

**MATHEMATICS WORKSHEETS AS A PEDAGOGICAL GENRE IN SECONDARY
SCHOOL CLASSROOMS**

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

in

THE FACULTY OF GRADUATE AND POSTDOCTORAL STUDIES

(Mathematics Education)

THE UNIVERSITY OF BRITISH COLUMBIA

(Vancouver)

October 2013

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Abstract

From kindergarten to the end of secondary school, worksheets are common and dominant curriculum materials in mathematics education with profound effects on pedagogy. While worksheets play an important role in mathematics classrooms, there have been few attempts to describe and understand this pedagogical genre and its effects on the sociology of the classroom. This study examines what worksheets are and how they are used and perceived by teachers in mathematics education through the perspective of genre theory. It provides insights into how worksheets may impact the sociology of the classroom in terms of power and classroom dynamics and offers suggestions for implications through text analysis, focus groups and interviews. Given the important role worksheets play in mathematics education, the findings of this study may shed light into our understanding of the textual and contextual features of worksheets. This may, in turn, raise awareness among educators to revise their practice creating and using worksheets, and ultimately, improve mathematics education.

Preface

This research is approved by UBC Behavioral Research Ethics Board. The Certificate Number of the Ethics Certificate is H13-00285.

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Acknowledgements

Foremost, I would like to express my heartfelt gratitude to my advisor Dr. Susan Gerofsky for her continuous support to my research with her immense knowledge, enthusiasm, care and patience. I could not have imagined having a better advisor, role model and mentor for my M.A. study. Her class has given me the inspiration to start my research, her work has given me the tools to ground my research on a strong foundation and her encouragement has given me the strength to pursue and finish my research. Besides my advisor, I thank the rest of my committee: Dr. Cynthia Nicol and Dr. Ann Anderson for their encouragement, insightful comments and thought-provoking questions throughout my degree.

My sincere thanks also go to Dr. Marina Milner-Bolotin, Dr. Samson Nashon and Dr. Anne Phelan. I am grateful for the opportunities to learn from each of them. I owe my research participants, Malka, Mohna, Pascal, Rambo, Serena, Chloe, Lizzy, Gina and Anton, my heartfelt appreciation. I would like to acknowledge Basia Zurek, Saroj Chand, Bob Hapke, Elizeth Usaqui, Kalie Ka Wai Fong and Scott Cartmill's wonderful support in administrative and technical issues during my research. I also thank Annette and Latika for giving me energy and hope to continue my work.

I am also obliged to my brothers, Bahadir and Inanc, for their long-distance support. And last, but not least, I am thankful to Gulnur, who has been with me all the time throughout my study in the best and worst moments. Words cannot express how grateful I am for her support and encouragement as a friend, as a sister, and as an academic mentor.

Dedication

This study is dedicated to my beloved husband, Can, and our daughter Mercan. I am indebted to their endless support.

This study is also dedicated to my parents, Gulay and Mustafa, and my in-laws, Nuran and Muzaffer. Mustafa and Muzaffer, you are no longer with us but we will remember you always with love and with gratitude. Gulay and Nuran, without your encouragement I could not have done this. Many thanks.

Chapter 1: Introduction

1.1 Problem statement

Mathematics educators have sought change in the curriculum and pedagogy of school mathematics for more than two decades (NCTM, 1991, 2000). In this period, a lot of effort has been made to understand the curriculum materials and their impact on mathematics classroom activities. Many studies indicate that curriculum materials, particularly texts used in classrooms, influence teachers' curricular and pedagogical decisions and actions (Remillard, 1999; 2000; Remillard, Herbel-Eisenmann & Lloyd, 2009) and affect students' learning (Reys, Reys, Lapan, Holliday, & Wasman, 2003; Schmidt, McKnight & Raizen, 1997; Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002; Van Dormolen, 1986). However, we still have limited knowledge of how texts affect "the relationships between teachers and students or the relationships developed between these readers and these curriculum materials themselves" (Herbel-Eisenmann, 2007, p.345). To understand these relations, Herbel-Eisenmann says, it is crucial to examine how the material itself "encourage" this involvement (p.346). Having a good understanding of what the text contains; how text is being presented to students; how teachers conceptualize and use texts provide insights into our understanding of these important curriculum materials within learning contexts as well. Through this understanding, it becomes possible to revise and improve our practice for enhancing mathematics education.

In mathematics education, textbooks and worksheets are the two mainstream texts used not only in North America but in many different education systems as well. Particularly, in secondary schools, students spend a lot of their learning time dealing with textbooks and worksheets to

create meanings with these texts (Haggarty & Pepin, 2002). In one of the large-scale international mathematics student achievement studies (TIMSS- Third International Mathematics and Science Study), it has been identified that it is very common for teachers to use textbooks and textbooks have a big impact on mathematics teaching and learning (Schmidt et al., 1997). Likewise, Mousley (2003) demonstrated that worksheets affect how teachers teach and interact with students. Given the importance of textbooks and worksheets as curriculum materials, it is reasonable to give substantial attention to these materials. As such, there is an abundance of research conducted on mathematics textbooks investigating their characteristics including content, pedagogical perspectives and physical features (e.g. Valverde et al., 2002) or the way teachers and students use texts in the teaching and learning process (e.g. Remillard et al., 2009). However, there have been very few systematic attempts to investigate this written curriculum material (e.g. Anderson, 1995). Moreover, literature also indicates that there is a dearth of research investigating mathematics worksheets in terms of their textual features and how teachers use them in the classrooms (Gerofsky, 2012). Understanding the textual and contextual features of worksheets and their effects on pedagogy would enhance this literature and provide further insights into use of worksheet practice.

Having said that, to better understand the characteristics of worksheets entails thinking carefully through multiple perspectives including the consideration of both content and pedagogy among other features that are embedded within worksheets. This calls for a holistic approach focusing specifically on the worksheets as the subjects of the study. Kearsey (1997) proposes genre analysis as a potentially valuable approach to understand features of text and the relationship between the participants (producers, consumers, and content itself) in that text. Gerofsky's

(2012) genre analysis method and her preliminary study investigating worksheets as genre is an example for such a holistic approach. Gerofsky's approach explores the question of what worksheets are from different disciplinary perspectives and encompasses asking questions about the presence and nature of these particular generic forms (2012).

In summary, worksheets are important curriculum materials affecting teaching and learning of mathematics. However, there is little research done investigating the place of worksheets, particularly with a focus on their textual and contextual features, in the mathematics education. Genre analysis may be a plausible approach to address this need through offering multiple perspectives to understand the relationships among text, teacher, student and context.

1.2 Researcher's position, problem statement and significance of the study

I describe myself both as a practitioner and a researcher. I was a mathematics teacher and a tutor in private schools and tutoring centers in Turkey before immigrating to Canada in 2009 and am currently tutoring grade 7-12 students in Vancouver.

My teaching philosophy promotes the development of my students in becoming creative, critical, reflective, collaborative and communicative learners. I treat learning not as "an accumulation of bits of information" (Hewson, Beeth, & Thorley, 1998, p.199; Cobb, 1994; Watson & Mason, 2005) but as a dynamic process that requires the active engagement of the learner (Vygotsky, 1978) through effective and systematized instruction (Ausebel, 1963). Most importantly, I believe it is crucial to invite my students to behave like "junior researchers" in the classroom, and do mathematics like real mathematicians by contributing to discussions authentically in a

democratic environment (Streefland, 1998, p.41). Similarly, the NCTM (National Council of Teachers of Mathematics) Principles and Standards for School Mathematics (1991, 2000), emphasized that a mathematics classroom must be a public sphere where the discussion and the generation of ideas are celebrated.

