synchronous online tutoring on a one to one platform. I employed ESA to analyse the learner tutor interactions as the tutoring protocols offer very little information about the participants.

Data Analysis

The ESA framework applied in this study is based on the framework of Lim (2006). Lim's framework is an extension and adaptation of Kneser et al. (2001) who applied ESA to online chat discourse. This provided a framework with which to analyse responses, moves, turn-taking and roles of students in online discussions. Lim's (2006) framework provides extra categories which account for Off-Task (OT) or categories which are particular to the online environment. These were useful guidelines for coding, but the specific nature of the Dr Math platform required a reworking of these categories. As there are possibly turns within episodes that do not reflect content directly relevant to the learning activities, Lim suggests a separate category for such non-task-oriented turns. These are not coded at ES or Move level, and instead are classified as "Other" or Off-Task (OT). The OT turns, encompass all turns which are not related directly to mathematical tutoring interactions. They are nonetheless important as they reveal other functions of the dialogue on Dr Math. As I encountered quite a few instances of interactions, which I could not place in any of Lim's suggested categories, I added a further three categories which are relevant to the Dr Math platform. Hence I categorized Off-Task or other categories as follows:

Additional coding categories

Code	Definition
NC not coded	Any contribution made by a participant which is not in any context and made no sense. Something is missing in the log, The message was mistyped, its meaning within the recorded dialogue could not be established.
F (Formatting)	Used when the Carriage return character \r was used (to indicate deliberate formatting). The carriage return was indicated in the data logs to indicate that a turn ran over more than one line.
OT-Social (OT-S)	Turns that support development of relationships such as greetings, social banter and emoticons. This code was used for all instances of social chat which was not related to the broad interactions of mathematics in anyway and therefore considered as “not on-task”.
• OT-Technical (OT-T)	Turns that result from technical problems/issues such as malfunctioning network connections or equipment.
OT- Bot (All contributions which resulted from the automated computer system)	Dr Math has its own bots for sending out bulk messages, supplying technical information for learners to access or scripted greeting messages. All these were coded as bot messages.
OT-Anti-Social – Lang/ inappropriate (OT-AS)	Expletives or inappropriate suggestions which cannot be coded as social and are Off-Task.

Table 1: Additional categories added for Dr Math (Off-Task or Other)

Applying ESA to Dr Math interactions

In my study, Exchange Structure Analysis (ESA) was adapted to identify interactional patterns that characterise the online synchronous tutoring of Dr Math. The interactions between tutors and learners are dyadic and mobile-mediated, suggesting that they will differ in structure from both traditional classroom and automated online tutoring interactions. In several respects, instant messaging differs from classroom discourse. In the first place, interactions are dyadic, taking place between two interlocutors with distinctive roles (learner and tutor) rather than between a large class and their teacher. This dyadic discourse also differs from the multi-user chatrooms, newsgroups or forums which are often studied in CMC research. The dyadic learning interactions of Dr Math allow tutors the unique opportunity to tailor the learning to the individual needs of learners.

Second, although the roles of tutor and learner differ in status, in a substantial number of cases, interactions will be initiated by the learner rather than the tutor.

Third, the boundaries in the Dr Math exchanges are not as clearly defined as they often are in teacher-directed classrooms. There are fairly large variances to beginnings and endings in transactions owing to the nature of online synchronous communication, which in the case of Dr Math is fairly informal in register.

Finally, discourse is not curtailed by the strict classroom regimes which regulate time. This means that interactions can be extensive if tutor, learner, and system are all available and interested in extending the dialogue and deepening understanding. It also means that tutors and learners can initiate and terminate interactions at any point during the sessions.

Coding using the Exchange Structure Analysis Model

The ESA model was chosen because of its widespread use and its simple interaction-focused coding techniques. The ESA method investigates the dynamics of taking turns in online tutoring sessions, in which a turn is defined as “a contribution by a particular participant and is delimited by that person starting and stopping speaking” (Kneser et al., 2001, 65). The ESA categories which were used in the transactional analysis of Kneser, whereby an exchange is defined as “a combination of Initiate and Respond moves”, (Kneser et al., 2001:65) were not defined as exchanges in this study. After an initial coding it became apparent that there was extensive use of RI and RC turns. Tutoring interactions were not framed or as bounded as initially anticipated. This was partly due to the great variations in when and how each tutoring episode began and ended. Some tutoring exchanges begin and end abruptly while others have clear boundaries, framed by social interactions at each end. Many of the transactions (tutoring interactions) begin or end with social exchanges such as greetings. In addition the Dr Math ‘bot’ sends out bulk messages which often form part of the preliminary transaction. Thus delineating the start and end point of a transaction is not always a simple matter in Dr Math discourse. Therefore the tutoring activity was defined in terms of an ‘interaction’ or “sequence”. Interaction is used in this study to indicate a continuous sequence of dialogue or activity between tutors and learners. Each learning interaction consists of a sequence of coded turns between a specific learner and tutor.

ESA Categories

TURNS AND DEFINITIONS	
INITIATE	An Initiate turn (I) is preliminary in the exchange, is not predicted from a previous turn and is a contribution that anticipates a response by another participant.
RESPONSE	A response is a contribution that is not initial in the exchange, usually does not anticipate a turn and commonly completes an exchange.
REINITIATE	A Reinitiate turn is not initial in the exchange, is a contribution that is a continuation of a current exchange and anticipates a response from another participant. Reinitiate turns are not predicted from an earlier turn. A Reinitiate turn indicates the intention to continue with a related topic in a sub-exchange.
RESPONSE-COMPLEMENT	An RC turn is a contribution predicted from previous turn. RC turns are feedback which can be either a form of acknowledgement or evaluation. RC turns are distinguished from (R) by the minimal information it conveys and feedback acknowledging response. An RC turn is never an initial contribution and although it often signals intention to close the exchange however, it can also be followed by a new exchange.

Table 2: ESA categories with definitions (based on Kneser et al., 2001)

Turns are first coded at the ES level according to four structure categories, Initiate (I), Respond (R), Reinitiating (RI) and Response-Complement (RC) (see Table 2).

Initiate (I)

An Initiate turn (I) is preliminary in the exchange, is not predicted from a previous turn and is a contribution that anticipates a response by another participant.

As discussed above, coding the initiating turn is complex in Dr Math since, owing to peculiarities of the MXit interface and logging process, in some cases the initial opening move is a blank line or 'bot' interaction, which is not recorded in the log. In the online tutoring environment of Dr Math the initial interaction may vary. All learners who want to use Dr Math must initially add Dr Math as a MXit contact. Whenever the learner is logged into MXit they will see whether Dr Math is available. This does not mean tutors are always available or present but the portal can be accessed. By sending any message, even a blank one, a learner indicates that they wish to speak to a tutor or use the portal by accessing the bot. Automated jokes and messages have also been sent out via the Dr Math bot and this can be the initiating action in an interaction. Sometimes learners respond to the joke but do not necessarily want to ask a mathematics-related question. The actual written chat interaction thus often begins with a learner asking a question or with a tutor asking "how can I help you?"

In many cases the log files do not record the initial contribution made by the learner. The learner logs on and initiates the exchange by sending an empty message to Dr Math. The tutor responds by asking if they have a mathematics question. Just as a learner might raise a hand to ask a question in class, the initiating exchange, which is thus made before the tutor responds, serves to indicate non-verbally that the learner wishes to interact.

Reinitiate (RI)

An RI turn is not initial in the exchange, is a contribution that is a continuation of a current exchange and anticipates a response from another participant. Reinitiate turns are not predicted from an earlier turn. A Reinitiate turn indicates the intention to continue with a related topic in a sub-exchange.

Stubbs (1981) includes a category R/I for a Respond followed by a new Initiate uttered by the same participant within a turn. That participant thus closes one exchange and begins a new exchange within the same turn. This enables us to count the number of exchanges initiated by a tutor or learner whilst still being able to track 'initiative swaps'. Initiative swaps record the number of instances where a participant switches from Respond to Initiate within their turn and hence regains the initiative in the dialogue. 'Reinitiating' (RI) in the Wishart and Guy (2009) notation is reserved for turns that do not signal an intention to close the current exchange and start a new one but, rather signals a continuation of the current exchange. RI predicts a response but is non-predicted and non-initial. In contrast to positive feedback, negative feedback is often combined with moves that continue the current exchange in this way.

Respond (R)

A response is a contribution that is not initial in the exchange, usually does not anticipate a turn and commonly completes an exchange.

The most frequent example of this pattern is when the tutor asks "do you have any maths question today?" and the learner responds by stating the specific problem.

Response turns indicate more substantial sharing of information than is found in RC turns. Response turns indicate the shared information between the tutor and learners in the interaction.

Response-Complement (RC)

An RC turn is a contribution predicted from the previous turn. RC turns are feedback which can be either a form of acknowledgement or evaluation. RC turns are distinguished from (R) by the minimal information it conveys and feedback acknowledging response. An RC turn is never an initial contribution and although it often signals intention to close the exchange, it can however also be followed by a new exchange.

When analysing the Dr Math logs, I follow Wishart and Guy (2009) and use RC (Response-Complement) for a turn which acknowledges having heard the speaker and signalling intention to close or "finish" the exchange.⁴ This marks the point at which a new exchange may be naturally initiated. Since RC is optional it is non-predicting, non-predicted and non- initial. In this study RC turns did not indicate the intention to terminate interactions, but more frequently were used when acknowledging a comment in the previous turn and indicating the other participant could proceed.

The RC distinguishes itself from a response in that it is short and offers either an acknowledgement of the previous turn or a short evaluative statement (see the Move level for further details).

⁴ Wishart and Guy (2009) replace the notation F for feedback with RC for "Response-Complement" to avoid confusion with the Move level term (*feedback*). The term Response-Complement avoids suggesting that this ESA category of turn must have evaluative content such as 'yes' or 'no'. There are many occasions, particularly outside the classroom, in which this turn slot is filled by a form of acknowledgement, which does not commit the speaker to any opinion about the truth, correctness or validity of the response. Rather, it acknowledges having heard the speaker and signals intention to close or "finish" the exchange, thus marking the point where the exchange may end or where a new exchange may be initiated.

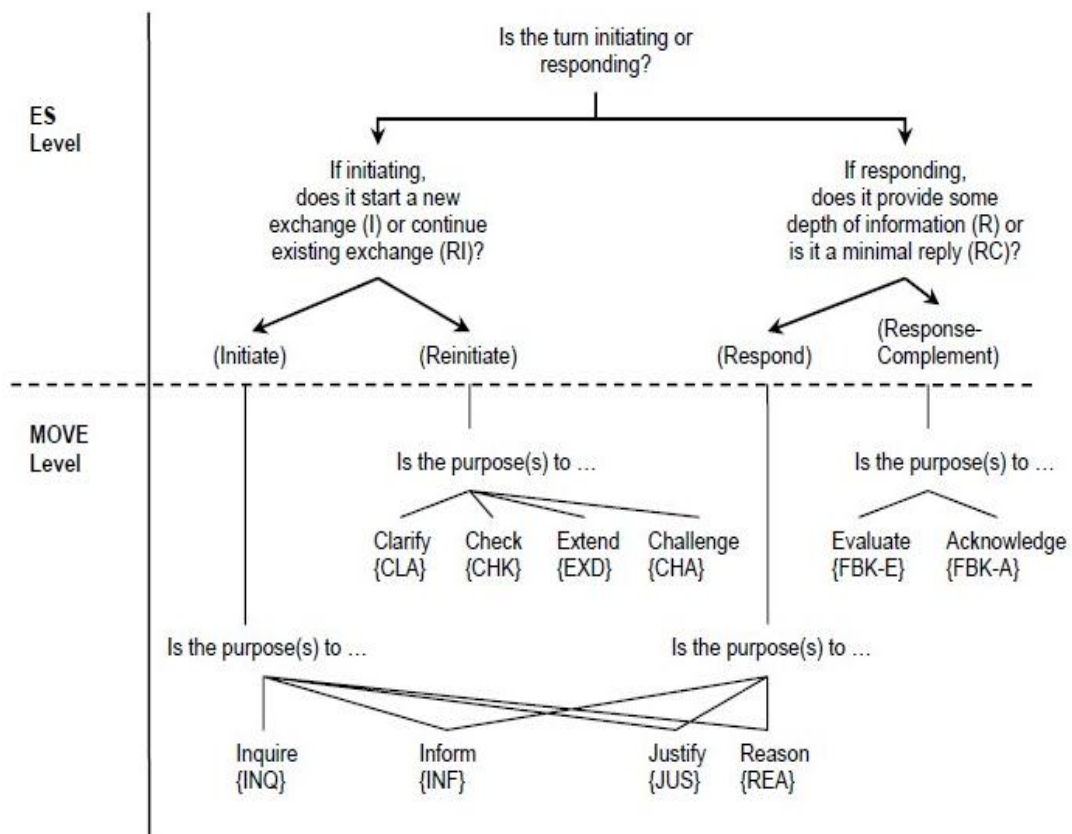


Figure 5: ESA scheme used in current study. Coding at ES and Move levels (source Lim, 2006:120)

Interactional Moves

ESA is used to analyse interaction at two main levels, firstly at the Exchange level and secondly at the Move level. The Move level (see Fig 5 & Table 3) describes the purpose of the turn, and establishes whether it is a move to challenge, justify, clarify, provide feedback, inform, inquire, or to provide the reason for the current posting.

Coding categories for the Move level

In this study, coding of structural positions and pragmatic functions of turns are largely guided by interpretations of their role in the tutoring interaction rather than in relation to the mathematical correctness or accuracy of the turns. The study of Move levels is particularly relevant when examining the roles of tutors and learners in the learning interactions, as well as identifying scaffolding interactions.

In Move level analysis, on-task turns previously coded as I, R, RI and RC were further categorized according to interpretation of their pragmatic functions. For instance, a turn coded as I at the ES level could be interpreted to have a communicative intention to Inquire (INQ), inform (INF) justify (JUS) or reason (REA) at the Move level (see Lim Framework for associated Move levels, page 35. Analyses of moves as frequencies and range of move types implemented should suggest information about the underlying interactional purposes of turns by participants. By examining the exchanges at the Move level it also sheds light on aspects of the roles assumed by learners and tutors in the interactions.

At the Move level the following definitions have been applied from the categories adapted from Lim (2006) and Cox et al. (2002, 2004) which were derived from Kneser et al. (2001).