Having gone through a rigorous top tier university education, my teaching intention for the twelve years while I taught in Turkey was to build the capability of my students to become creative, reflective, collaborative and communicative learners. I valued active engagement of the learner for conceptual understanding and encouraged my students to contribute to the creation of mathematics knowledge. To that purpose, I guided my students to be active in their learning process by using diverse teaching techniques such as think-pair share activities, role playing, group discussions, and employing different assessment tools such as rubrics, projects, journals, mini boards, post-tests (exit slips), and flashcards. I also used educational technology to promote greater depth of understanding through interactive simulations and illustrations and by providing my students immediate feedback regarding their work. While doing this, I frequently found myself spending a lot of my lesson preparation time creating worksheets and most of my class time having my students work on these worksheets.

Recently, I had the opportunity to consider how my practice mirrors my teaching philosophy through a methodology developed by Whitehead and McNiff (2006). This methodology involves going through a reflective process and understanding our own practice systematically. In this investigation I had a closer look at the teaching tools I used and came to a realization that worksheets were the most common and dominant learning/teaching tools in my classrooms.

Meeting mathematics teachers from many different backgrounds in my graduate courses, I also realized that this was not unique to me. The use of worksheets is widespread, not only in Turkey but also around the world and in many different cultures. This realization made me think critically about worksheets and question whether these worksheets are benefitting the instruction in the classroom as the we, educators, intend (Eisner, 1985). I started thinking about how the use of worksheets affects the mathematics classroom culture, what the reasons or motivations are for us to use worksheets, how we are using worksheets and what we do expect to achieve through worksheets.

1.2.1 My reasons to use worksheets

I began my self-study by exploring the reasons I used worksheets. The first and primary reason was the lack of effective textbooks or workbooks. Being a reflection of orthodoxies of national agencies (Apple, 1992) and their Platonist point of view, textbooks were portraying mathematics as a science of abstraction. Moreover, they were promoting it as a mastery of calculation where there was no place for exploration, interpretation or relational thinking. Since this perspective conceptualized mathematics education as narrow skill preparation rather than as a challenging engagement with the disciplinary knowledge, textbooks were content/text based with very few exercise questions involving connections to daily life.

However, even if I had a comprehensive textbook (it is really hard to define a good/decent textbook, let's say an ideal-utopic book) I would still have designed worksheets, because I support the claim that no textbook can meet the necessities of all the students and address their current abilities (Herbel-Eisenmann, 2007; Appelbaum & Gerofsky, 2012). Moreover, having a

textbook as the only source of knowledge would limit students' thinking and discourse when they articulate their mathematical solutions (Herbel-Eisenmann & Wagner, 2007; Herbel-Eisenmann, 2007). Therefore, I attempted to introduce different perspectives through worksheets.

The other reason for creating worksheets was to use them in training my students for standardized exams while emphasizing the most common question types. The repressive/oppressive power of the testing system resulted in alienating students from mathematics and the creation of mathematics knowledge by de-contextualizing the learning material and mass producing future citizens who lacked critical thinking skills. It seemed, these tests were ruining the joy of exploration by reinforcing rote memorization, speed, accuracy and were leading students to learn test-tricks to get the right answer rather than facilitating internalization of knowledge. In addition, these exams were neither valid nor reliable due to several factors such as: stolen test booklets, wrong sampling questions, questions being open to misinterpretation, one test per year, etc. I was aware of the devastating impact of these tests on students' learning and morale; however, I made myself believe that if my students were able to pass the exam then they would be able to pursue their education in good schools and worksheets were wonderful tools for the purpose of test preparation.

1.2.2 How did my practice look back then?

I was using worksheets in many different ways and forms: *daily* ones to go through in-class to introduce topics, *weekly* ones as weekend homework - to re-enforce the main ideas of the week's lessons and *unit review* worksheets for exam preparation. I was drawing upon the most popular

exam preparation books and the recent exams to prepare my worksheets. My worksheet questions were similar to most common question types that were found in past exams. I was also referring to some textbooks from England and the US to get ideas. I was mashing up the questions from these resources and combining them with the Turkish textbook questions and adapting them to the Turkish context. My students were required to paste these worksheets into their notebooks and this encouraged them to create a resource for their personal study.

1.2.3 How did the outcome look?

Having worksheets as an important component of my teaching, made things look promising; my students were doing well in the school exams and scoring high at national exams and I received good reviews for my teaching from my administrators. I spent less time in front of the class solving questions at the blackboard but more time in helping my students one-on-one. Parents were happy to have worksheets to guide them in helping their children, while students were happy not being obliged to carry a big textbook. As a result, I never needed to question my practice of using worksheets and its place in the larger picture of mathematics teaching and learning, until now. Drawing from my experience as a practitioner teacher and a scholar equipped with research skills and curiosity, I sought to explore the use of worksheets in secondary level mathematics education on a broader scale to contribute to the larger body of literature and practice.

1.3 Contribution of the study

Worksheets are a dominant part of mathematics education, are important curriculum materials, impact the ways teachers teach and interact with their students, and influence teachers' and

students' interaction with the subject matter (Mousley, 2003). However, there is a lack of research investigating mathematics worksheets in terms of their textual features and how teachers use them in the classrooms (Kaymakci, 2012). Given the intensive use of worksheets in mathematics education, this research sets out to explore worksheets from their textual and contextual characteristics points of view and thus fills an important gap. The review of the existing text analysis literature suggests genre analysis as a viable way to analyze worksheets. Genre analysis is proposed as a dynamic method which allows incorporation of multiple perspectives to understand the forms of text that shape how producers create the text and how consumers receive and react to it. Therefore this study exemplifies an application of genre analysis within the context of worksheets in mathematics education. Stemming from this application, one may potentially use genre analysis to understand the nature of other curriculum materials.

1.4 Research questions

This study specifically examines what worksheets are and how they are used and perceived by teachers in mathematics education through the perspective of genre theory and includes text analysis, focus groups and interviews. It also provides context for how worksheets may impact the sociology of the classroom (authority, creativity, power, and classroom dynamics) through investigating the following core research questions:

1. What are textual and contextual features of mathematics worksheets in secondary education?
2. How do teachers understand and use mathematics worksheets?

1.5 Outline of the thesis

Chapter two offers a review of literature relevant to this study. The first part of the literature review reports on studies focused on textbooks and mathematics worksheets through which it depicts how texts are analyzed in mathematics education contexts. The second part of the chapter examines genre theory and discusses how a genre perspective would enrich our understanding of generic forms, i.e., written text in the learning and teaching mathematics. This part also explores the notion of deviation from genre and how this departure would help to think the forms differently. Chapter three describes the methodology employed in this study including the explanation of the methods, research participants, limitations, data collection and data management. Results are presented in chapter four where the focus is on the questions of what mathematics worksheets are, what they are for, where they come from, how they have changed, and, what teacher intentions, and finally how they posit teachers and students and shape the interaction in the mathematics classroom. The discussion of the results, implications of the study, recommendations, and questions for further research are incorporated in the final chapter.