TURN	ASSOCIATED MOVES WITH DEFINITIONS	
INITIATE AND RESPONSE	INFORM	When describing or making observations of facts or events Stating rules or definitions Summarizing information or repeating it from memory or external sources (e.g. text book)
	INQUIRE ⁵	When eliciting or requesting information Asking a favour which can be accepted or rejected by the participants
	JUSTIFY	When defending a stated position in the current turn with evidence or information Challenging or disputing a stated position in previous turn with evidence or information
	REASON	When presenting a problem with solution or cause and consequence presenting support or contradicting alternative hypotheses Stating reasoned (constructed) beliefs or implications
REINITIATION	CLARIFY	When seeking more information on the previous turn Making meaning clearer or understanding easier
	CHECK	When making certain the meaning of the previous turn(s) hypotheses Checking readiness of the participant and establishing if there are any problems
	EXTEND	Describing or making observations of facts or events State retrieval of beliefs, definition of rules Summarizing information or repeating it from memory or external sources (e.g. text book)
	CHALLENGE	Propose, assert or suggest another direction for the discussion or thinking

⁵ Inquire is not associated with Response moves, only Initiate

TURNS	ASSOCIATED MOVES WITH DEFINITIONS	
RESPONSE - COMPLIMENT	FEEDBACK EVALUATIVE	Evaluative feedback (FDB-E) which validates the truth/ correctness or comments on the quality of the previous turn (s)
	FEEDBACK ACKNOWLEDGING	Acknowledgement feedback (FDB-A) which acknowledges or claims understanding / having heard the previous turn. Can also report the state of the speaker

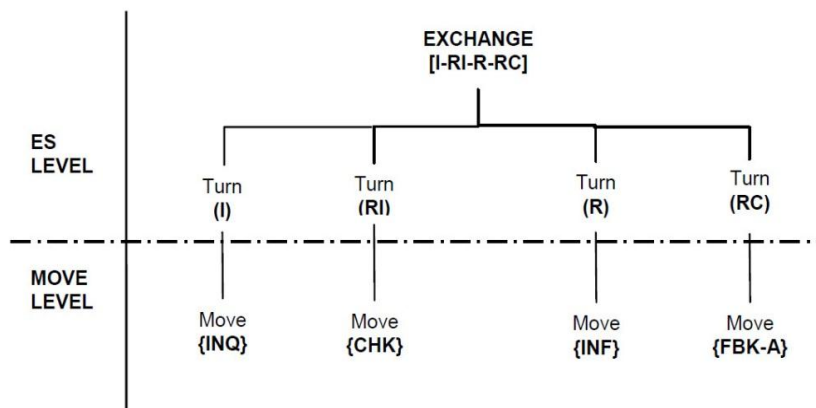
Table 3: Interactional Moves associated with turn types and their definitions

Move level analysis reveals the ways in which participants are making these specific interactional moves, and this can help to sketch the communicative intentions which may have motivated the exchange.

Turns in each interaction are first coded at the Exchange level into four structural categories namely: Initiate (I), Reinitiate (RI), Respond (R) or Response-Complement (RC) to derive exchanges. At the Move level, codes are assigned according to the pragmatic function or intention level. Coded turns are further classified according to their associated moves. For instance, an (I) turn could be coded at the Move level as having the pragmatic intention to Inquire (INQ). Lim (2006) suggests that coding of structural positions and pragmatic functions of turns are guided to a great extent by interpretations of their relevance in terms of the discussion context and not so much in relation to the accurateness of the content in the turns.

In other words, moves represent the pragmatic function or intention of utterances at the speech act level (Searle, 1969). By combining levels of analysis it is possible to track the instances and the number of times a participant informs about a cause or inquires about a problem.

Figure 6: ES and Move levels in online chat discourse (source: Lim, 2006: 121)



The coding scheme utilised by Lim (2006) is based on and adapted from insights gained from the reports of Kneser et al. (2001), Carr et al. (2002) and Cox et al. (2004). Lim's (2006) adaptations include the following:

Each ES category is associated with its own move categories (see **Table 3** and **Figure 5**). These categories indicate the underlying intention of turn categories, but were also useful as a way to identify codes which were difficult to interpret.

“Other categories” (OT) are included to indicate coding which is not directly relevant to the learning interaction. These OT categories reflect insights about the online interactions between participants, such as bot-related turns, technical issues and also all social interactions which often framed learning interactions or were prevalent when non-mathematics related interaction occurred.

Single coding is standardised at the ES level and double coding is allowed at the Move level, in cases when a turn could be interpreted as having multiple or more than one pragmatic function (Lim, 2006). The ESA scheme allows double-coding at the Move level when a turn is interpreted as simultaneously performing more than pragmatic function e.g., (RI) to both (Clarify) and (Challenge) as shown below. However, only the range of moves associated with the (RI) category could be assigned to the turn.

Limitations of the framework

One of the challenging aspects of using the ESA framework for coding mathematics chat interaction was distinguishing between ‘Initiate’ and ‘Reinitiate’ categories. This was due to the abbreviated nature of the discourse where it was often unclear whether a turn was new or a response to something uttered previously. The abbreviated nature of IM discourse made deciphering the conceivable pragmatic intention of speakers more challenging than initially anticipated. The condensed conventions used for mathematical notation added to the challenges when coding ESA turns. In any language the position of the words, the nature of the sentence construction, the choice of vocabulary and punctuation all serve to assist us in deciphering the possible intent of the writer. Despite rigorous coding, the compact nature of the discourse and lack of punctuation, proved to be a limitation when applying ESA to this corpus.

Delineating transactions in Dr Math

A feature of the Dr Math interactions is that the tutoring exchanges did not all begin in a uniform manner. Many of the transactions (tutoring exchanges) began or ended with social exchanges such as greetings or informal social chat. These social exchanges framed the transactions and provided clear boundaries for establishing interactions between a specific learner and tutor. Other exchanges however, often began and ended abruptly and it was not always possible to determine the cause of this, for example when technical issues arose or learners were swapped between tutors in the middle of an exchange. In addition, the Dr Math 'bot' sent out bulk messages which often formed part of the preliminary transaction, but which were not consistently visible in the log data. Learners responding to the bot therefore began an interaction with a response. Thus delineating the start and end point of a transaction was not always a simple matter in Dr Math discourse.

Coding the Dr Math logs

Transcript 2: The flow of one interaction and example of coding

Tut1Seq46Ln50	TUTOR	when the last number is postiive the two other integeres will be either both positive or bot negative	I	INF
Tut1Seq46Ln51	LEARNER	Okay i understand	RC	FB-E
Tut1Seq46Ln52	TUTOR	now when the last term is negative that means one of the numbers will be positive and one will be negative	RI	CLA
Tut1Seq46Ln53	LEARNER	Okay	RC	FB-A
Tut1Seq46Ln54	TUTOR	so if we take $x^2-3*x-10$ because the 01 is negative one of the numbers will \r	RI	CLA
Tut1Seq46Ln55	TUTOR	be postiive and one will be negative.	F	
Tut1Seq46Ln56	LEARNER	Okay	RC	FB-A
Tut1Seq46Ln57	TUTOR	then you just have to juggle them to get the middle term. so it will be a 2 and 5 but oine will be positive and one will be negative and when you add them together you must get -3	RI	CLA
Tut1Seq46Ln58	LEARNER	Okay kwl	RC	FB-E
Tut1Seq46Ln59	TUTOR	so the numbers will be -5 and 2 and the factors will be x- 5 and x+2 \r	RI	CLA
Tut1Seq46Ln60	TUTOR	\r	F	
Tut1Seq46Ln61	TUTOR	what about \r	I	INQ
Tut1Seq46Ln62	TUTOR	$x^2 +3*x -10$	F	
Tut1Seq46Ln63	LEARNER	-5 and 2	R	INF
Tut1Seq46Ln64	TUTOR	no because we need to get positive 3 so the 5 must be positive and the 2 negative	RI	CLA
Tut1Seq46Ln65	LEARNER	Oh yeah i forget	R	INF ⁶

⁶ /r is highlighted as it indicates a carriage return and is not part of the actual exchange.

Transcript 2 displays coded turns at the Exchange and Move level. In this example it is evident that applying conventional ESA coding is challenging. Decisions regarding the assignment of RI code to a turn were influenced in this specific project by the content and context of the mathematics tutoring interaction. The tutoring of mathematics involves the breakdown of complex operations into more doable parts (this is an aspect of scaffolding). In an ESA exchange, turns cannot stand alone, but are dependent on the previous turn in a sequence. In Dr Math tutoring interactions, when learners responded either with an RC or R turn, it did not necessarily complete the exchange, but often indicated that they wished the tutor to continue, or acknowledged they had understood the previous utterance and that the tutor could proceed. Tutors used RI turns when continuing or extending the exchange. By scaffolding the problem, the tutor could continuously assess the learner's understanding before continuing with the next aspect of the problem. **Transcript 2** is an extract from a lengthy tutoring sequence where the prevalence of RC turns was particularly apparent. The learner constantly gave feedback (FDB-A) indicating that they understood the tutor's explanations and could follow the logical progression. The tutor used RI turns when clarifying aspects of the problem and in order to explain in greater detail. The last line of the exchange could have been coded as R or RC as the utterance provides feedback, informs and closes the exchange.

Ethical considerations

The Meraka Institute is a branch of the CSIR which is involved in numerous research projects. Permission to use the site for research was granted by the CSIR through the administrators of the Dr Math project. Ethics procedures and guidelines were already in place and I signed a Memorandum of Understanding (MOU) which stated both the nature of the research and the use of the recorded log material. As the agreement stated that I would only utilize the anonymous data logs and not access learners who were involved in the project, I did not have to gain their direct consent or parental permission.

Anderson & Simpson (2007) explain that it is regarded as essential to gain informed consent from participants when undertaking face-face research in the field of applied linguistics. However, when researching online interactions, a number of problems emerge and there are still debates about when informed consent from participants is

needed. When online users or participants are self-anonymised through the use of aliases or nicknames, it is challenging to gain access or trace them. Anderson & Simpson (2007) explain that for many the visit to online portals is transitory which makes further contact or follow up extremely difficult. As Dr Math tutoring interactions are not on a public forum, the data was treated as private, however, the nature of the content and the use of aliases for participants, assured that this research did not pose harm to any participant. Learners accessing the portal are encouraged to use aliases to protect their identity by not revealing personal information. Furthermore, in order to prevent abuse of the facility, all conversations on Dr Math are logged and users of the portal are made aware that all the conversations are recorded. By keeping logs of the interactions it is possible to monitor whether the learners are actually using the facility correctly and assess which topics or questions are discussed most frequently. Logs also provide the possibility to examine the methods used by tutors when responding to learners and determine if there are any issues during the tutoring interactions which need to be addressed. By having recorded logs of all conversations, tutors are protected from false allegations should these arise, and also prevent learners being enticed into any unsafe or illegal activities by tutors (Butgereit, 2011).

Position of the researcher

"A researcher's background and position will affect what they choose to investigate, the angle of investigation, the methods judged most adequate for this purpose, the findings considered most appropriate, and the framing and communication of conclusions" (Malterud, 2001: 483-484).

Discourse analysis is a way of understanding social interactions. Parker (1994) explains that, especially in qualitative studies, researchers position themselves by the way in which research knowledge is used or fore-grounded. With discourse analysis, decisions are made about transcription and different coding schemes (Stubbs, 1983). Furthermore, issues relating to confidentiality, as well as the motivation and interest of the researcher in the project, all influence the research.

Reliability and validity

In discourse analysis, the question of reliability should consider whether different researchers would interpret the text in similar ways. According to Stratton (1995:116) there is no guarantee that such reliability is possible, given that researchers are likely to differ in their "motivational factors, expectations, familiarity, and avoidance of

discomfort”. Therefore it has to be accepted that the interpretations of the data in this report are subjective and another researcher may interpret the data differently.

Sudweeks and Simoff (1999: 31) explain that in online research, rapid changes in CMC technologies and application features imply that the “path of information communication” is seldom stable. Also, given delays/time lags in synchronization and the creative use of language, participants on each side of the real-time link in this case study are likely to experience “a unique conversation” (Ruhleder, 2000, p.13).

This study acknowledges issues of validity by using a single case and a single coder for in-depth understanding of tutoring chat interaction. This was unavoidable given the constraints of a minor-dissertation. Knowledge gained from this inquiry is based on interpretations of a specific time/context and I do not claim that they are generalizable to other tutoring programs which are using synchronous mobile chat for mathematics tutoring.

This study recognizes that in coding there is a degree of coder subjectivity, especially when interpreting turns at the Move level. As coding was done using a relatively small sample of the total chat interactions and considering the aforementioned constraints of the research dissertation, it is understood that the overall understanding of the tutoring chat interaction is limited.

Intra-coder reliability check: A check was made by doing an initial coding on a subset of the data and allowing an independent coder to check the coding done by the researcher, before applying this to the data. Revisions to the coding scheme were made when specific categories and procedures were adapted or discarded. This was to ensure that the coding scheme could be applied consistently to the data sample. Nonetheless the final coding is the work of a single coder.

Turn- and Move level consistency: In the case of this study the Move level analysis was very important when seeking clarity on the coding of the turn coding. Sometimes turn coding only became clear when the process was reversed. This is confirmed by Lim (2006:167): “reliability of category assignment to turns was enhanced when bottom-up coding from Move level led to occasional reconsideration of the ES category previously assigned”.

Limitations of the study

The purpose of the analysis of the transcripts was to explore the nature of mobile mathematics-tutoring discourse rather than to describe pedagogy or evaluate the mathematical content.

The ethics agreement signed in the MOU with the CSIR Meraka Institute permitted access to data logs of the project. As a discourse analysis of the data logs was intended, it was agreed not to have direct access to learners. For an initial exploration of the learning interactions, this was sufficient. In order to better understand the context of learners and tutors when engaging in the learning interactions however, feedback from participants would be recommended. This could enhance the understanding of the challenges and benefits of these learning interactions and could be a possible area for future research.

As discussed above, another limitation of the study is that the sample from the data logs reflects only a small portion of the copious data available but this is appropriate within the limited scope of this study.

Although the issue of the reliability of this coding scheme has been addressed by Cox et al, (2004), Kneser et al. (2001) and Lim (2006), the reliability of dialogue analysis remains an issue. Steps were taken to apply coding schemes consistently within the unique context project data. The reliability of schemes varies somewhat as ESA coding was originally developed for classroom discourse, which traditionally is one-to-many. This has subsequently been adapted and readapted.

Having acknowledged the limitations of data analysis in the research project, I now present the findings in the following chapter.

CHAPTER FOUR: FINDINGS AND PRESENTATION OF DATA

As stated in Chapter One the main purpose of this study was to examine the interactional and multimodal strategies in synchronous mobile mathematics tutoring on MXit. To reiterate, my research question asked “What interactional genres and discourse characterise learner-tutor interactions in an online mobile mathematics tutoring environment?”

In this chapter the findings from the analysis of the data on tutoring interactions are presented in two parts, Part A and Part B, in order to address my research questions which are both quantitative and qualitative.

As explained in Chapter Three, turns were coded at both Exchange and Move levels. Results at Exchange level help reveal the roles of tutors and learners in the exchanges. At Move level the results suggest the pragmatic intentions of users and provide an interpretation of the interactional purposes of an exchange. The quantitative results of this analysis are presented in Part A of this chapter. Part B presents an analysis of the qualitative aspects of the study, particularly the quality of the interactions by three of the Dr Math tutors and the nature of the discourse.

PART A: QUANTITATIVE FINDINGS

Participation

A simplified version of Lim’s (2006) framework was used for coding. Some coding categories were added to code anomalies in log data, as these did not fit previous schemes. These additional coding categories assisted in forming a clearer picture of the data, specifically the ratio of on-task to Off-Task (OT) interactions. In doing so, it was possible to identify the distribution of turn types at the Exchange level, but also get some indication of the proportion of exchanges which were not related to mathematic tutoring, yet which constituted a large part of the Dr Math February data. Before dealing with the ESA exchanges it is necessary to indicate the overall patterns of participation of learners and tutors on Dr Math, as revealed by the data.

Distribution of activity on Dr Math

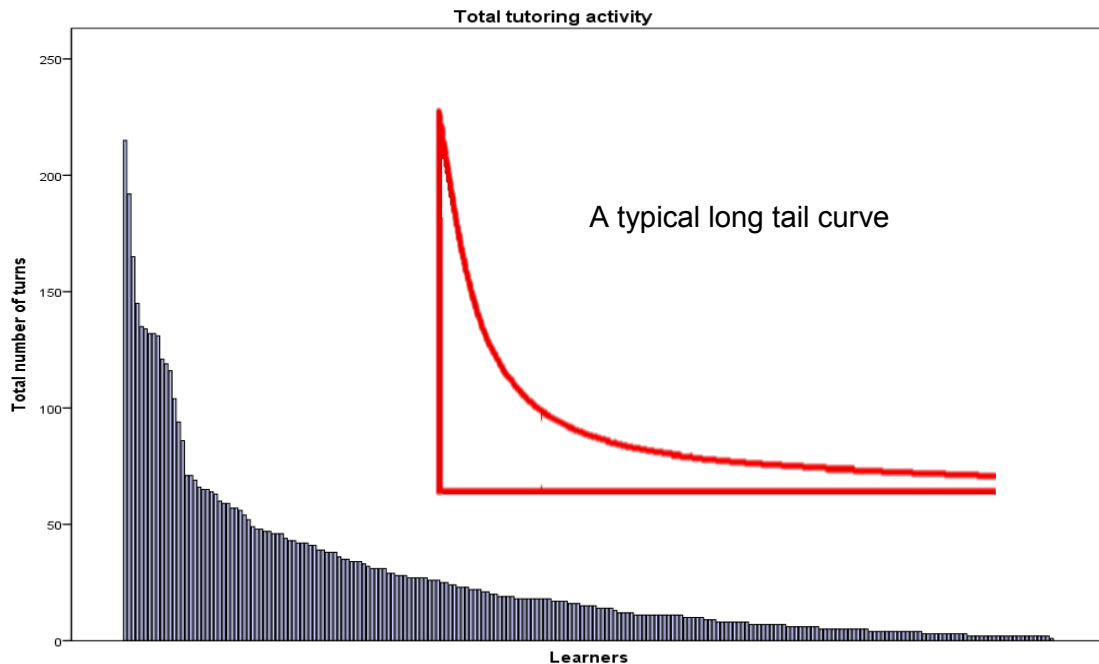


Figure 7: The overall frequency of turns per learner. (N (turns) = 6084) and N (learners) =190)

As there are a large number of learner interactions in the sample for this study, I do not describe specifics of interactions in great detail. **Figure 7** illustrates the overall tutoring activity during February 2010.

The distribution of activity on Dr Math reveals a characteristic 'long tail' pattern of activity, whereby a small number of learners account for most of the tutorial activity, while most learners participate only briefly, with many contributing just one turn of dialogue.

Figure 7 represents the total number of turns in learner-tutor exchanges (i.e. the graph reflects both tutor and learner participation), per learner, as logged on Dr Math during February 2010 (see **Figure 4** for the distribution for tutoring sessions). The learner with the greatest activity participated in exchanges with tutors which amounted to over 200 turns of dialogue. By contrast, a large number of learners (the 'long tail') participated very little. This distribution thus reveals a smaller number of learners accessing the portal over an extended period or engaging in more intensive dialogue with tutors, while a large number of learners participate only in very short or minimal exchanges.

Learners may have returned for additional tutoring in later months, but this analysis reflects the activity for February. The long tailed distribution graph in **Figure 7** reflects the characteristically short or nominal and isolated tutoring exchanges for the majority of Dr Math users which contrast with the extended interactions by a smaller group of active users. These active users characteristically engaged in either multiple or lengthy exchanges over the course of the month.

Subject to the availability of tutors, Dr Math offers users the possibility to log in whenever, for as long and as often as they wish to. This leads to variations in the way users chose to make use of the service. Some learners log in once or twice and have long conversations; others may just try it out once. Others access the portal more regularly for shorter interactions. This multiplicity of possibilities is typical of online social networks and inevitably results in long tail distributions (Anderson, 2006b). **Figure 7** shows that very few learners had extended interactions or engaged extensively during the month of February. For the purposes of this study an extended interaction is considered to be any interaction above the median of 10 (**See Table 4**). A larger and less active majority had minimal or even isolated exchanges. Further detail about the nature of the participation will be explored by examining the results of coding individual turns in the tutoring exchanges

Off-Task (OT) interactions

In order to establish how much of the talk was on-task (directly related to mathematics learning), the analysis of turn-taking in the tutor learner interactions included Off-Task (OT) turns. **Figure 8** provides an overview of the distribution of on- and off-task turns.

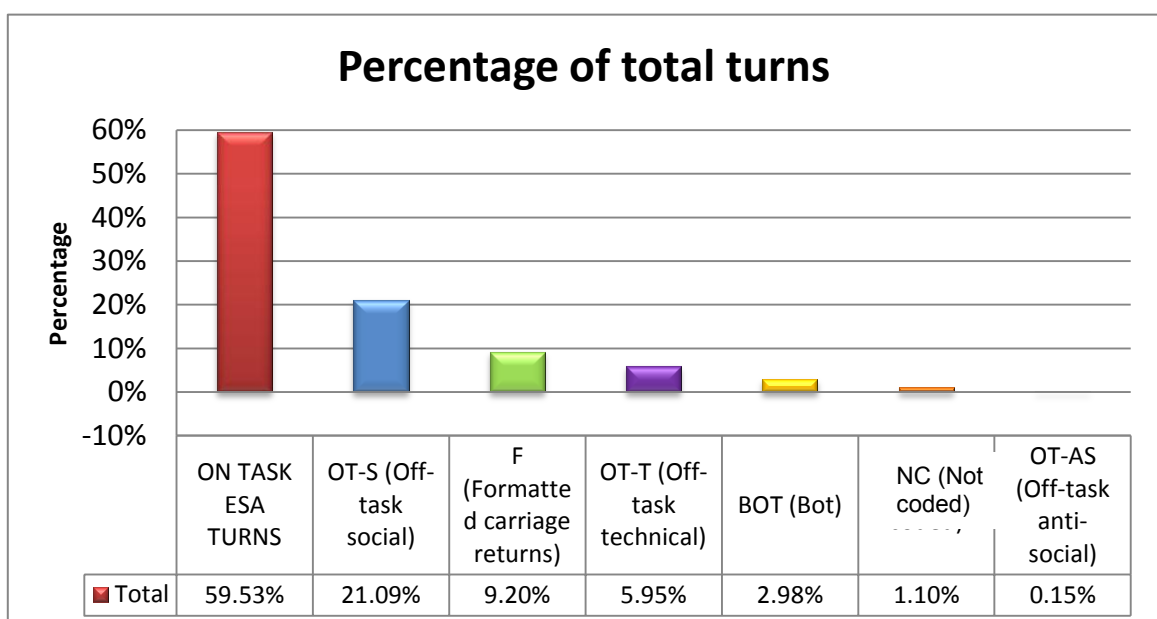


Figure 8: Percentage of total turns at the Exchange level N= 6084

Figure 8 shows that the majority of turns were on-task (59.5%). Of the Off-Task (OT) turns, a large number were broadly social in nature (OT-S), and such interactions constituted 21.3% of the total number of turns coded at the Exchange level. OT-AS (Off-task Anti-social) turns were another form of OT interaction and consisted primarily of inappropriate / explicit language or suggestions of inappropriate (usually sexual) behaviour. Such interactions were negligible, comprising only 0.1 % of the total turns in the logged exchanges (refer to codes in **Table 1**).

The category of Off-Task technical turns (OT-T) accounts for 5.9% of the total turns (**see Figure 11**) and indicates that a certain amount of dialogue was OT, because it focused on solving technical issues with Dr Math communication.

Of the total turns generated, 3% were bot-generated (OT-BOT). Apart from bulk messages at the beginning of the exchange, only one of the three tutors (who is also the designer of the system) actively used the bot to extend learners' knowledge or to link them to alternate resources.

The remainder of turns were considered Off-Task (OT) in some way, in that they did not relate to mathematics problems. A small number of turns could not be coded for various reasons. In total this "NC" (not coded) category formed only 1.1% of the total turns.

Transcript 3: Social exchange which provides opportunity for establishing rapport.

LEARNER Lol.hahahaha [*laugh out loud, laughing*]
TUTOR remember to tell your parents that one when you need to LOL
LEARNER Lol, i'll DEFINATELY remembr t.hw u [*laugh out loud, I'll definitely remember to. How you*]
TUTOR fine thx, how's school going? [*Fine thanks, how's school going?*]
LEARNER Bad. Was p4orming 2dae, nd ma voice wasnt top notch :-? [*Bad. Was performing today and my voice wasn't top notch (emoticon)*]
TUTOR oh, you sing? that's nice
LEARNER Yea it z hey :-) nd d maths test 2dae was nt so bad [*yes it is hey (smiley face) and the maths test today wasn't so bad*]
TUTOR that's nice to hear.
TUTOR what was the test on?
LEARNER Calculus

In **Transcript 3** the learner enters into dialogue by responding to the pre-scripted joke (from the Dr Math 'bot'), sent out to contacts who have signed up for the service.

The tutor picks up on this joke and then uses the opportunity to ask about school and discuss careers. By showing interest in these aspects of the learner's life, the opportunity is created for further exchanges. The discussion does not cross ethical boundaries by sharing personal information, yet it indicates to the learner an interested and supportive tutor.

The parameters of these social exchanges are defined and controlled by tutors, and by Dr Math's policy. Thus not all of the social interactions initiated by learners can be accommodated, as flirtatious or romantic exchanges are not permitted. Individual tutors handle off-topic social interactions which are not mathematics-related very differently. **Transcript 4** is an example of how a tutor goes about defining these boundaries, steering the learner away from personal topics in an overt manner. In the following example the tutor attempts to steer the conversation away from personal issues (see ethics agreement of tutors), but it is clear the learner did not intend conversing about mathematics, so after a very short exchange the tutor terminates the interaction.

Transcript 4: Tutor defining parameters of discussions on Dr Math

LEARNER Uhm..d0 u luv maths *[um, do you love maths]*
TUTOR well loves is a strong work. but i sure enjoy it. any questions today?
LEARNER Uhm d0 u luv me *[um do you love me]*
TUTOR don't get me in trouble. remember all these conversations are recorded. any math questions for me today?
LEARNER Wel im nli curi0us 2 kn0w *[well I am only curious to know]*
TUTOR just math questions please
LEARNER What d0es luv symbolize *[what does love symbolize]*
TUTOR bye bye
LEARNER Y then *[why then]*
TUTOR we chat about math here, not emotions

OT-AS (Anti-social) turns

The tutor's response in these instances was to warn the participant and if they continued to make inappropriate comments, the interaction would be terminated.

Off-Task technical

The category of Off-Task technical turns (OT-T) accounts for 5.9% of the total turns for the month of February. This proportion is fairly high, but early in the year new tutors sign up to access the Dr Math portal and if technical glitches occur, possibly this accounts for the high percentage of OT-T turns. These technical errors could also arise from general mobile connectivity problems, and tricky connections between the Dr Math and MXit servers (see Transcript 5).

Transcript 5: Technical challenges during tutoring sessions - evident in discourse

LEARNER Helo *[Hello]*
TUTOR hi there, are you receiving me, mxit/google seems problematic today
LEARNER
TUTOR hi, are you receiving me?
LEARNER Helo. *[Hello]*
LEARNER Jep. . I am. .so hw r u dwng *[Yes..I am...so how are you doing]*
sorry :(google/mxit is down *[sorry (sad face) google or mxit is*
TUTOR *down]*
LEARNER :| *(face)*

The distribution of turns at the Exchange level indicates that the majority of interactions on Dr Math directly pertained to mathematics. Although tutors spent some time solving technical issues, and occasionally had to steer the focus away from less relevant topics, the majority of learners wanted to discuss mathematics. Nonetheless, social interactions constituted almost a fifth of turns and thus appear to play an extremely important role in the provision of the tutoring of mobile mathematics.

Initiating exchanges

3612 turns were coded at the Exchange level and the majority of turns were on-task (see Figure 9). The long tail Graph in Figure 12 indicates the distribution of Initiate turns for learner interactions.