Chapter 2: Literature Review

A number of studies investigated whether curriculum materials, particularly texts used in mathematics classrooms have an influence on teaching and learning in mathematics education (e.g. Valverde et al., 2002). These studies explored what the texts are, how they are accessible to students, how teachers and students conceptualize and use texts to better understand and improve the ways they affect learning. A majority of these studies focused on textbooks specifically and examined textbooks from different aspects. Some of these textbook studies centered on their content, pedagogical intentions, and the language they employ while others focused on the way students and teachers handle texts. In addition to large and small scale international comparative studies, textbooks are also investigated for their textual features ranging from language to the nature of mathematics that they present. These studies were aimed at gaining a better understanding of how teachers and students interact with textbooks and how such interactions affect students' learning. Worksheets, on the other hand, were not investigated thoroughly. Although the existing studies draw our attention to the importance of these curriculum materials, there is a need for further research to understand textual and contextual features of worksheets. Although textbooks and worksheets may show differences in terms of their content and the intentions for their use, textbook analysis literature provides insights into our inquiry of constructing a framework for the investigation of worksheets. This literature review starts with textbook analysis and moves to worksheets, followed by genre analysis as a plausible way to analyze worksheets.

The literature review presented below has been undertaken to achieve three goals: to make epistemological and methodological evidence for text analysis in the field of mathematics education; to find theoretical support for the current study and to construct a possible framework for worksheet analysis.

2.1 Mathematics textbooks and textbook analysis

Modern textbook use dates back to the printing press (Cronbach, 1955). Textbooks are curriculum materials that help define school subjects, are widely used universally. Textbooks are physical artifacts that bridge between the intent of curricular policy and the instruction that occurs in classrooms (Valverde et al., 2002). They are most intimately connected to teaching and learning. They provide students learning opportunities to master knowledge and skills deemed important by national curriculum policies, i.e., they translate the abstract policies into practice such that students and teachers can execute and can communicate with other stakeholders (Schmidt et al., 1997).

Textbooks are used widely as a teaching and learning source in mathematics education at all levels of primary and secondary schools and beyond (Howson, 1995; Mesa & Griffiths, 2012; O’Keeffe, 2013; Pimm, 1987; Shield, 1998; Remillard, 1999, 2000, 2005; Schmidt et al., 1997; Skemp, 1976; Valverde et al., 2002). As Van Dormolen (1986) proposes mathematics textbooks can be used “in every possible way” (p.142): Students could access them without mediation and work alone (Love & Pimm, 1996); students use them through teachers’ mediation (Pepin, Haggarty & Keynes, 2001; Stein, Remillard & Smith, 2007) or teachers use textbooks as a reference book for themselves (Erbaş, Alacaci & Bulut, 2012; Remillard, 2005). In one way or

another, textbooks have a major influence on teachers' organizing curriculum and designing classroom activities for teaching (Remillard et al., 2009). Having a good understanding of what the text contains; how the textbook's content is being presented to students; how teachers conceptualize and use textbooks and how textbooks affect student learning provide insights into our understanding of these important educational materials and learning context as well. Through this understanding, it becomes possible to revise and improve our practice for enhancing teaching and learning mathematics. There have been many studies looking at various aspects of textbooks to understand their impact on learning and teaching of mathematics. These studies can be considered under three main categories as Van Dormolen (1986) proposed:

- *a priori* analysis which concerns textbooks as a possible means for instruction and includes examining mathematical content and pedagogical intention. A priori analysis provides insights into the nature of the subject matter present in the textbook, use of language, and clarifies the curricular intentions that align with the national vision for education.
- *a tempo* analysis concerns the way teachers and students use texts in the teaching and learning process. The mediating role of textbooks is not simple and involves how teachers and students use textbooks in creating educational opportunities when they bring their own visions and goals for teaching and learning. Therefore, *a tempo* analysis clarifies how textbooks are translated into practice through the views of teachers and students.
- *a posteriori* analysis is based on comparing learning results to the use of the text. This analysis provides insights into how specific decisions made (e.g., content, structure, physical nature etc.) in textbooks effect student achievement.

The following part of the literature review is centered on the analysis of textbooks as possible means of instruction – content, pedagogical intentions and language use (a.k.a. *a priori*) (Herbel-Eisenmann & Wagner, 2007; Howson, 1995; Love and Pimm, 1996; Morgan 1996; O’Keeffe, 2013; Robitaille, 1992; Schmidt et al., 1997; Valverde et al., 2002; Van Dormolen, 1986) and as a way students and teachers handle texts while learning and teaching (a.k.a. *a tempo*) (Floden, Porter, Schmidt, Freeman & Schwille, 1981; McClain, Zhao, Visnovska & Bowen, 2009; Pepin et al., 2001; Haggarty & Pepin, 2002; Remillard, 1999, 2000, 2005; Remillard et al., 2009; Stein et al., 2007).

Thus, it provides a foundation for this study which is intended to better understand textual features and pedagogical intentions of the use of worksheets in secondary school mathematics education. It starts with an in-depth review of the *a priori* analysis strategy including language analysis and is followed by *a tempo* analysis.

2.1.1 *A priori* analyses through the lens of cross-national studies

Students’ schooling experiences vary considerably from country to country and even among schools and classrooms in the same country (Valverde et al., 2002). Since cross-national studies have the potential to point out diverse perspectives from various cultures, reviewing this literature would “lead to a deeper understanding of issues that are central concern in different countries” (Pepin, et al., 2001, p.158). Therefore, we will start our textbook analysis literature review with international comparison studies.

The focus of this review is on a large scale cross-national study (i.e. TIMSS - Third International Mathematics and Science Study) which considers a wide range of characteristics of textbooks including content, pedagogical perspectives and physical features rather than on small scale comparative studies which usually provide insights into a particular feature of textbooks. Stemming from this study's aim of constructing a framework for the analysis of mathematics worksheets as curriculum materials used in mathematics classrooms, this study focuses on TIMSS rather than other cross-national studies. Unlike studies such as PISA which is detached from the curricula and focused on students' use of their knowledge and skills in their present and future life (Wu, 2009), TIMSS is a curriculum based study and is conducted to provide all the stakeholders with information about mathematics and science achievement and learning context. TIMSS is focused on educational policies, practices and outcomes; documents about how well countries' school-age population know, communicate and apply their knowledge to problem-solving situations; and moreover, presents suggestions regarding what can be done for improving students' achievement.

In this endeavor, TIMSS investigates the role of mathematics textbooks in translating national policy to teaching and learning practice (Schmidt et al., 1997, Valverde et al., 2002) through the analysis of four hundred textbooks from almost 40 different countries. It illustrates similarities and differences among mathematics curricula as they are reflected in the textbooks (Charalambous, Delaney, Hsu, & Mesa, 2010). TIMSS comparative study uses "tripartite model of curriculum", which parallels *a priori*, *a tempo* and *a posteriori* analyses strategies, as a basis for its conceptual framework. This model considers curriculum as *intended*- "system goals" at the level of national policy; *implemented*- "instruction and practices" at the level of classroom;

and *attained*-“student achievement” at the level of students (O’Keeffe, 2013, p. 2). Valverde et al. (2002) also consider a link between the intended and the implemented curricula as potentially implemented curriculum which is mainly shaped by the textbooks. This consideration emphasizes the power of textbooks as a “surrogate curriculum” and provides a framework analyzing and comparing the mathematics textbooks as an important element informing teachers’ curricular and pedagogical decisions (O’Keeffe, 2013, p.3)

In the process of analyzing textbooks based on TIMSS study three aspects are considered: *content, performance expectations* and *perspectives* (Schmidt et al., 1997; Valverde et al., 2002). The content aspect represents the content of school mathematics divided into ten major categories such as numbers, measurement, geometry, etc. The performance expectations aspect refers to the kinds of performance that students are projected to demonstrate while engaged with a given content. This aspect is considered through the categories like knowing, using routine procedures, either simple or complex and integrated understanding, investigating, problem solving, communicating or mathematical reasoning. Finally, the perspectives aspect is projected to embody curricular goals that focus on the interdisciplinary and daily life relations (Valverde et al., 2002) and the development of students’ attitudes, interests, motivations in mathematics teaching (O’Keeffe, 2013).