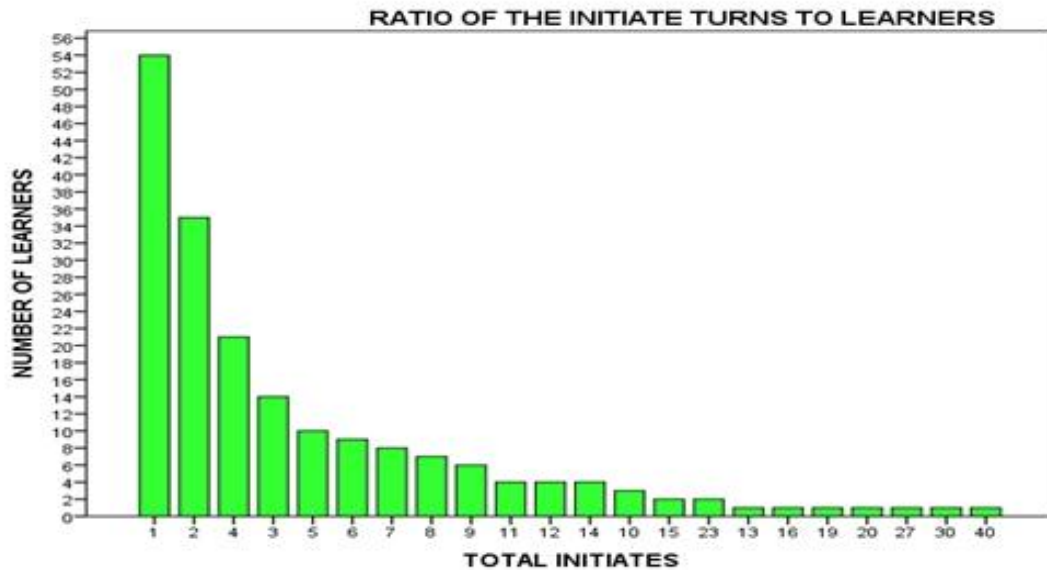


Figure 9: Ratio of Initiate turns at the Exchange level (N=3612)

According to **Table 4** the maximum number of Initiate turns was 40 and the mode for Initiate turns was one, which indicates that while the most common experience was one Initiate in the interaction, there were some outliers who experienced a high volume of activity. A smaller group of learners, who constituted the minority in February, did have more frequent Initiate interactions. The median number of initiating turns per learner-tutor exchange is three, suggesting that many learners participated in only one or two exchanges with tutors during February (they may of course have returned again later).

Given the limited time frame of the data and the fact that February was a fairly quiet month, it would be useful to follow up the activities of these learners in subsequent analyses. Further research could attempt to code patterns of interaction throughout a full year, or over a longer period, to ascertain whether interactions on the platform remain at this relatively low level, or whether they follow a seasonal pattern that responds to test and exam periods in South African schools.

Nonetheless in February, many learners asked only between one and three questions to Dr Math in the month (as indicated by Initiate turns), despite the fact that they most likely received mathematics homework on many days. The log data is not helpful in explaining this pattern, and instead it would be useful to interview some users of Dr Math in future research.

Patterns of more extensive and comprehensive use of Dr Math’s services are evident in the long tail graph (**Figure 9**). These extended tutoring exchanges, although less frequent, were prevalent in the interactions with two of the tutors, namely Lawrence and Bosch. These interactions and the particular style of these tutors will be examined in more detail at the Move level.

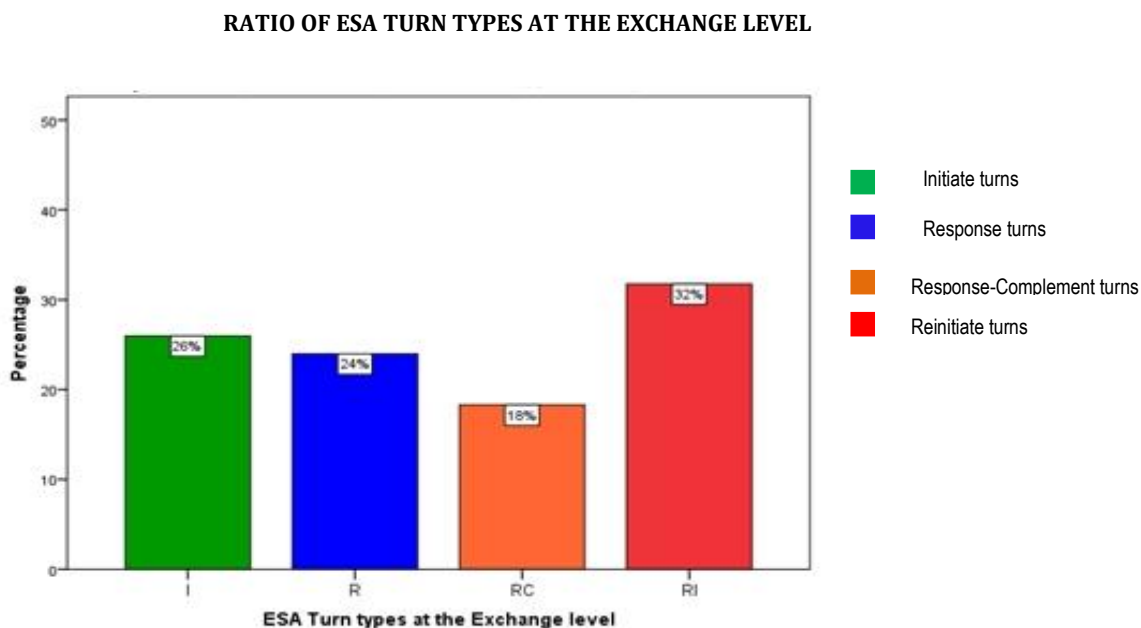


Figure 10: ESA turn types at Exchange level (n=3612)

Characterising tutor-learner exchanges

The following section provides an overview of all the turn types and their significance in examining the overall activity and participation of tutors and learners during the month. I now turn to an analysis of the on-task learning interactions between tutors and learners.

In **Figure 10** the distribution of the mathematics related or on-task turns is shown. All four categories of turn types are represented. The Reinitiate category occurred most frequently with 32% of the total ESA turns. Initiate and Response turns each make up a quarter of the turns at the Exchange level.

Table 4 gives an overview of the tutoring activity and highlights statistical results for the turns at the Exchange level.

Exchange Structure Analysis of turns per learner

ESA coding of turns per learner						
		I	R	RC	RI	Total turns
N	Valid	190	190	190	190	190
	Missing	0	0	0	0	0
Mean		4.95	4.57	3.48	6.03	19.04
Median		3.00	2.00	2.00	2.00	10.00
Mode		1	0	0	0	1
Kurtosis		10.779	6.441	12.406	13.706	9.448
Std. Error of Kurtosis		.351	.351	.351	.351	.351
Range		39	32	39	71	152
Minimum		1	0	0	0	
Maximum		40	32	39	71	

Table 4: ESA turns per learner (N= 190)

On-task turns

In the ESA coding scheme, ‘on-task’ turns are classified in terms of Exchange Structure categories: Initiate (I), Reinitiate (RI), Respond (R), and Response-Complement (RC) reflect the structural organization of chat exchanges (Kneser, Pilkington, & Treasure-Jones, 2001; Lim, 2006; Wishart & Guy, 2009).

The data includes recorded interactions of 190 learners who engaged with tutors in learning exchanges on Dr Math. The long tail distribution suggests that the data is not “normally distributed” (a normal distribution creates a “bell curve” on a graph).

When data is not normally distributed, standard descriptive statistics, such as mean or standard deviation, are not always the most informative way to summarize the data. Given the skewed distribution of participation on Dr Math, measures such as the Mean (in **Table 4**) do not provide an accurate model of participation in Dr Math. The median level of on-task activity per learner involved only 10 turns of participation in tutor-learner dialogue, while the mode (or the most common level of dialogue experienced by a learner) amounted to only 1 turn, which barely counts as dialogue

Initiating exchanges

Initiation of the learning exchanges is fairly evenly distributed between tutors (12%) and learners (14%), but, as discussed above, this opportunity to initiate exchanges was not taken up by all learners.

Reinitiating - Deepening the dialogue

The Reinitiate turns (coded RI), appear to be characteristic of Dr Math tutoring discourse in that they constituted the dominant category of the on task turns in the

February data (**Figure 9 & 10**). Reinitiating turns consist of intermediary questions or statements which respond to a previous turn or anticipate a subsequent turn by another participant continuing the current exchange. In this study RI turns are of particular significance owing to their crucial role in scaffolding mathematical learning.

Figure 14 reveals that tutors are responsible by far for the greatest percentage of RI Reinitiating turns, although not all three of the tutors contributed such a high proportion. This will be discussed in more detail when referring to the roles of tutors and their individual contributions to the tutoring on Dr Math.

Response - Providing information or closing exchanges

Respond (R) replies to a previous turn and usually signals the close of the current exchange. Response turns were also often followed by Reinitiates (RI), when participants needed to clarify something in the previous turn. One of the distinguishing aspects of the Response turn is that it provides more information than RC turns. Responses often consisted of numbers or symbols and thus appeared to be very short, resembling Response-Complements (RC). Just as both tutors and learners initiated exchanges, both learners and tutors responded to queries. Learners' numbers of responses were greater than tutors specifically when tutors posed many Reinitiating questions to extend the interactions.

Response-Complement - Closing exchanges or indicating presence

The Response-Complement (RC) turn is a minimal reply to a previous turn conveying either acknowledgement or evaluative feedback and is used when closing exchanges. Owing to the synchronous nature of Instant Messaging, RC turns frequently indicated acknowledgment of the previous turn and gave a signal for the other participant to continue. Turns were short and often a participant typed a part waiting to see if it made sense to the other participant. If tutors were scaffolding a complex operation the learner frequently typed RC responses, indicating they were following the tutor's explanations. In face to face communication this could be compared to a nod or short verbal utterance of acknowledgment.

While the discourse does not indicate much about the context of the interactions, it is possible to infer that because the two parties are not physically present when conversing, there is an absence of gestures and auditory cues present in face-to-face communication. Both tutors and learners had numerous RC turns indicating that short utterances are given as reciprocal feedback to acknowledge or confirm the previous

speakers input. Learners frequently used this strategy of interjecting with an RC turn as a tutor scaffolded the problem into more manageable parts and clarify each what aspect. Tutors commonly asked questions requiring an RC response, to check if the learner understood or could follow, before they continued. These RC (feedback) turns are either 'acknowledging' (FDB-A) or 'evaluative' (FDB-E) in nature, although this is not always clear when phrases such as "great" or "ok" are used. Such phrases are not specific and therefore also difficult to categorise. The topic of feedback will be discussed when considering the roles of tutors and learners at the Move level.

Significant time lapses between turns visible in the log files seem to indicate pauses between responses and frequently repeated RC responses signified that one party may have been distracted while engaging on the portal, yet remained engaged during the session.

Comparing tutor and learner participation in ESA

Unlike typical classroom discourse as discussed by Sinclair & Coulthard (1975), dyadic tutoring discourse in Dr Math is not controlled by the teacher. While traditional classrooms are run as one-to-many environments, Dr Math is a one-to-one tutoring space. This can afford more balanced interactions, in that both tutors and learners initiate exchanges. Given the approach to tutoring on Dr Math, and the theories discussed in Chapter 2, we might expect several differences in the amount and nature of participation between tutors and learners. The following null hypotheses were formulated to test the theory that tutors and learners take on distinctive roles when participating in Dr Math tutoring:

Hypotheses:

1. Tutors and learners participate equally, with neither group dominating (as revealed by the number of on-task turns they contribute).
2. Learners and tutors are equally responsible for setting the agenda of tutoring dialogues (as revealed by the proportion of learner Initiate [I] turns)
3. Tutors and learners take the same amount of responsibility for reinitiating in tutoring dialogues (as revealed by a higher proportion of Reinitiate [RI] turns)

Equality of participation by tutors and learners

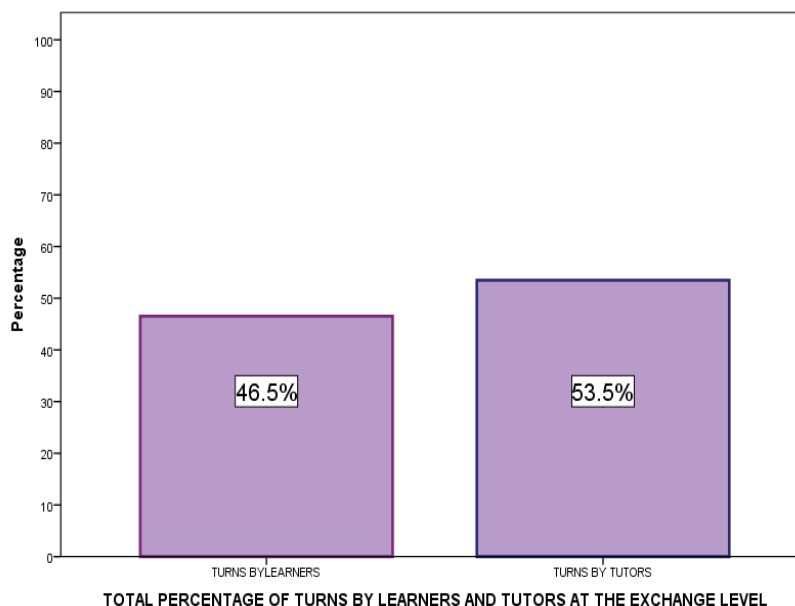


Figure 11 Turns by learners and tutors at the Exchange level (N=6084)

The percentage of turns contributed differed by role, with tutors responsible for slightly more dialogue turns (54%) than learners (46%), $\chi^2 (1, N = 3615) = 17.57, p < .001$. Thus null hypothesis (1) regarding equal levels of participation is disproved, although in comparison to traditional teacher-dominated classroom discourse, turns are still relatively evenly shared between tutors and learners (**see Figure 11**). This suggests that the shared space of this online tutoring platform provides possibilities for shared responsibility in the tutoring interaction and that (at least numerically) neither the tutors nor the learners in this study dominate the agenda of interactions (**Figure 11**). From the ratio of the shared activity at the Exchange level we can thus infer that although tutors still play a leading role, there is a shared responsibility in the tutoring exchanges for the dialogue.

Exchange structure of tutoring dialogues

The graph in **Figure 12** represents the distribution of these turns as coded according to ESA categories for both learners and tutors.

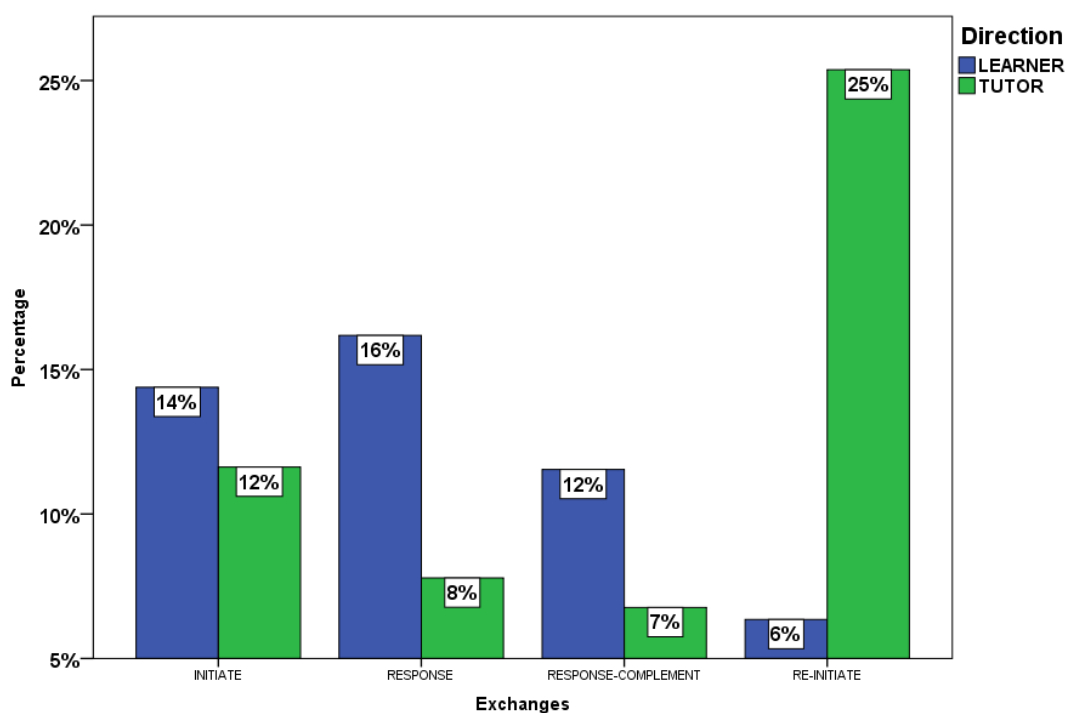


Figure 12: Ratio of tutor to learner turns at the Exchange level (N=3612)

Setting the agenda for tutoring dialogues

Of the 26% of initiating turns, learners contributed more Initiate turns (506) than tutors (433), $\chi^2(1, N = 940) = 5.68, p < .05$. This disproves null hypothesis (2), revealing that on Dr Math, learners are playing a more important role than tutors in setting the agenda for interactions or Reinitiating exchanges.

Almost a third of all of the tutoring turns are Reinitiating turns. The most substantial difference is visible in the Reinitiate turns which are dominated by tutors (25% of all turns), who contribute to a quarter of all the activity. This is considerably more than the learners (6% of all turns), $\chi^2(1, N = 1120) = 421.78, p < .0001$. In both the response categories, learners contributed considerably more than tutors with 12% RC moves compared to the 7% of tutor RC moves.

The roles of tutors and learners in tutoring dialogue

Moves in chat exchanges

In ESA coding schemes, moves represent the inferred pragmatic purposes of turns and reflect the rhetorical tactics that seem to be used by participants to achieve certain interactional purposes (see Glossary p 6). In this section, results from tutor analyses of moves associated with each ES turn type are first described, followed by a discussion of the results.

Results from the analysis of Move range are shown in the following:

In **Table 5** we see that Inform moves form the single largest pragmatic function of the tutoring exchanges (17%). Other well represented Move level categories are Inquire (12%) and Clarify (11%).

Justify, Reason and Challenge each form less than one percent of the moves and are conspicuous by their absence.

MOVE LEVEL				
		Frequency	Percent	Cumulative Percent
		2482	40.8	40.8
CHA	CHALLENGE	24	0.4	41.2
CHK	CHECK	396	6.5	47.7
CLA	CLARIFY	643	10.6	58.3
EXT	EXTEND	87	1.4	59.7
FB-A	FEEDBACK (acknowledgement)	247	4.1	63.8
FB-E	FEEDBACK (evaluative)	397	6.5	70.3
INF	INFORM	1029	16.9	87.2
INQ	INQUIRE	755	12.4	99.6
JUS	JUSTIFY	10	0.2	99.8
REA	REASON	13	0.2	100
Total		6084	100	

Table 5: Proportion of each move category

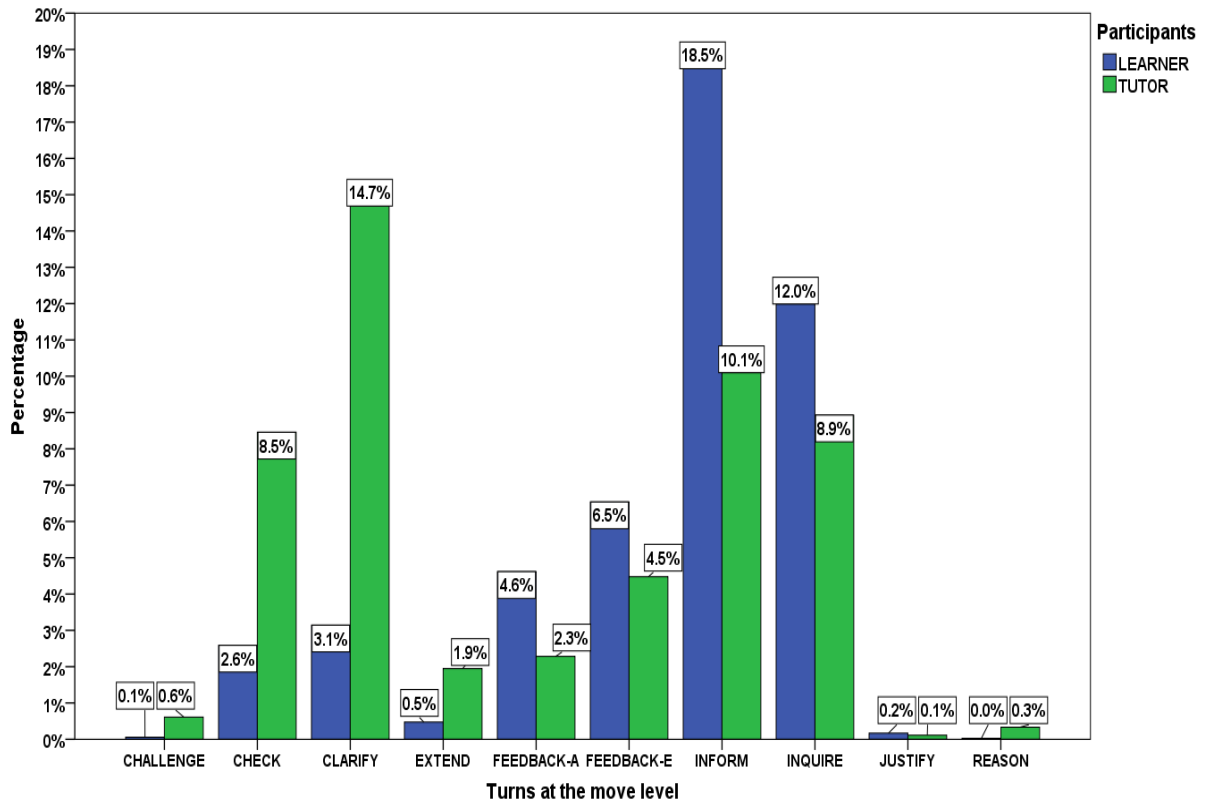


Figure 13: Ratio of tutor to learner turns at the Move level (N= 6084)

Figure 13 shows the frequency of moves associated with turn types which were adopted by tutors and learners during the tutoring episodes. The distribution of the moves between tutors and learners (**Figure 13**) indicates that learners provided almost double the amount of information (18.5%) to that of tutors (10%). According to **Figure 13**, the number of learners' inquiries (12%) was marginally greater than those of the tutors (9% of turns).

The main contribution of the tutors was to clarify meaning (15%) and check the understanding (8%) of the learners. Both tutors and learners gave feedback, but learners gave proportionally larger percentages of both evaluative and acknowledging feedback responses.

An assessment of the R associated moves in the log data found very few reasoning moves (**see figure 13**). Reason moves are used when stating constructed beliefs or effects and also when presenting support or contradicting alternative hypotheses. It would be reasonable to assume that there would be a fair amount of reasoning when discussing mathematics; however on the Dr Math platform there is an interesting lack of reasoning moves. While no quantitative data exists to explain this phenomenon, it is

evident that the tutors probe, elicit information and clarify basic principles. This could be dependent on the content discussed or be a tutoring strategy which has not been fully explored.

Tutors and learners regularly give some form of feedback. Feedback moves are either evaluative or acknowledgement. The coded moves RC- (FBK-E) accounts for the evaluative responses, when there was minimal comment but an indication of agreement, disagreement or support is given. Interestingly it is the learners who are giving the most feedback which is both acknowledgment and evaluative. This is dissimilar to typical classroom discourse structures as identified by Sinclair and Coulthard (1975), where teachers are more frequently offering feedback on the responses of learners. Feedback on the tutoring platform which was coded RC-(FBK-A) was given by both learners and tutors for phatic functions (to establish social contact or acknowledge the hearing of previous turns by reporting the state of the speaker), but to a lesser degree than evaluative feedback. When findings from ES and Move level analyses were considered, a comparison between tutors and learners indicated that learners were required to offer far more feedback to indicate whether they had understood the previous turns or agreed with what the tutor suggested.

Tutoring styles

Figures 14, 15 and 16 allow us to compare the ESA for each tutor.

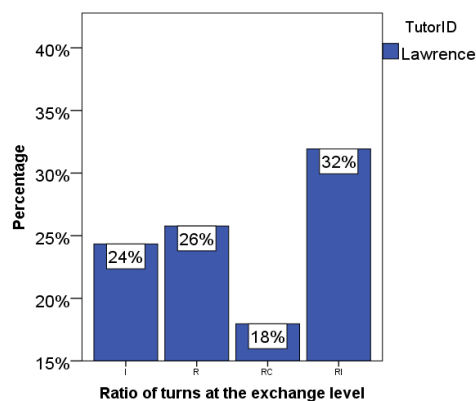


Figure 14: Ratio of turns in Dr. Math tutoring for Tutor Lawrence (N=4344)

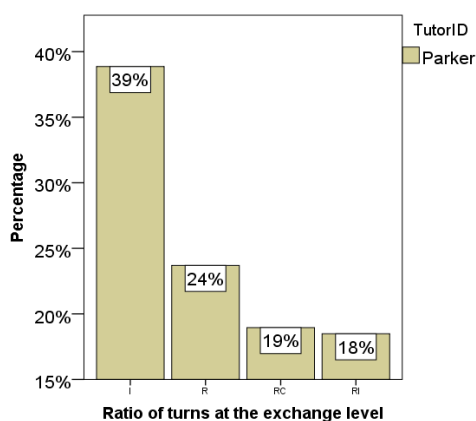


Figure 16: Ratio of turns in Dr. Math tutoring for Tutor Parker (N=611)

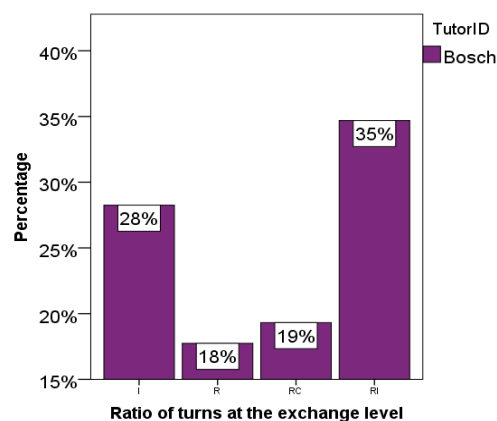


Figure 15: Ratio of turns in Dr. Math tutoring for Tutor Bosch (N=1129)

Both Tutor Lawrence and tutor Bosch produced a high proportion of RI turns: Bosch (35%) and Lawrence (32%). In contrast to the high number of RI turns, tutor Lawrence has a relatively low number of RC and I turns. **Figures 14-16** reveal major differences between tutor Parker and the other two tutors. Tutor Parker produced the lowest percentages of RI turns at the Exchange level (18%).

Overall the extensive use of RI and limited use of I and RC turns by tutor Lawrence and Bosch indicates that learners took on a dominant role in initiating with these two individual tutors who focused their efforts on reinitiating dialogue with learners. These two tutors played a key role in extending exchanges, breaking down problems into smaller parts, by using the RI turns strategically. As learners produced a greater proportion of the RC turns, it indicates more evaluative and acknowledging feedback, usually in response to the step-by step scaffolded explanations.

The more limited use of RI turns in Parker's interactions suggests that this tutor did not often engage in extending or clarifying a problem for a learner. While learners may have received help from him/her in accessing the answers to their homework problems, Parker's discourse patterns were more typical of the traditional IRF patterns described in detail by Sinclair and Coulthard (1975) where the teacher initiates, learners respond and there is some form of feedback. By contrast, when scaffolding a particular problem tutors Lawrence and Bosch first established whether the learner understood the basic principle or operation. By asking questions they established which aspect of the problem was the most challenging and where the learner required more structured support.

Comparing the ESA coding for the three tutors reveals that each tutor produced all four ES turn types, but they did so in varying proportions. Furthermore each tutor utilised different approaches to the tutoring interaction. While this study does not evaluate the pedagogies or the methodology of tutors, the analysis of the exchanges indicated tutoring which produced sustained tutoring interactions and revealed strategic use of Reinitiating questions by tutors Bosch and Lawrence, which helped them to extend the dialogue with learners beyond the levels found with tutor Parker.

The tutors who scaffolded interactions using RI turns frequently posed questions which required some response. This resulted in a high count of learner RC turns throughout the tutoring interactions.

The findings of the Move level analysis revealed that while all three tutors primarily adopted I (INF) (**Figure 13**) for providing information or making observations (see examples of coding conventions in Chapter 3), tutor Lawrence displayed a greater use of inquiry moves. This suggests that besides giving ample information, Lawrence also tended to use questions for initiating further interactions or accessing information regarding the learner's mathematical knowledge so as to assist the learner more effectively.

Move level analysis findings also indicate that tutors used RI mainly to CHK and CLA. RI – to check (CHK) is used when checking the meaning of previous turns, usually through statements or closed questions specifying what information needed to be confirmed. The RI- CLA code was applied when participants were seeking more information on previous turns in order to make the meaning clearer. This clarification was usually sought through the use of open-ended questions.

The results suggest that while all tutors produced a high percentage of I, Tutors Lawrence and Bosch were relatively balanced between initiating to give information and using questions to elicit more information during discussions.

A similar pattern was observed in the distribution of (R) associated moves to include R- (INF, JUS, REA). Tutor Parker used only R- INF or INQ. This suggests that the (R) turns which Parker produced were mainly replies stating information rather than responses that exhibit reasoning or to defend/dispute stated positions.

Conclusion: Part A

This section presented the findings of the Exchange Structure Analysis as applied to the Dr Math data on tutor-learner interactions. The findings revealed that while there are variations in learners' engagement with tutors, the range of the interactions and the extent of the dialogue, it is evident that tutors play a significant role in encouraging and supporting learning interactions. Extended tutoring dialogue is maintained by tutors applying careful questioning strategies evident in the presence of increased RI turns at the Exchange level and manifest through clarifying and checking turns at the Move level. Learners and tutors share control of the interaction by initiating exchanges fairly evenly and providing sufficient information.