In the analysis of TIMSS textbooks, a two-step process is employed: (i) dividing each document into major structural components called units such as lessons, introductions and instructional appendices which are partitioned into smaller chunks, called blocks such as narrative blocks, graphic blocks related to (or not related to) narratives, exercises and questions blocks; and (ii)

assigning content, performance expectation, and perspective categories to these units (Schmidt et al., 1997). Textbooks are also analyzed through other interrelated features such as the sequencing of content, physical characteristics, classroom activities (Valverde et al., 2002). For example, physical features of the textbook are considered in terms of its size, width, length, number of pages, appearance of visuals, graphics, tables and models. On the other hand, classroom activities are considered as the nature of pedagogical circumstances illustrated by the textbooks such as “whether the textbook situation is a piece of narration to be read, set of exercises to be worked, an example of how to solve a specified type of problem, an illustration or a graph to be examined” (p. 15).

The TIMSS study reveals that a majority of teachers from participating countries are using textbooks for teaching and the majority of students are required to practice computational skills through textbooks. Although textbooks from different countries include similar topics they demonstrate variations in their embodiment of “technical ability expected” (Howson, 1995, p.89). Also, “[c]ountries have developed their own ways of engaging students in the substance of mathematics ” (Schmidt et al., 1996, p. 132), for instance, while many of the textbooks connect number ideas to daily life situations such as temperature, some adopt a formal algebraic approach to the topic. Textbooks also differ in terms of their physical characteristics, structure and student expectations (Valverde et al., 2002). However, one thing common to the majority of textbooks analyzed in the TIMSS is that they “intend children to read and to practice skills they read about” but do not intend to encourage students’ use of different skills (p.168). Schmidt et al. (1997) and Valverde at al. (2002) conclude that “textbooks translate policy intentions into practice” (p.167) by providing educators with a guideline to how goals might be attained. Since

textbooks and other “printed curriculum materials” (Remillard, et al., 2009) are “important mediators between policy and pedagogy” (Valverde et al., 2002, p. 171) it becomes very important to analyze and revise these texts.

In addition, other researchers indicate that TIMSS studies would be enhanced by including an analysis of language and how concepts are treated in textbooks. For instance, because the way in which language is presented and established within a text affects students’ learning, O’Keeffe (2013) suggests adding a language dimension “to strengthen’ the TIMSS framework for textbook analysis as needed in order to understand the function of particular language choices (p.1). Considering mathematics has a complicated and distinctive language, the role of language analysis to interpret and to understand the features of mathematics text can not be underestimated (O’Keeffe, 2013). From this perspective, the language analysis method offered by Morgan (1996) is a viable option in mathematics text analysis (O’Keeffe, 2013). Because this method is particularly designed for the analysis of mathematics text, it provides further insights (e.g., how mathematics activities are presented, what kind of mathematical messages portrayed throughout the text and how). In addition, it has been argued that the TIMSS approach “overlooks fundamental differences in the learning opportunities offered to students in different countries” by analyzing them based on general characteristics (e.g., structure, physical features, the organization of the content across the book), and thus, does not provide in-depth insights into “how concepts were treated within each textbook to structure learning opportunities for student” (Charalambous et al., 2010, pp. 119-120).

To recap, *a priori* studies such as TIMSS demonstrate that textbooks are dominant elements of mathematics teaching and learning. There are substantial differences in presenting and structuring pedagogical situations among different countries and that student achievement is impacted by curricular and pedagogical intentions presented in the textbooks. One of the drawbacks of these studies is the lack of in-depth language analysis which gives insights into our understanding of how language choices made for textbooks impact student learning. Another drawback is the lack of in-depth analysis of how mathematical knowledge is presented in textbooks.

2.1.2 *A priori* analysis through the lens of the nature of mathematics

Another approach to mathematical textual analysis is proposed by Van Dormolen (1986) who discusses a wide range of perspectives on the nature of mathematics from a formalistic view (a.k.a. instrumentalist view as in Skemp, 1976) to activist view (a.k.a. relational view as in Skemp, 1976). A formalistic view one considers mathematics as “a cultural heritage” or systems of facts, rules, theorems and skills with a goal of acquiring knowledge. The activist view sees mathematics as a dynamic field open to “intuitive reasoning” (Van Dormolen, 1986, pp.144-146). While the formalist perspective emphasizes receptive learning of the technical terms and their definitions, skills and techniques with much symbolic recording (Ernest, 1991 as in Pepin et al., 2001, p.160), an activist perspective aims for “acquisition of process skills” like generalizing, exploring, problem solving, finding patterns (Pepin et al., 2001, p.160). Policy makers or practitioners themselves adopt a view of school mathematics and teaching somewhere between these two extreme views to make curricular and pedagogical decisions (Shield, 1998). By focusing on investigating the presence of mathematics in the text, Van Dormolen’s textual

analysis framework helps to bridge the gap between curriculum development and practice (Shield, 1998).

However, rather than seeing mathematics as either just “human activity” or “cultural heritage” or “a mixture of both” Van Dormolen views mathematics as “ a combination of posing problems, of activity and as a product of activity” (pp.145-147). Through the activity, new knowledge is shaped and communicated in textual form consisting of definitions, theorems, rules, methods and conventions which Van Dormolen refers to as kernels. Accordingly, the following aspects are considered by researchers in order to examine how mathematics knowledge presented in the kernels: *a theoretical aspect* involving of theorems, definitions and axioms; *an algorithmic aspect* consisting of explicit 'how to do...' rules; *a logical aspect* containing statements informing the reader about how we are allowed to handle theory; *a methodological aspect* consisting of all heuristic hints for example how to use mathematical induction; and, finally, *a communicative aspect* emphasizing commonly adopted conventions and how to write down a proof, for instance. These aspects resemble the performance expectation component of the TIMMS framework, albeit more of a focus on the activities students are projected to demonstrate.

Moreover, Van Dormolen identifies two pedagogical functions embedded in the text: *cursorial preparation* (introducing logical mathematical progression) and *conceptual preparation* (embracing the development of cognitive structure of the learner and connecting the past and the future). Love and Pimm (1996) refer these preparations as a “curricular aspect” of pedagogic function of a text. Love and Pimm (1996) emphasize the importance of examining the collection

and organization of the material in the text, whether it builds up on the students' assumed prior knowledge and learning process and whether language is appropriately and consistently used in the text. Van Dormolen (1986) also emphasizes the importance of correctness of the contents and says a text should be "free from mistakes", consistent, clear and genuine (p. 160).

It seems most of Van Dormolen's ideas stated above can be subsumed under the categories developed in the TIMSS mathematics framework as it too considers content, structure and pedagogical functions of the text. One component missing in Van Dormolen's consideration is the analysis of physical features of the text although verbal and graphic representations and symbol and signal effects are considered in relation to how they communicate mathematics knowledge. Pepin et al. (2001) say Van Dormolen's categories stress the potentiality of text itself in terms of its effect "to enhance or hinder students' learning"; however, "it requires more detail in application" (p.161). Shield (1998) adopted Van Dormolen's method to analyze mathematics textbooks at the lower secondary level and extends this method in "a coding scheme ... with some minor renaming of categories" (which is very similar to the TIMSS method) based on categories such as; all statements- verbal and symbolic in the text (e.g. kernel [K], exemplar [E]) are characterized according to their "aspect of mathematics" (e.g. theoretical [T], logical [L]) and "level of language" (e.g. particular procedural [PP] or particular descriptive [PD]) (p.20). These categorization techniques resemble TIMSS method of dividing each document into major structural components and assigning content, performance expectation, and perspective categories to these units. Interestingly, Shield employed the linguistic approach- developed by Halliday (1973) and adapted by Morgan (1996) to analyze mathematics text (as also suggested by O'Keeffe (2013) to strengthen TIMSS textbook analysis framework) to interpret the findings.