The following section analyses specific strategies used by tutors and learners in the meaning-making process and provides examples of these strategies as they were implemented in Dr Math tutoring interactions.

PART B: MEANING-MAKING IN THE DR MATH TUTORING PROCESS

Part A above presented the quantitative findings of the Exchange Structure Analysis of the Dr Math tutor-learner exchange data. While this offers insights about the flow and patterns in tutoring interactions, it is necessary to look at more specific examples of tutoring exchanges to see how tutors and learners used the possibilities and tools at their disposal to communicate meaning. More specifically the semiotic choices available to tutors and learners in online mathematics learning will be discussed in more detail.

Owing to the constraints of this dissertation only a few examples of semiotic meaning-making are highlighted.

Intra-semiosis and meaning-making in Dr Math

As the mathematics tutoring interaction is based only on the visual interpretation of written text, modality is limited and therefore visual or verbal representations of mathematics or clarification of the representations are absent from the tutoring process. In this section I investigate how the restricted multimodality on Dr Math provides insights as to how tutors and learners work around these challenges to create new shared semiotic resources.

Transcoding is an important practice in the process of meaning-making between tutors and learners on Dr Math. Transcoding in the context of this study is the adaptation of a message from one semiotic representation to another. Transcoding can involve a shift to alternative alpha-numerical-representations or from a visual semiotic representation into symbols. The representations of mathematics problems in textbooks involve compact mathematics notation with specific conventions for placement of numbers, size and spatial positioning. On Dr Math, these standard conventions are often not available to represent a problem, either because these are not included in mobile phone semiotic resources or because the notational formatting does not permit this. In such cases, successful tutoring requires extensive transcoding (see **Transcripts 11 & 12** for examples).

While it is possible to express mathematical meanings verbally, if learners are not familiar with either the terminology or the function of the various symbolic representations in mathematics, transcoding is more difficult and the process of meaning-making is likely to be frustrating. Much depends on the skill and experience of the tutor in eliciting the question from the learner, clarifying the correct terminology, giving adequate examples to demonstrate the rules and principles of operations and assisting in transcoding.

Complex issues such as understanding of positional digit in the number, Arabic number transcoding or deciphering the interdependence of mathematical representations, can all impact meaning-making. Language limitations and lack of mathematical competency can deter learners, since mathematical processes require manipulating symbols, numbers and words, and transcoding, like translation, requires fluency in more than one semiotic mode.

For example, the concept of $\text{Pi} = \pi$ (sometimes written **pi**) can also be written in numerical notation as approximately equal to 3.14 in decimal notation. Hence the same concept can be represented as a word concept, a symbol or numerical value.

A standard mobile phone keypad does include scientific symbols such as π but at the time of this study downloadable symbols of scientific notation were not available on the Mxit platform. A learner who needed to use π needed the skills to translate mathematical notation in another semiotic form, in this case by using either the word pi or the numeric notation.

Spatial and positional notation

The overall spatial arrangement of mathematical symbolic text is standardised so that main equations, definitions and solutions are immediately accessible in the texts (O'Halloran, 2005). Mathematical statements typically appear in standardized fonts which are universally recognisable and indicate their functional status. Examples of this are the various fonts assigned for functions, variables, text, the Greek alphabet and so forth, with specific sizes according to their function. O'Halloran (2005) explains that an important aspect of recognising and deciphering mathematical symbolism is the precise encoding of the relations in a condensed format to enable the re-organization and solution to the mathematics problem.

Exponents and fractions were the most relevant examples of positional and spatial notation in Dr Math logs. For example, positional notation plays a role in the following case: x^3 , means x (multiplied by) x (multiplied by) x because of the spatial position of the 3 as a superscript. In the case of the fraction $\frac{3}{4}$ the process of division is realized through the spatial arrangement of the three (numerator) and the 4(denominator). The correct terminology (superscript, numerator, denominator sigma, pi) all assist in transcoding (see **Transcripts 11 and 12 on p. 71**).

MXit is text based and also linear so every mathematical operation is written on one line. Not only do learners, who may not be proficient in mathematical notation, need to learn to transpose spatial conventions into linear text, but the possibility of typing errors also needs to be entertained. As the size and positioning of the numbers and text cannot be varied on MXit, learners and tutors have to use either descriptive phrases or supplementary symbolic notation.

Terminology such as numerator, exponent, denominator, fraction all assist in clarifying the spatial positioning of numbers and it is paramount that tutors first clarify whether learners know these concepts. This vocabulary cannot be taken for granted since learners using Dr Math may have English as a second or third language. If a learner does not understand the mathematical concept the challenges for tutors can be far more complex. Sometimes learners grapple to find the vocabulary to describe the spatial position of symbolic notation even if they can recognise the symbolic notation. When a tutor utilises words such as numerator and denominator, top and below, to indicate the position of the various elements, it helps clarify the relationship of each individual part to the whole. The following example highlights some of the challenges of communicating spatial positioning via instant messaging while also ensuring a common understanding of the problem.

Transcript 6: The challenges facing learners engaging on the platform

Exchange reference	p	Message
Tut1Ex134Ln1	L	Do ul hav a place in pietermaritzbrg whrby i cn go thr 4 extra lessons? <i>(Do you have a place in Pietermaritzburg where I can go through for extra lessons)</i>
Tut1Ex134Ln2	L	?
Tut1Ex134Ln3	T	we only tutor over mxit. you will have to ask your teacher for help in Pietermaritzburg. but let me help you now. what's your question
Tut1Ex134Ln4	L	Ay cnt explain ova mxit:(<i>(I can't explain it over MXit (sad face))</i>
Tut1Ex134Ln5	T	is it geometry?
Tut1Ex134Ln6	L	Exponents
Tut1Ex134Ln7	T	I use ^ for exponents and * for multiply so $2^3 = 2*2*2 = 8$

Tut1Ex134Ln8 T what's your question

Tut1Ex134Ln9 L Its lyk 12 and n on da top plus one x 9 nd 2 on da tp wit n nxt t 2 nd minus 1 nd dat divided by 36 n on da tp x 8 1 on da tp 1 minus n (*It's like 12 and n on the top plus x9 and 2 on the top with n next to and minus 1 and that divided by 36n on the top x 8 1 on the top 1 minus n*)

Tut1Ex134Ln10 L Ay c u confusd 2 (*I see you're confused to*)

Tut1Ex134Ln11 T i will use ^ for exponent do you mean\r

Tut1Ex134Ln12 T \r

Tut1Ex134Ln13 T (12^{n+1} times 9^{2n-1}) all divided by (36^n times 8^{1-n})

Tut1Ex134Ln14 L Yes

Tut1Ex134Ln15 T so now what must you do

Tut1Ex134Ln16 L Explain it 2 m pls (*Explain it to me please*)

Tut1Ex134Ln17 T but what must you do that monster? graph it? simplify it? factor it? what?

Tut1Ex134Ln18 L Simplify it,

Tut1Ex134Ln19 T well do you see that 9 is a power of 3 and 36 is a multiple of 9?

Tut1Ex134Ln20 L Yes

Tut1Ex134Ln21 T so you need to change the 36^n to $(9^n)(4^n)$

Tut1Ex134Ln22 L :?im confusd nw (*What? I am confused now*)

Tut1Ex134Ln23 T when you have a number to a power, you can factor the number and raise each\r

Tut1Ex134Ln24 T factor to the same power. $4*9 = 36$

Tut1Ex134Ln25 L Okay i see nw

Tut1Ex134Ln26 T so take the 12 and do the same thing

Tut1Ex134Ln27 L So its gna b (*So it's going to be*)

Tut1Ex134Ln28 T i'm not going to do all the dirty work, I'm just walking you through it

Tut1Ex134Ln29 L $(3^n)(4^n)=12$

Tut1Ex134Ln30 T close = 12^n

Tut1Ex134Ln31 L Ok

Tut1Ex134Ln32 T so do that for the 12, 9, 36 and the 8

Tut1Ex134Ln33 L $12...3^n*4^n=12^n$ and $9...9^n**4^n=36^n...8...2^n*4^n=8^n$ is dat right r wrng? (*Is that right or wrong?*)

Tut1Ex134Ln34 T now some of the factors will start canceling using the rul\r

Tut1Ex134Ln35 T \r

Tut1Ex134Ln36 T $(a^n)/(a^m) = a^{(n-m)}$

Tut1Ex134Ln37 L Im confused nw

Tut1Ex134Ln38 T for exmple you have powers of 4 on top and on the bottom of the fraction, right

Tut1Ex134Ln39 L Ryt (*right*)

In **Transcript 6** the learner does not even want to try to explain the problem as s/he believes it is not possible to do so via MXit. Tutor Lawrence encourages the learner to attempt to present the question but first provides a few tools by offering symbolic alternatives such as * and ^.

It is evident why the learner struggles to describe the problem – at the secondary education level, exponents are indicated by their spatial relationship and size in relation to the base figure/number. Tutor Lawrence offers the possibility of using the symbol ^ to replace a mathematical concept, namely the exponent. The ^ used in this way indicates the position and function of the numbers that follow. Whilst most learners would not be

familiar with this notation, it is indeed standard practice in mathematics to utilise both the \wedge symbol to indicate “to the power of” or * for “multiplication” (line 7) when transcoding symbolic notation into text, such as when writing a computer program. In MS Excel, for example, these functions are built into the program software.

To most learners who do not have access to computers and have never used Excel for mathematics calculations, this convention is not common knowledge. By consistently using such notation learners are given tools that they will be able to use in other contexts to understand standard mathematics practices.

In **Transcript 6** the learner is unable to utilise this knowledge to represent his/her mathematics problem and so s/he uses words to describe the problem (see **line 9**). The description is still very unclear so tutor Lawrence deciphers the line and clarifies it by rendering it in recognisable mathematical notation (line 13). Once tutor and learner have both understood the same concepts, tutor Lawrence can clarify what operations need to take place. Through careful questioning Lawrence establishes which aspects of the problem are problematic and keeps the learner engaged by breaking down the problem into manageable parts and checking what has been understood and can be applied. Through a combination of numbers, letters and recognisable mathematics symbols the learner is able to express quite a complicated operation in scientific language.

Transcript 7 shows that some learners are able to express a complex operation in this way.

Transcript 7: Complex transcoding and use of linear mathematical notation.

Tut1Seq47Ln1	LEARNER	Helo <i>Hello</i>
Tut1Seq47Ln2	TUTOR	hi there, any questions today?
Tut1Seq47Ln3	LEARNER	K if u where given <i>Okay, if you were given</i>
Tut1Seq47Ln4	LEARNER	81p, 27p ² , 9 ³ , 3p ⁴ ,(p€0)
Tut1Seq47Ln5	LEARNER	calculate the comon ratio? <i>Calculate the common ratio</i>
Tut1Seq47Ln6	TUTOR	is your 3rd term right, should it be 9p ³ ?
Tut1Seq47Ln7	LEARNER	Yes
Tut1Seq47Ln8	TUTOR	so divide 27p ² by 9p ³ and what do you get

Parentheses and Brackets

Brackets are used to organize and order operations so as to stipulate intended meaning in mathematical symbolism efficiently and exactly. O'Halloran (2005) explains that brackets are used to indicate the value of the function, for instance $f(x)$. They are also used to indicate the grouping of terms when the order of operations is changed, for instance: $3 [(8 + 2) - 2]$. There are very few instances in the logs which indicate any problems for learners with this positioning despite examples of numerous sets of consecutive brackets.

In **Transcript 8**, the tutor uses the descriptors given by the learner to show how words can be translated into mathematical symbols. In **line 9** the learner utilises a combination of non-scientific terminology to describe what they see in a text book or homework problem. Whilst they see the problem written correctly in front of them, they struggle to replicate the positioning and symbols through MXit. Nonetheless they can describe what they are seeing. The experienced tutor is able to decipher the descriptive notation written in a combination of letters, numerals and abbreviated words and write them as a mathematical problem. The learner and tutor are then looking at the same problem and know that they are speaking about the same operations and values. I found numerous examples of this complex process of interpretation, translation and clarification. Learners did not always have the ability to arrange and scientifically notate concepts which are complex in a linear form and preferred to describe what they observed in words:

Transcript 8: Strategies used in meaning-making

- Tut1Seq134Ln23 T when you have a number to a power, you can factor the number and raise each
each\
- Tut1Seq134Ln24 T factor to the same power. $4 \cdot 9 = 36$
- Tut1Seq134Ln25 L Okay i see nw *Okay I see now*
- Tut1Seq134Ln26 T so take the 12 and do the same thing
- Tut1Seq134Ln27 L So its gna b *so it's going to be*
- Tut1Seq134Ln28 T i'm not going to do all the dirty work, I'm just walking you through it
- Tut1Seq134Ln29 L $(3^n)(4^n)=12$
- Tut1Seq134Ln30 T close = 12^n
- Tut1Seq134Ln31 L Ok
- Tut1Seq134Ln32 T so do that for the 12, 9, 36 and the 8
- Tut1Seq134Ln33 L $12 \dots 3^n \cdot 4^n = 12^n$ and
 $9 \dots 3^n \cdot 3^n = 9^n \dots 36 \dots 9^n \cdot 4^n = 36^n \dots 8 \dots 2^n \cdot 4^n = 8^n$ is dat right r
wrng? *(is that right or wrong?)*
- Tut1Seq134Ln34 T now some of the factors will start canceling using the rul\

Tut1Seq134Ln35 T \r
 Tut1Seq134Ln36 T $(a^n)/(a^m) = a^{(n-m)}$
 Tut1Seq134Ln37 L Im confused nw *I am confused now*
 Tut1Seq134Ln38 T for exmaple you have powers of 4 on top and on the bottom of the fraction, right
 Tut1Seq134Ln39 L Ryt *right*
 Tut1Seq134Ln40 T i'm sure lots will factu rout
 Tut1Seq134Ln41 L Yes
 Tut1Seq134Ln42 T hmmm, now I've lost you
 Tut1Seq134Ln43 L Wat u mean *what you mean*
 Tut1Seq134Ln44 T your conversation got all corrupted on my screen.
 Tut1Seq134Ln44 T did you have another quesiton
 Tut1Seq134Ln45 L Gtg chat 2m *got to go chat tomorrow*

In **Transcript 8**, the exchange ends with a combination of the technology failing and the learner terminating the interaction, so one cannot establish whether the learner progressed to the point where they were able to apply the knowledge independently. Nonetheless the learner has been introduced to new semiotic resources which enable him/her to express a problem and discuss it using accurate mathematical language and symbolic notation via the MXit application. The tutor uses a combination of modelling, explaining and questioning skills to scaffold the interaction, each time checking if the learner is able to apply this knowledge.

The X factor

In most interactions there are symbolic statements and elements embedded within the linguistic text. For instance the letter x appears 784 times in the tutoring interactions of February. This letter is used in a variety of ways. It is a letter of the alphabet which appears in words. According to Deumert (2008) it could also be a typographic symbol representing a kiss; X is also a symbol which indicates a mathematical operation, namely multiplication (2×2) and it can be used to indicate a mathematical variable ($2x + xy$). As the possibilities of using X on the MXit platform for the purpose of mathematics could prove confusing, alternative conventions come into play. X was seldom abbreviated in any words which could be mistaken as parts of a formula such as sx (six) or fx (fix).

Graphs and diagrams

Graphs are also visual representations of numerical systems and equations. Graphs help visualize the relationship of one bit of data to another. The relationship can also be translated into a mathematically meaningful equation. Then others can use that equation to understand the system, because mathematics is a universal language. We can use graphs to predict the behaviour of simplified natural systems or to understand the relationships of variables within a system. Often the visual mode helps the learner recognise the patterns or consolidates what the tutor has explained. If there is no possibility of translating the numerical into a visual representation, neither the tutor nor the learner are actually able to check if they have both understood and represented the information in the same way. Using appropriate scientific language to represent the operations can be challenging for some learners and there is a risk that what one describes the other understands differently, especially when dealing with visual information, such as graphs.

Transcript 9 shows how, if the learner has a firm grasp of the basic concepts and can interpret the specific mathematical terminology sufficiently well, then the tutor is able to guide him/her in plotting each point on the graph until the image is completed.

Transcript 9

Exchange reference	p	Message
Tut2Ex52Ln45	L	Cn we sketch da graph <i>Can we sketch the graph</i>
Tut2Ex52Ln46	T	usually the basic things to sketch are, the intercepts, the turning points and studying the nature of the graph when x is infinity to the positive and negative
Tut2Ex52Ln47	L	K <i>okay</i>
Tut2Ex52Ln48	T	ya it is possible to draw rough sketch
Tut2Ex52Ln49	L	Lets do it
Tut2Ex52Ln50	L	Lets sketch
Tut2Ex52Ln51	T	try on a paper and ask whenever u wish to ask
Tut2Ex52Ln52	L	K <i>okay</i>
Tut2Ex52Ln53	L	U cn sketch on computer <i>You can sketch on the computer</i>
Tut2Ex52Ln54	T	do u think this is important. Ya computers can work this but what we should learn is how to sketch roughly the graph with the informations we get
Tut2Ex52Ln55	L	lwnt 2 see anyway it will 2 look the same <i>I want to see anyway it will look the same</i>
Tut2Ex52Ln56	T	r u on mxit or internet now? <i>Are you on MXit or the Internet now</i>
Tut2Ex52Ln57	L	Mxit

Clarifying and rephrasing

In **Transcript 10** the learner interchanges numbers, letters, abbreviations, and includes words which, even in IM language, are regarded as misspellings. The learner has difficulty in stating the problem with which he/she needs assistance. The combination of mathematics notation in the form of spatial markers, such as lines and parentheses, do not indicate clearly what the mathematical operation should be.

When using a mobile texting platform, expressions are arranged in linear format. This proved challenging for the learner who struggled to express the problem as a cohesive statement. Line 3 of **Transcript 10** indicates a lack of clarity and order. A number of issues can be noted: first, the placement of the line which reads $x|2$ but possibly should read x over 2. Even the clarifying questions posed by the tutor fail to bring clarity. What probably is a simple operation becomes complex when describing the configuration using limited mathematical notation. The learner attempts to clarify the position of a single stroke namely the “_”. What should read $x \leq 6$ cannot be written this way with the available semiotic resources and therefore needs to be written as “x<_6” and the explanation follows: (<has 2 be On tOp Of_). In the absence of mathematical notation and semiotic resources, descriptions are used in place of symbols, which can be tedious when engaging on a mobile platform such as MXit, where brevity is valued.

One of the biggest (non-technical) challenges facing the tutors is the interpretation and meaning-making of the various semiotic choices of the learner and their relationship to each other. A solid background in mathematics may assist tutors in recognising principles of mathematics and patterns of mathematic notation, so they are more easily able to infer probable meanings from learners who struggle to express their mathematic problems with the resources and constraints of the platform. It takes a skilled tutor to decipher possibilities within the constellation of semiotic resources represented in any given mathematics problem, as the example in **Transcript 10** illustrates.

Transcript 10

Exchange reference	p	Message
Tut1Ex72Ln49	L	Okay we xal d0 dis 2mrw wn i gt da calculatOr...lts g0 2 da real namberz...eg...1set bulda n0tati0ns...2 interval n0tati0n 3 number lines <i>(Okay we shall do this tomorrow when I get a calculator.....It goes to the real numbers for example 1) set builder notation, 2) interval notation, 3) Number lines</i>
Tut1Ex72Ln50	T	ok, what's the problem

Tut1Ex72Ln51	L	We hav 2 represent number line...i dnt gt dis (x 2 <x<_6;x? n) (<has 2 be On t0p Of_
Tut1Ex72Ln52	L	_
Tut1Ex72Ln53	T	what do you mean by x 2?
Tut1Ex72Ln54	L	Ahm m c0nfusd ma slf dats hw its written (<i>I'm confused myself- that's how it's written</i>)
Tut1Ex72Ln55	T	I don't understand that notation x 2
Tut1Ex72Ln56	L	K lts put it lyk d4s x 2 n rem0ve dat (<i>Okay it is put like the 4s x 2n remove that</i>)
Tut1Ex72Ln57	T	hmm and what does the ? n mean?
Tut1Ex72Ln58	L	N0 the n is 4 and
Tut1Ex72Ln59	T	well i'm not real sure of your notation but I think you need to draw a line between the 2 and 6 on the number line. but draw a circle on the two because it doesn't actually touch the 2
Tut1Ex72Ln60	L	Oh i get it n0w! Tnxu a lif saver (<i>Oh I get it now! Thanks you are a life saver</i>)

In **Transcript 11**, the tutor has first to check what aspect of the concept of sigma is unclear by offering the correct spelling of the term, by explaining the value of the symbol and then checking whether the learner has connected the term, the symbol and the function. Actually, using the symbol in a mathematical problem would be pointless if the learner has not linked concepts and terms, as well as established a common symbolic notation, which can be used to express the mathematic problem. By offering the possibility of using 'E', a new semiotic value comes into play. Both the tutor and the learner understand that this symbolic form of representing sigma is only valid in this context.

Transcript 11: Transcoding 1

Exchange reference	p	Message
Tut1Ex99Ln5	L	K n th is smthng i dnt undrstnd (<i>Okay and there is something I don't understand</i>)
Tut1Ex99Ln6	T	like what?
Tut1Ex99Ln7	L	Zigmal i dnt knw if i wrote it ryt or nt (<i>Zigmal – I don't know if I wrote it right or not</i>)
Tut1Ex99Ln8	T	"zigmal" did you mean "sigma"?
Tut1Ex99Ln9	L	My is it
Tut1Ex99Ln10	L	Myb is it (<i>Maybe it is</i>)
Tut1Ex99Ln11	T	"sigma" looks like a uppercase E but with angles instead of right angles? it's to do summations. does that sound familiar
Tut1Ex99Ln12	L	Ja
Tut1Ex99Ln13	T	I will use E for sigma. Then under the E is something like n=1 and on top of the E is something like 10 then to the right is an expression like n. Familiar?

Transcript 12 gives an example of a learner who is familiar with the symbol, and aware that it represents a mathematical operation, but unable to transcode with the semiotic resources available on MXit. Transcoding the symbolic value into an operational action,

and applying this in a specific problem, is the challenge. The tutor needs to establish the level of understanding and grade of the learner to know how to frame the explanation and example.

Transcript 12: Transcoding 2

Tutoring Sequence	p	Message
Tut1Ex146Ln36	L	Sigma notation is challenging part 4me i mean taugh one (<i>Sigma notation is challenging part for me, I mean tough one</i>)
Tut1Ex146Ln37	T	but do you understand the log problem first before we go to sigma?
Tut1Ex146Ln38	L	Yah bt laws cofuse me same times (<i>Yes, but the laws confuse me some times</i>)
Tut1Ex146Ln41	T	so for sigma what is your question De sings cofuse me smtyms u cn c under de GREEK LETTER ND
Tut1Ex146Ln42	L	FRONT SIDE (<i>The signs confuse me sometimes you can see under the Greek Letter and front side</i>)
Tut1Ex146Ln43	T	ok what grade u in? I will use E for sigma

The above examples are only a few of the features directly linked to challenges facing learners and tutors engaged in mobile mathematics' tutoring. For learners who struggle with visual to alpha-numeric transcoding, such as that required when explaining geometry on MXit, or learners who lack the vocabulary to express mathematical concepts and operations, engaging with tutors is challenging. The limited multimodality of MXit may be contributing to the cognitive overload for students who already battle with mathematics. This may well explain why the data shows that so many learners initiated only one or two interactions via Dr Math.

Tutors, who are aware of some of these challenges and are able to scaffold the learning, can, nonetheless, engage learners in highly beneficial tutoring exchanges in that they challenge learners to express complex mathematical procedures with clarity and confidence and to pay attention to minute symbolic details.

CHAPTER FIVE: DISCUSSION AND IMPLICATIONS

The aim of this study was to examine the characteristics of the interactions between tutors and learners in a synchronous mobile mathematics tutoring environment. First this was done by applying ESA to the tutoring log files so as to identify characteristics in the structures and patterns of the tutoring interactions. The quantitative findings were supplemented with qualitative investigations to explore salient themes in the learner tutor discourse. While there were many aspects of the discourse which could have been discussed, the focus was on the semiotic resources used by tutors and learners when dealing with the constraints of the tutoring platform for mathematics learning. In Chapter Five, Parts A and B, the quantitative and qualitative findings were presented. This chapter now reflects on salient issues raised by both the qualitative and quantitative data and suggests some of the implications of the findings.

PART A: DISCUSSION AND IMPLICATIONS

Exchange and Move turn types

The investigation of turn types at the Exchange and Move level (**Figure 11**) indicates how tutors and learners participated in the interactions around mathematics and the roles played in the interactions. ESA is a valuable method of identifying these roles, but it applies primarily to on-task interactions, and a great many turns were coded Off-Task (OT). These Off-Task (OT) turns merit a brief introduction.

Off-Task - Social and anti-social interactions

Over one fifth of the turns were social in focus. Social interactions therefore form a substantial number of interactions, suggesting that they play an important role in tutoring. Although the social aspect of tutoring discourse is not the central focus of this research, it nonetheless plays an important role and is definitely worth further investigation in future studies. Here I merely outline the broad characteristics of the turns coded as (OT-S) or social in nature, rather than their contribution to learning in Dr Math.

The range of social exchanges varies greatly. Some participants access the portal with no intention of discussing anything related to mathematics. Others discuss general topics which help establish rapport between the tutor and learner while dealing with topics such as tutor availability or the identity and personae of Dr Math.

Direct and indirect scaffolding

Botha and Butgereit (2012:18) mention that in the broader context of a scaffolded learning environment, “emotive approachability” is an area of indirect scaffolding which is valuable for support in the wider context of learning. Building rapport with the learners, offering feedback and support in this manner promotes less formal interactions where learners feel they can discuss not only mathematics homework, but can also talk about their aspirations and the challenges and daily events of their schooling. Anghileri (2006) clarifies “emotive feedback” as indirect scaffolding which does not relate directly to the mathematics’ learning. This emotive feedback is nonetheless helpful in assisting learners to achieve their goal as it includes statements for gaining attention, encouraging and offering approval. It thus differs from ‘direct scaffolding’ which is discussed in relation to frequency of RI turns.

The results suggest that specific and distinctive roles were adopted by tutors and learners at the Exchange level. Tutors had a higher number of Clarify and Check turns at the Move level, which revealed their need to frequently use Reinitiating questions to clarify and check the previous statements made by learners in a tutoring dialogue. Careful examination of the Clarifying and Checking turns also suggests that tutors use this strategy to break down the problem into smaller more manageable parts, a common scaffolding strategy. In doing so, they are also clarifying the learner’s prior knowledge and establishing which aspects of the problem need to be explained so that the learner can progress. This is in keeping with scaffolding strategies that assist in mathematics learning (Anghileri, 2006).

Initiate - Sharing the task:

An Initiate (I) turn anticipates a subsequent turn by another participant and starts a new exchange. The analysis reveals that there is minimal difference between the Initiates of tutors and learners, as both were responsible for initiating on-task interactions. From the close correlation of Initiate turns by tutors and learners, it can be inferred that there is no formal or prescribed format for the learning exchanges to begin. There were no great variations in exchanges where learners initiated (requesting assistance) or tutors

initiated by asking probing questions. Some learners asked for assistance on multiple tasks, while others required extended assistance with a specific complex mathematical problem.

Despite the variation between individual tutors, it seems that tutors and learners assumed different roles in the tutoring dialogue. This was particularly apparent in their use of Reinitiating turns, the regulation and direction of exchanges, and specifically the way different tutors handled the questions which were posed by learners.

Mathematics, as is language, is based on interlinking systems of knowledge. Therefore the teaching of these interlinking systems requires a systematic and cumulative approach. If foundational tenets are missing, this can obstruct further understanding or progress. Tutors thus need to identify areas of difficulty for a particular student in relation to a specific problem. In doing so the tutor is then able to scaffold the learning and provide the support necessary to bridge any gaps in learning. For learners struggling because they have missed or failed to grasp a specific step in the learning process, such one-on-one tutoring can be very valuable. However, the onus is on the tutor to ascertain what aspect of the learning is most challenging and then find the best path to guide the learners so that they can not only complete the problem presented, but apply this knowledge and skills to similar problems.

Scaffolding as a tutoring strategy suggests purposeful communication and directed collaboration. Tutors actively explore the meanings of the previous turns by asking Reinitiating questions and extending the dialogue through carefully scaffolded exchanges. Complex mathematical operations are separated into smaller more doable parts. Strategies such as simplifying, modelling, prompting, probing and negotiating meanings and rephrasing, all assist the learner in achieving understanding and success, before progressing to the next part of the problem (Botha & Butgereit 2012). By limiting the complexities of the specific problem at hand and scaffolding the interaction, the learner gains the necessary knowledge, skills, and confidence to apply this to the full problem. While this is valid for complex problems, it must be noted that learners also accessed the portal simply to clarify terminology or refresh their understanding of a rule. Not every interaction needed to be scaffolded.

In the context of collaborative learning, the use of a wide range of moves indicates greater effort by participants to provide information, convey meaning, prompt, probe, or

shape the direction of discussions. Tutors extended the learning support by scaffolding the interactions – this could be seen from the analysis of the moves associated with the specific turn types at the Exchange level.