Briefly, in this *a priori* analysis through the perspective of the nature of mathematics, Van Dormolen draws on the view that mathematics is “a combination of posing problems, of activity and as a product of activity”. This method provides insights into how mathematics is presented through the analysis of kernels - definitions, theorems, rules, methods and conventions - and also considers pedagogical functions embedded in the text in terms in selection and sequencing of the material, expanding on the students’ learning process, using appropriate language and generating occasions for handling text alone.

2.1.3 *A priori* analysis through the lens of language

Drawing from systemic functional linguistic approach and mainly from the notion of Halliday’s metafunctions (for more background information see section 2.3.1), Morgan (1996) proposes a method to analyze mathematical texts through the analysis of three language metafunctions.

Morgan (1996) explains that through this analysis it becomes possible to gain insights into “how the language of a text may influence the ways in which its readers make sense of it” that provides knowledge for teachers to improve the classroom situations where mathematics language is developed (p.2). Although Morgan, particularly, focuses on the ways where teacher as a reader interpret the texts produced by students, mainly in secondary school level, the analytic tools used in the analysis of texts have a wider application to understand the mathematical text and the power of language employed in various texts. As such, Herbel-Eisenmann and Wagner (2007) adopt this method in the analysis of mathematics textbooks and ask how a textbook positions its reader to each other and to the subject matter. Likewise Herbel-Eisenmann (2007) compares two secondary level mathematics textbooks through Morgan’s method and examines their claim of reflecting current reform ideas such as NCTM, 2000.

In order to understand the context where the texts are “produced and consumed” and relationships among author, reader and subject matter are constructed Morgan (1996) examines the language of a mathematical text through ideational, interpersonal and textual metafunctions (p.3). To consider an ideational aspect in a mathematical text Morgan suggests asking “What is mathematics (as it appears in the text being analyzed)?” (1996, p.3). In her study, Herbel-Eisenmann (2007) examines ideational function of two mathematics textbooks through a discussion of “a) who is involved in doing what kinds of processes; and b) the depiction and suppression of agency” (p.351). The interpersonal metafunction, on the other hand, defines the interaction between participants of the discourse and requires examination of how the readers are positioned in relationship to mathematics (Morgan, 1996). Herbel-Eisenmann’s study traces the use of “imperatives, pronouns and modality” to understand the interpersonal function as it is suggested in Morgan’s study (2007, p.349).

Alongside ideational metafunction explaining what is being discussed in the text and interpersonal metafunction focusing on social interactions a text emphasizes, Morgan (1996) considers textual metafunction. As Bawarshi and Reiff say “[t]extual [metafunction] describes the flow of information within and between texts, including how texts are organized, what is made explicit and what is assumed as background knowledge, how the known and the new are related...” (2010, p.31). Morgan examines this function by asking what is the message conveyed through the mathematical text, and considering “the ways in which reasoning is expressed” (1996, p.7). Herbel-Eisenmann (2007) considers textual function by analyzing “the modes of reasoning and the features of the text that preserve continuity” (p.351). The examination of a language metafunctions raises awareness to the effects of various language choices made

throughout a text that leads to making conscious and accurate choices to address the nature of the mathematical activity, the relationships between the participants and the mathematical activity.

For example, Morgan explains that personal pronouns help us to interpret “author’s personal involvement” by the use of singular or plural first person pronouns (e.g. *I* and *we*) and also provide insights how an imaginary audience is expected to be involved in the text. For instance, the use of first person singular pronouns (i.e., *I*) demonstrates a real human agency doing the activity; the use of “you” on the other hand addresses the reader directly and involves them with the process of creating a solution. However, the involvement of “you” in the consideration of nominalization (the language structure that conceals human agency like the use of rotation rather than use of rotate) is very important because the use of second person pronouns could be in two ways: i) you+verb and ii) an inanimate object+an animate verb+ you (as direct object). The second use may mask the involvement of a human who is actually doing the activity like “the chart tells you” (you are the one who is interpreting the chart which is not literally “telling” you). As Morgan (1996), says the absence of first or second person pronouns shadow the human involvement with mathematics and distances both mathematics and the author from the reader.

Likewise, particularly drawing from the discussion of teachers’ choice of using “we” and “I” in different occasions, Pimm (1987) stresses the importance of pronoun use in mathematics classroom and explores the notion of different pronoun use in terms of user’ intention and its “effect on hearers” (p.68). According to Pimm (1987), different usage or non-usage of personal pronouns conveys different messages regarding the nature of mathematics. Correspondingly, Herbel-Eisenmann and Wagner (2007) articulate that the use of the pronoun “I” can model an

actual person doing mathematics; however, the use of “we” refers to “vagueness” (p.10). The usage of “you”, on the other hand, may “connect the reader to mathematics because it speaks to the reader directly” or may “obscure” human subjectivity. Therefore, analysis of personal pronouns provides insights how a text position students in relation to mathematics. Authors also pay attention to modality which reveals “the role of humans in relation to mathematics” and indicates probability, certainty or uncertainty. Modality can be studied through modal auxiliary verbs such as must, can, could, will, etc. and through the use of some of these forms (e.g. must, will) the text may suggest absolute certainty whereas the use of “hedges”-words that indicate uncertainty (e.g. might, may), the text may be open for further interpretations and possibilities (Rowland, 1995, pp. 328-330).

According to Herbel-Eisenmann and Wagner (2007), imperatives, which are discussed by Morgan (1996) in the consideration of interpersonal metafunction, give important clues as to how a text might position a student in relation to other students and their teachers. Rotman’s (1988) attention to imperatives as “inclusive” and “exclusive” shed light on our understanding of this argument. In his study of *Toward a Semiotics of Mathematics* Rotman (1988) mentions “the tripartite agent of Agent/Mathematician/Person who reads and writes mathematical signs and suffers its persuasions”, that is, the first one representing “the pure thinker” has an impersonal voice, the second one carries out the mathematical activities, “scribbler”, and the last one is the actual person who is pursuing these two (pp.30-35). Rotman considers imperatives as inclusive imperatives (e.g. describe, explain, prove, consider) which lead a reader to be a thinker and exclusive imperatives (e.g. write, draw, calculate) which direct a reader to be a scribbler. Herbel-Eisenmann and Wagner (2007) articulate that “[t]he ‘thinker’ imperatives construct a

reader whose actions are included in a community of people doing mathematics, whereas the ‘scribbler’ imperatives construct one whose actions can be excluded from such a community” meaning one who “scribbles” does not need to work with other people such as a student can work independently from his/her teacher and classmates. (p.12). Since mathematics involves not only scribbling or thinking but both, it is important to analyze how a text employs inclusive and exclusive imperatives and makes a thinking or scribbling demand.

To conclude, analyzing the language features of a text (e.g., mathematics textbook) including pronouns, modality and imperatives provides insights into how the language choices in a text may influence its readers to make sense of it. That raises awareness of teachers to improve the classroom situations where mathematics language is developed (Herbel-Eisenmann & Wagner, 2007; Morgan, 1996; Pimm, 1987).