Initiating exchange

When tutors initiated exchanges they tended to do so primarily to provide information, but also to ask questions about learner problem areas in mathematics. When learners initiated exchanges they did so mainly to inquire about a problem or ask questions pertaining to mathematics learning or careers. The high percentage of inform turns are derived from Initiate and Response turns. Participants spend a great portion of the tutoring activity providing information. Typically this is the role of the learner who needs to explain what they don't understand and what knowledge gaps may exist - they are anonymous and the tutor cannot assume anything about the abilities or understandings of the learners who log on.

According to Lim (2006) the presence of RI-(CHK), in terms of the learning processes, suggests an expertise on the content/topic under discussion as alternate perspectives are offered. Similarly, the presence of RI-(CLA) suggests an awareness of a knowledge gap or the incongruity of ideas presented in previous turns. The use of both CHK and CLA in the Dr Math data revealed interactions where participants used checking and clarifying to better understand the written representation used for mathematics procedures or operations used in the previous turn. This is discussed in more detail in part B of Chapter 5 which focuses on the challenges of meaning-making. When learners reformulated complex problems or interpreted problems involving graphics or equations, tutors frequently needed clarity on the choices of representation and placement of symbols used in the previous turn.

Overall, when compared to tutor Parker, tutors Lawrence and Bosch were found to use a broader range of moves associated with each ES turn type. These results suggest a greater tendency of tutors Lawrence and Bosch to provide information, convey more specific meaning, prompt, probe, or shape the direction of discussions through specific questioning procedures. The display of such interactional purposes reflects greater involvement by both tutors Bosch and Lawrence in supporting extended learning interactions. Additionally, the wider move range used by tutor Lawrence, but also to a large degree by tutor Bosch, suggests greater efforts in tutor scaffolding, also indicating

that tutors Lawrence maintained a more visible tutor presence and was more involved in learning processes.

Scaffolding is only one of the methods observed in this study whereby tutors engaged with learners in the process of honing the skill of discussing mathematics, finding alternate symbolic representations for depicting their understandings of mathematics problems and ultimately finding solutions to their homework.

Characteristic structural patterns identified in the tutoring interactions

Hypothesizing CMC educational discourse as a hierarchical model consisting of turns and moves, facilitated the investigation of the interactional patterns of tutors and learners in a synchronous chat environment. The structure of the exchanges at a turn and Move level illuminated the dynamics of turn-taking, the pragmatic intentions of the participants and the roles played by tutors and learners during the learning interaction.

In this study where the CMC consisted of dyadic interactions between tutor and learners, the following was evident: Tutors and learners assumed shared responsibility for initiating learning interactions. Learners choose to access the portal and initiate contact with Dr Math by logging into the portal - it is the bot message which begins the tutoring interaction. From the tutoring log it was evident that learners often simply wrote the mathematical problem or equation from the text book and the tutor unpacked the problem by asking Reinitiating questions. The onus was on both tutors and learners to work towards a shared understanding of the problem and then collaborate on finding the solution to the problem. The high volume of Reinitiating turns by tutors is confirmation that tutors extended the learning interactions by scaffolding the process. Although this was not practised by all the tutors, it was an effective strategy which provided the necessary structure and support for learners to work in stages through more complex mathematical problems. Not all problems required scaffolding. Often a simple reminder of a formula was all the learner needed. Experienced tutors used the opportunity to extend the learning exchange by asking questions either directly about related work or more general topics such as school or careers. The dialogue in the logs gave evidence of the rapport the tutor developed with the learner.

Roles within the tutoring interactions:

Botha and Butgereit (2012:22) maintain that "interactions are learner initiated and the onus is therefore on the learner to explain their problem". However, my study indicated that both learners and tutors shared the initiation of exchanges. It also indicated that there were an almost equal number of tutor Initiates as there are learner Initiates in the exchanges. These Initiates were not only at the start of tutoring interactions but also indicated the start of new exchanges within a learning sequence. While the number of learners who logged onto the system within the month was substantial, the findings indicate that the number of sustained or extended exchanges was limited to only a few learners. These extended interactions occurred as single prolonged interactions within one session, or multiple less intensive tutoring exchanges over the course of a month. While this finding reflects the typical nature of social media interactions (long tail distribution), it begs the question as to how tutors can keep learners engaged and encourage greater and more sustained participation. The platform offers a variety of mathematics related activities such as games, quizzes and Wikipedia searches (Butgereit, 2011; Botha and Butgereit, 2012), still the actual communication with real time tutors is the focus of the interactional activity.

It is essentially the role of the tutor, to keep learners engaged during the learning interactions and then, to scaffold the learning interactions into manageable parts so that the learners are able to experience success and apply this to the examples they furnish. While individual tutors approached this in various ways, the extended interactions indicated scaffolded learning exchanges and multiple learner Initiates throughout the interaction. Tutors encouraged extended interactions by asking questions which helped clarify or check the learners' understanding of the information presented in previous turns or offering information to extend the learners' knowledge. Initially the tutors tried to establish what the learners knew and could do without assistance. They then formulated questions pertaining to the parts which the learner perceived as challenging or difficult. Although the pedagogy of scaffolding was not the focus of this research, the high number of RI turns, specifically evident in the tutoring interactions of tutors Bosch and Lawrence, indicate sustained engagement with learners. The evidence of sustained engagement was partly due to scaffolded mathematics learning interactions, but also from engaging learners in discussions on mathematics related topics such as their school experience of and attitude towards mathematics, further studies and careers.

Very typical of the social exchanges were informal chats about the mathematics curriculum, careers, and learners' experiences of and attitudes towards mathematics.

PART B: DISCUSSION AND IMPLICATIONS

Findings from specific tutoring interactions highlighted the intricacies and challenges of a limited mode of interaction and semiotic resources available during tutoring interactions.

Modality and intra-semiosis – the challenges for tutors and learners

In traditional classroom teaching a variety of modes are used to help learners grasp mathematical concepts. As the Dr Math platform utilises a text based application, only the written mode can be utilised⁷ to represent the mathematical knowledge. The challenges of having one mode for interaction and clarification provide opportunities for creative interactions and meaning-making between learners and tutors. However, if a tutor lacks training or experience, it can hamper understanding and be a source of frustration for learners.

In Chapter Four, I gave examples of multisemiotic representations of mathematics from the research and the strategies tutors and learners used in the meaning-making process. One of the important considerations is that learners who are accessing Dr Math represent a range of ages and skill levels in mathematics. For those who are weak in mathematics and who are not competent in explaining themselves, it is an added challenge. If however, they encounter a skilled tutor who is able to ask appropriate questions, scaffold the learning and model alternate strategies for the semiotic representation of problems, this platform can be of great benefit. Learners then have the opportunity to reflect on their own mathematical understandings and discuss specific challenges. If, however, they encounter tutors who do not have these skills, they will receive the answer to their homework, but may have an experience of mathematics which reinforces their belief that they are unable to do mathematics.

⁷ Subsequent to data analysis and initial findings, the feature for attaching graphics and audio files was added.

The lack of visual representation for symbols and mathematical procedures has been discussed and the challenges in clarifying problems with highly specific notation, such as graphs and tables, presented.

Mathematics is multisemiotic and this provides certain challenges when representing mathematical symbols and concepts on a platform with limited modality and semiotic resources. Conventions are adapted and the tutor and learner find ways of making meaning around these constraints.

CHAPTER SIX: CONCLUSION

This chapter acknowledges the limitations of the study, outlines the significance of the findings, and presents suggestions for future research into this area.

Limitations of this research

As many of the interactions were limited to numeric values, the ESA coding scheme was found to be somewhat problematic when applied to mathematics interactions. The nature of mobile IM discourse, combined with mathematics notation, often made deciphering not only the pragmatic intention of the speaker challenging, but also following the interaction as a discourse. In a classroom or written communication, meaning is made through the sentence construction, placement of words and other cues. However, the brevity of the notation and the lack of modalities on the mobile platform, presented considerable challenges in the coding procedure.

Learners accessing the portal experienced a fair number of technical issues which could also have contributed to the brevity of the exchanges and account for the higher proportion of Initiate turns. While an evaluation of the actual mathematics learning is not the aim of this research, it is evident that there were many instances of sustained interaction between tutors and learners. An immediate aim of Dr Math is to assist learners with their homework. However, if an aim is also to nurture an interest and appreciation of mathematics, it is strategic to encourage learners to acquire the skills to discuss mathematics. By asking questions and assisting learners to express their understandings, they are challenged to verbalise their thought processes and logically represent them in a condensed form.

While modern technology has advanced capabilities permitting ubiquitous access and multimodal interactions, two assumptions made are: that these functionalities or affordances enhance learning, and, that technology devices with the possibility for multimodal or multifunctional interactions are utilised in a way which engages a variety of these possibilities. Dr Math provides an example of a project where this is not the case, despite the possibilities afforded by the technology. The platform utilises a limited range of visual resources for text-based tutoring interactions and this brings with it many challenges which could be viewed in a critical or constructive way. In South Africa, where access to educational support is more complex than merely having access to

well-resourced schools, factors such as internet costs, the quality of teaching, after school support and mobile access, also enter the equation. Resources in the broader sense include technological artefacts as well as symbolic resources such as language.

Significance of the study

This research amplifies the body of empirical research on mobile programs for educational assistance, especially in areas of critical and scarce skill such as mathematics in South Africa.

When implementing strategies for tutor training, this study could possibly assist mobile tutoring programs to reflect on the challenges experienced by users of scientific language with limited semiotic resources.

It is significant that since the research was undertaken some aspects of the platform have been adapted which indicate that assessments made by the researcher are in line with improvements which could be beneficial to tutoring interactions. Learners now have the possibility of attaching audio and graphic files when logged in with a Dr Math tutor. While this suggests additional modes for interaction, and the possibility for future research, this option to include files will result in data costs which could deter learners who experience financial challenges. Another recent adaptation is the extension of the initial bot message to include an enquiry about the learner's age and topic of discussion. This gives tutors some indication of the level at which to pitch the interaction. When extrapolated to comparable cases, findings from this study could guide supportive tutoring approaches of volunteers when engaging in chat interaction in mathematics tutoring.

Finally, one of the significant contributions this study makes to the field of discourse analysis, specifically the analysis of learning discourse, is the application of the ESA framework to one-to-one synchronous mobile mathematics tutoring discourse. The original framework of Sinclair & Coulthard (1975) was adapted for online chat discourse by Kneser, Pilkington, & Treasure-Jones (2001) and applied with further tweaks to the specific research asynchronous (Cox et al., 2004) and synchronous (Lim, 2006). Both projects investigated chat in many-to-many chat exchanges within educational contexts.

The distinguishing features of this research are the dyadic tutoring interactions, which update earlier chatroom and forum-based research to include instant messaging.

Second, the findings highlight the participation ratios of learners to tutors when interacting on the platform. The Move level analysis sheds light on the roles tutors play in the learning interactions and suggests the significance of various tutoring approaches as a means to extend the tutoring dialogue. While the sample is relatively small, the size of the corpus analysed within the period of a month, assisted in findings that make a contribution to the discourse on mobile tutoring.

Recommendations for Further Research

The Dr Math project has won several accolades and has been a forerunner in the field of mobile mathematics tutoring in South Africa. Many of the challenges faced in establishing a tutor base, working through ethical issues and understanding the challenges of mathematics tutoring in a mobile environment, have been piloted by Dr Math.

The aim of this study was to explore the tutoring interactions and identify characteristics of the exchanges. The findings of this research made it possible to identify strategies used by tutors to encourage greater learner involvement. The Dr Math tutoring project is sustained by volunteer tutors who are proficient in mathematics. However, in order to extend the dialogue between tutors and learners, further skills are necessary, such as the ability to work with the affordances and constraints of mobile tutoring tools and effective questioning skills, to elicit the information from learners necessary to provide scaffolded support. In a country where mathematics education is under great scrutiny and school results are problematic, the availability of this service and the potential it has to increase learner participation is a valuable contribution in the space of mobile learning.

Scaffolding relies on techniques such as good questioning skills, anticipation of the possible problems with which learners are struggling and the ability to offer adequate support to enable learners to get to a point, even if it is only one aspect of the process, where they can solve problems without the assistance of the tutor. It was evident from the data that the greatest difference in tutoring quality was in tutor experience and the attention they paid to detail when engaging with learners. Tutor Lawrence, who engaged the learners in in-depth interactions challenged them constantly and also took

a personal interest in their attitudes towards mathematics as a subject. Whilst the discussions remained framed within the content of mathematics learning, a positive

attitude and interest in mathematics was encouraged, and opened the learner to further learning interactions. One of the challenges faced by Dr. Math is monitoring and assisting tutors who lack the experience to scaffold learning interactions in a way that keeps learners engaged.

In recent years MXit has provided the opportunity for educational initiatives to utilise the platform more extensively. In doing a number of mathematics learning applications are available via the MXit platform. In order to make it easier to utilise mathematics symbolic notation, emoticon packs could be designed and made available which contain essential mathematical symbols such as:

π or Σ . These could be offered free to all learners and students who use MXit as a way of supporting mathematics learning.

The fact that there are learners who return, to engage with tutors, is the validation of successful tutoring interactions. A possible area for future research could be a study of learner experiences and their perceived challenges when engaging with tutors on the Dr Math platform. Impact studies are difficult to design and control, especially when dealing with the complexities of learning. However, an analysis of the tutoring practices, from a pedagogical perspective, could also contribute to assisting new tutors with guidelines for extending tutoring exchanges. As this study straddles areas of linguistics, information and communication technology (ICT), and educational technology research, the project offers a number of potential areas for future research in these fields.

In closing

One of the challenges in Education is that there is no 'one size fits all' model. This is to a large extent because we are dealing with individuals who have different levels of expertise, different interpretations and understandings of the world and also uneven access to the sharing of knowledge. Even in an area of learning such as mathematics, where operations and procedures follow universal rules and have pre-set signs and symbols, which are embedded in a universally accepted language, much depends on the level of expertise of both tutors and learners in communicating their understanding to each other.

The aim of this study was not to evaluate the effectiveness of the project but present an overview of the characteristic interactions taking place between tutors and learners. I have highlighted the challenges facing both tutors and learners in making meaning,

given a brief summary of the constraints when tutoring with limited semiotic- and restricted texting resources. More encouragingly, I have also highlighted the ways in which skilled tutors are able to scaffold interactions and open up possibilities for meaningful discussion with alternate semiotic notations that express the same conventions, but adapt to the constraints of the limited modality of linear text-based representations possible on the Dr Math platform.

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