The studies reviewed above examine the role of textbooks as a possible means for instruction maintaining and controlling the curriculum and mainly draw from textual features of textbooks (e.g. Schmidt et al., 1997; Valverde et al., 2002; Van Dormolen, 1986; Morgan, 1996; Herbel-Eisenmann & Wagner, 2007). Under the paradigm of textbooks as intermediaries in the education system (Schmidt et al., 1997), the depiction of textbooks is suggesting “probabilistic rather than deterministic opportunities to learn mathematics” (Mesa & Griffiths, 2012, p.86) which can be addressed through investigating how teachers use textbooks. Also, Pepin et al. (2001) underlines that although “textbooks have a controlling power on what happens in the classrooms” (p.165) teachers use every kind of books in every kind of way and although *a priori* analysis provides valuable insights into the effect of textbooks in learning and teaching

mathematics, it needs to be “supplemented by studies of textbooks actual usage in a range of classrooms” (p.166) including investigation of intended and unintended messages conveyed in the text. In the next section we will review the literature focusing on the usage of textbooks.

2.1.4 A *Tempo* analysis

There are a number of studies focusing on teachers’ use of textbooks (Remillard et al., 2009) which is a crucial component to better understand the role of textbooks in the learning and teaching of mathematics. This part of literature review will discuss various ways that textbook use is conceptualized and “how individual teachers interact with, draw on, refer to and are influenced by [textbooks]” (Remillard, 2005, p.212).

Although researchers approach textbook use in various perspectives, the majority of studies stresses the teachers’ role as mediator of the textbooks (Mesa & Griffiths, 2012). However, the relationship between teacher and textbooks is a complex one involving teachers' knowledge, beliefs, and their social and human capital, school context, etc. resulting in a variety of mathematics practice (Remillard, 2005). Throughout the literature, there are cases of teachers who do not follow textbooks as a curriculum guide closely, while some suggest close fidelity (Remillard et al., 2009). Some studies indicate that teachers use a textbook as a reference book for themselves (Erbaş, Alacaci & Bulut, 2012), while some studies show that teachers use textbooks for students’ revision of the topic (Haggarty & Pepin, 2002).

According to Remillard (2005) contemporary studies differ from traditional studies in terms of conceptualizing teachers “as active users of curriculum materials [e.g. textbooks] and shapers of

the enacted curriculum” (p.215). However, even within this framework scholars approach curriculum material use (e.g. use of textbooks) in a wide range of perspectives due to their “different assumptions about curriculum, teaching and reader-text interactions” (p. 216). Many studies, for example, theorize curriculum as a fixed entity portraying “the complete images of practice” and the teachers’ role is illustrated as “enactor of planned curriculum” and they either “follow or subvert” it (p. 217). These studies (e.g. Manouchehri and Goodman, 1998) aim at investigating fidelity and how it can be increased through improvements in the textbooks or context of the school. Another perspective focuses on classroom practice and considers teachers as active designers of the enacted curriculum. From this view, textbooks are one of the teaching sources that teachers choose but that they do not have the power to shape classroom activities and do not act as a “subject-mediating artifact-object (Rezat, 2006, pp. 411-413 as in Erbas, Alacaci & Bulut, 2012, p. 2325). This research mainly investigates “agency of teachers” (Remillard, 2005, p. 216) and discusses the influence of teachers’ choices (Smith, 2000).

Unlike the two prior perspectives presented, another view claims that close fidelity with curriculum material (e.g. textbooks) is not plausible (Floden et al., 1981) because teachers interpret the text and make meanings out of it which are influenced by their beliefs, experience, interaction with the context and the curriculum represented in the textbooks (Remillard et al., 2009). The research adopting this view examines how teachers make sense of textbooks and how these effect curricular and pedagogical decisions (Pepin et al., 2001), whereas more recent studies conceptualize textbooks as social artifacts and teachers as “collaborator with curriculum materials to design enacted curriculum” (Remillard, 2005, p.217). The studies under this category (Remillard, 1999, 2000; McClain, Zhao, Visnovska & Bowen, 2009) identify the

relationship between teacher and curriculum as “participatory” and aims at exploring the dynamics influencing that relationship; the relation itself and its effect on the sociology of the classroom (Remillard, 2005, p. 221).

Briefly, there is a body of studies that differentiates textbook use “as either following or subverting it” (McClain et al., 2009, p.56) and discusses the text as “a tool” and teachers as “designers”. These studies approach the issue in terms of “fidelity” which raises the following questions: “What is the level of fidelity that promotes students’ learning?” or “What are the potential negative or positive effects of fidelity?” On the other hand, others include “interpreting, drawing on and participating with the text” (Remillard, 1999 as in McClain et al., 2009, p.56) and approach teaching practice and textbook use from a dynamic and complex perspective which considers the interaction among teachers, students, text and context. Drawing from the latter view, McClain et al.’s study identifies teachers’ instructional reality, agency, and teachers’ professional status as the important features affecting textbook use.

To recap, textbooks are important elements of mathematics teaching and learning and translate national policies, intents and goals into practice. Teachers and students use textbooks in different ways across the world. The features of textbooks and how they are used have a big impact on teaching and learning mathematics and vary country to country. Given the importance of textbooks, analyzing textbooks in terms of their textual features, how they are used and how they impact student performance provides information about educational achievement and the learning context. In addition, in-depth language analysis of textbooks gives insights into our understanding of how language choices made in textbooks impact classroom activities and

presentation of ideas throughout the textbooks. Having said that, textbook analysis is complex in its nature due to multi-dimensional features of textbooks, and requires one to consider different analysis options when analyzing textbooks. For example, studies may focus on content or pedagogical aspects of the textbooks within the realm of *a priori* or a tempo analysis, however both content and pedagogy among other features are embedded within textbooks and may benefit from both *a priori* and a tempo analyses merged in the exploration of textbooks.

Textbooks are a dominant part of the mathematics teaching and learning; however, they are not the only curriculum materials used in classrooms and are usually accompanied by other instructional tools, particularly supplemented by worksheets. Worksheets are also a widespread text with a significant impact on mathematics teaching and learning and demonstrate differences from textbook in nature. Do these differences lead to different patterns of interaction in the classroom? Do worksheets affect mathematics classroom culture in ways different than textbooks? How do teachers use worksheets? Why do teachers use worksheets? Following is a review of literature focusing on worksheets that attempts to better understand the place of worksheets in mathematics education.

2.2 Mathematics worksheets and worksheet analysis

While textbooks are produced by curriculum makers and reflect the intentions of national policies, worksheets are often the products of teachers' decisions and reflect teachers' intentions and teaching choices to address their students' needs. Although textbooks and worksheets are widely used in mathematics classrooms, they differ from each other in many ways. For example, while textbooks include explanations, theorems and proofs, examples, exercises, etc., worksheets

include mostly questions. Textbooks are published by educational authorities whereas teachers either design their own worksheets or copy them from different resources such as websites, other textbooks and reference books or use published materials; there are also online versions of worksheets. It is curious how/if worksheets may impact teachers' pedagogical intentions and practices differently than textbooks.

Worksheets are extensively used at elementary (Anderson, 1995) and secondary (Oren & Ormanci, 2012) levels for many purposes such as for evaluation, drill practice, homework or for exploring topics that are not covered in the textbooks (Celikler & Aksan, 2012). While there is an abundance of research done on textbooks as reviewed above, there is only a few studies focusing on worksheets (e.g. Mousley, 2003). These studies concentrate on exploring worksheets in terms of their content and use. This, in turn, parallels with the textbook analysis literature described earlier in terms of *a priori* and a tempo analyses.

For example, an earlier report (Potamkin 1963), focuses on a tempo analysis of worksheets. Potamkin reflects on her personal teaching experience with ditto worksheets "instead of being circumscribed and hemmed in by the indoctrination of prescribed doses of knowledge, the pupils are given a direction and released to follow it [by the use of worksheets]" (p.163). Potamkin says that the idea of creating worksheets was inspired by a necessity to provide work, on a particular topic, which was not covered by the textbook. In her implementation of worksheets (which was mainly based on creating a worksheet center resource with different levels of worksheets regarding every one of the topics for students to freely use) students became involved in their learning more, they developed self-esteem, and the class atmosphere evolved to a more co-

operative and collaborative environment. The way Potamkin used the worksheets gave students autonomy in their learning and positively affected the learning, at least in her own account of it. This practice was far beyond the practices that had been implemented during that period of time and actually presented itself as an innovation. Nevertheless, in this relatively dated study, Potamkin's articulation of her practice raises many questions regarding limited student learning activities and positioning the students as the receiver of the information but not the creator; all of which still hold today.

Marks and Mousley (1990) examine a number of writing genres that are accessible to students in primary and secondary school mathematics through text analysis and classroom observations. The authors claim that “[t]exts, chalkboard and worksheet patterns of communication model a very limited range of linguistic form” and criticize worksheets for dominating the language used in the classroom and thus hindering students' use of their own language (p.122). The authors argue that “to be mathematically literate, students need to be able to control a number of different context-appropriate genres of mathematics” (p.134). That would lead students “to imagine, to report, explain, judge and teach” and be involved in “expressive activities” (p.127) through the use of different tools such as charts, posters, models, exhibitions. According to Marks and Mousley, mathematics teaching and learning can be enhanced through raising teachers' awareness to a broad range of mathematical writing genres available. Their findings of the importance of language in mathematics learning is in agreement with that of Van Dormolen (1986) who highlighted the effect of language use in mathematics classrooms.

Opposite to Marks and Mousley who perceive worksheets as a closed text demonstrating uniform language pattern, Anderson (1995) proposes that an interdisciplinary perspective to

worksheets facilitates students' acquiring and practicing different forms of language. Anderson's (1995) articulation of worksheets elicits that it is not the worksheets but how they are used that changes the educational possibilities in a mathematics classroom. Anderson (1995) explains that "teachers who use worksheets do want to give children meaningful and thoughtful experiences; however, they are constrained when worksheets are used in traditional ways... Practice is a key component of mathematical learning, but so is thinking. Children cannot make connections or see patterns if they complete the task by filling in the blanks in isolation" (p. 78). Learning mathematics is possible through making connections, seeing patterns, solving problems and being active in the learning process therefore it becomes important to depart from traditional way of "completion of worksheets" but explore different opportunities to promote students' "participation" in the creation of mathematics knowledge (pp. 72, 78). Drawing from her daughter's mathematics worksheet experience, Anderson offers creative ways to use worksheets through the incorporation of art (e.g. drawing, coloring, drama); language (e.g. storytelling, role playing, brainstorming, oral or written language); science (e.g. study of nature) or social studies (e.g. lifestyles of particular groups of people, current or historical). Although this exploration is done in an elementary school context, particularly for grade 1, Anderson's critical and innovative perspective to worksheets provides insights into how worksheet practice can be revisited at a secondary school level. That, worksheets encourage students' engagement with mathematics and guide them to develop "number sense and problem-solving skills within meaningful contexts" (p.72) as contemporary reform initiatives suggest (e.g. NCTM, 2000).

In a later work, *California Dreaming*, Wilson (2003) writes about math education reform process in the State of California during the last half of the 20th Century and identifies worksheets as

repetitive, a skill-drill tool, which promotes “solitary work” rather than “community activity.” She addresses the dominance of worksheets in the classrooms as a result of oppressive progressivism and criticizes the education system of the United States which, Wilson claims, discourages critical, multilayered and meaningful thinking. She talks about herself in a mathematics classroom as “always giving the teachers the answer [she] knew they wanted, and then sometimes scribbling questions about the validity of alternative solutions in the margins of worksheets” (p. 7). Her exploration is similar to the a tempo analysis of textbooks where the focus is on understanding how teachers use and interpret textbooks; however, it lacks systematic methodology of collecting evidence to support her claims.

Mousley (2003) conducts a study at the grade six level and explores how two mathematics teachers choose to use a particular worksheet (on percentages) in different ways and how their choices impact the interaction and the learning in the classroom. Mousley’s findings indicate that the common use of worksheets may constitute a predominant influence in the classroom and hinders students’ learning in the sense that students are forced to learn in one way and are treated as cohorts rather than individuals with different abilities, interests and needs (Mousley, 2003).

This might lead to the teacher or the text of the worksheet becoming the only source for knowledge (i.e., power) and leaving little room for students to contribute to the creation of knowledge. Moreover, a mathematics worksheet may emphasize the procedural and calculational aspects of mathematics but not conjecturing, relating, testing or describing the nature of mathematics. Thus, worksheets seem to place barriers for teachers’ and their students’ imagination and creation and close a door towards exploration of knowledge by implementing a fixed curriculum (Mousley, 2003). However, Mousley’s claims are based on her two different

classroom observations regarding the use of a single worksheet and could have been strengthened by expanding the data and carry out a more in-depth textual analysis of worksheets.

Literature focusing on mathematics worksheets reveals that worksheets have a big impact on the sociology of the classroom; what teachers teach; and how they interact with students (Mousley, 2003); however, it also reveals that there is a lack of research investigating mathematics worksheets in terms of their textual features and how teachers use them in the classrooms (Kaymakci, 2012). Analyzing textual and contextual features of different sets of worksheets (*a priori* analysis) and their effects on pedagogy (*a tempo* analysis) would enrich this literature and provide further insights into worksheet practice. In addition, comprehensive language analysis of worksheets would give insights into our understanding of how language choices made in worksheets impact classroom activities and presentation of ideas throughout these forms. Having said that, the features of worksheets vary and are different from textbooks and thus worksheet analysis requires us to think through different perspectives to consider both content and pedagogy among other features embedded within worksheets. A holistic text analysis approach where both *a priori* and *a tempo* analyses are merged may suggest possibilities to better understand the nature of worksheets.

From this perspective, Kearsy (1997) suggests genre analysis as a potentially valuable way to understand features of text and the relationships between the participants in a text (Kearsy, 1997), while Gerofsky's (2012) genre analysis method and her preliminary study investigating worksheets as genre brings a holistic approach by conceptualizing the worksheet as a genre. That approach involves asking questions about the presence and nature of these particular generic

forms and explores the question of what worksheets are from many different disciplinary perspectives (Gerofsky, 2012). In the following section, genre analysis and the theory behind it will be reviewed.

2.3 Genre analysis

Genre analysis originated from literary studies and has applications in many areas such as film studies. There are three fundamental approaches to genre studies; systemic functional linguistics (SFL), rhetorical genre studies (RGH), and English for specific purposes (ESP) (Bawarshi & Reiff, 2010, p.57). SFL view is originated from an attempt to promote literacy for those students who struggle with reading and writing the language and draws from linguistic. This view conceptualizes genre as a text type that fulfills a particular function within a communicative interaction. It attempts to understand genres related to social function and context (Bawarshi & Reiff, 2010). The RGS view argues that “a rhetorically sound definition of genre must be centered not on the substance or the form of discourse but on the action it is used to accomplish” (Miller, 1984, p.151). One difference between these two approaches is that the SFL approach looks for “systematic similarities” from a static view while the RGS looks for “family resemblances” from a dynamic understanding. The ESP view approaches genres in terms of their communicative purposes and effects (Swales, 1990). The ESP view has a pedagogical focus and targets “disadvantaged learners” to guide in their professional or academic enculturation (Bawarshi & Reiff, 2010, p.43). While SFL convention “locates genre at the level of context of culture”, the ESP view identifies genre “within more specifically defined contexts (what Swales first termed ‘discourse communities’), where the genres’ communicative purposes are more specified” (p.44). Furthermore, unlike RGS, ESP context has been used to understand text and

communicative purposes and not social action. In the following section, SLF and RGS views will be discussed in detail due to their relevance to this study.

2.3.1 Genre as classification of text based on mutually shared features

The word genre has been adopted from French and means “type”, “kind”, “class” or “category”. Genre studies have been traced back to Aristotle's Poetics where he clustered literature into categories like epic, lyric, or tragedy according to a list of shared criteria. Since then genre has been a common term in many different fields such as literary, folklore, film studies, linguistics and rhetoric within many different considerations (Bawarshi & Reiff, 2010). Swales (1990) explains “...genre is quite easily used to refer to a distinctive category of discourse of any type, spoken or written, with or without literary aspirations...” (p. 33) as we can recognize countless genres within the territory of literary studies, such as comedy, short story, novel; and apart from it such as television genres-news, shows, sitcoms; speech genres- greetings, interviews, sermon; academic writing genres- master's thesis, grant proposal, journal articles; or pedagogical genres- chalk talk, mathematics textbooks or worksheets.

Genre can be considered as “a classificatory category” or as a form with special features (Swales, 1990, p.34). For instance a film may be classified as a comedy or a melodrama or a story may be classified as a fable or a tale based on the different components like their storyline, setting, theme or style. Abbott (2008) mentions describing a specific genre (e.g. hard-boiled detective fiction), in terms of the common features of its elements like “plot or character in a novel” (p.335). Similarly, the focus of classical genre studies in linguistics is on a classification of texts based on shared formal characteristics (Devitt, 2004). Like many genre theorists, Swales (1990) values

classification as “a research tool for categorizing and filing individual texts” that helps us with interpreting and understanding them (p.34); however, he underlines that “at the end of the day, genre analysis is valuable because it is clarificatory, not because it is classificatory” (p.34).

For instance, Systemic Functional Linguistics (SFL), which is also known as The Sydney School focuses on the reoccurring structural and linguistic features of genres that is, as the SFL view argues, connected to social motives within a culture (Martin, 1985). The SFL approach is developed based on Halliday’s (1978) *Language as Social Semiotic* and examines the language structure of a text in relation to its social function and context. In this approach *functional* refers to the purpose for which a language is used while *systemic* refers to the structure of language or “systems of choices” accessible to language users to realize/create meaning (Christie, 1987, p.759 as in Bawarshi & Reiff, 2010, p.30). SFL scholars argue that genres can be the focal point of literacy teaching as genre knowledge helps students gain access to and select more efficiently from the language choices for the realization and the creation of meaning in different texts and specific contexts (Martin, 1985). Hence, it is claimed that by focusing on genres’ textual features and the social functions embodied in them, students learn to employ appropriate linguistic choices regarding to needs, purposes and meanings and “produce texts more effectively and critically” (Bawarshi & Reiff, 2010, p.32).

To reiterate, SFL conceptualizes language as a system where choices are accessible to serve a particular social function. Functions, therefore, have impact on the structure and organisation of language in creation of text achieved via metafunctions. According to Halliday (1978), texts fulfill three broad communicative metafunctions: ideational, interpersonal and textual. The

ideational metafunction is the function of constructing representations of what is being discussed in the text. "Agent," "process," and "goal" are some elements expressing ideational metafunction (Kopple, 1995, 86). In other words, as Bawarshi and Reiff (2010) assert "[i]deational refers to the linguistics representation of action (answer the questions of who is doing what, to whom, when and where)" (p.31). The *interpersonal* metafunction is the function of language to constitute social interactions and expresses the approaches towards what is being said in the text. That is the roles the authors choose in the text and can be found in "clauses" or in "modal verbs". Interpersonal metafunction, Kopple (1985) concurs, gives clues about who is involved in the text (producing it, or interpreting it). The *textual* metafunction, on the other hand, is related to coherence of the text, communicative events and the thematic structure (Bawarshi & Reiff, 2010). Kopple (1985) discusses an example as follows to explain how these metafunctions are analyzed in a text:

In the pair of sentences "My wife and I went hiking yesterday. We discovered a new trail" the 'We' in the second sentence functions ideationally, interpersonally, and textually. It functions ideationally by expressing the agents of the action referred to in the second sentence. It functions interpersonally by being structurally related to the finite element of the verb (in this case, a past-tense marker) in such a way that readers know that within the indicative mood this sentence is declarative (we discover-ed= we did discover) and not interrogative (Did we discover?). And it functions textually by expressing what in this particular context is given information or in-formation derivable from sentence one, thereby helping to link sentence two to sentence one (p.86).

Briefly, proponents of SFL approach genre as a staged, goal oriented, purposeful activity in which language users engage as members of a culture (Bawarshi & Reiff, 2010). This approach

focuses on the structural and linguistic features of genres through conceptualizing language as a system where choices are available to make meaning in order to serve a particular social function that accomplished throughout the text via three metafunctions.

2.3.2 Genre as common set of meanings in culture

Contemporary perspectives on genre address the inadequacy of “[t]he classification and hierarchical taxonomy of genres” because a rigid classification or definition ignores the hybrid nature of genres (a film could be an action-comedy or a dramatic-musical) (Chandler, 1997). As Chandler (1997) proposes “genres overlap” (p.2) and a particular text can fit into various genres in different context or time frames. As Derrida concludes “a text cannot belong to no genre, it cannot be without... a genre. Every text participates in one or several genres, there is no genre-less text” (1981, p.61 as cited in Chandler, 1997, p.6). Therefore, although classification helps us for grouping texts together and realizing the certain conventions in their contents and forms, it may lead to “a failure to understand particular discourses in their own terms” (Swales, 1990, p.42).

Are genres forms with “distinctive” features? “Even so, genre remains a fuzzy concept, a somewhat loose term of art”, Swales notes (1990, p.33). Tudor (2003), from film studies, mentions genre as “a common set of meanings in our culture” rather than as “common themes, certain typical actions, certain characteristic manners” or established collection of criteria (p.4-6) and adds “we feel that we know a western [genre] when we see one, though the edges may be blurred” (p.6). This view identifies genre as a loose set of bases for a category of composition with which we are familiar but of which, maybe, we are not consciously aware. A number of

scholars discuss empiricist dilemma in identifying and defining genre (e.g., Altman, 2003). That is, in order to define characteristics of a genre such as a film genre, one needs to “isolate the body of the films” that identify that specific genre but how can one “isolate this body of work” before defining the characteristics for representing this genre (Tudor, 2003, p.5)? In order to overcome this problematic, Tudor (2003) suggests, “lean[ing] on a common cultural consensus as to what constitutes a [genre] then go on to analyze it in detail” (p. 5).

In a similar way, proponents of Rhetorical Genre Studies (RGS) emphasize the culture and social elements of genre. After Miller’s definition of genre as typified social action associated with recurrent situations (1984), rhetorical genre studies conceptualize genre as generic forms and variations in everyday life. Miller argues that, “a rhetorically sound definition of genre must be centered not on the substance or the form of discourse, but on the action it is used to accomplish” (1984, p.151). Thus, Miller conceptualizes genre knowledge as not only form and content or lists and categories, but as a repetitive social action which embraces “cultural rationality” (Miller, 1984, p. 165). This definition allows us to understand genres beyond the regularities in textual form or substance as a reflection of underlying regularities and social dynamics. In short, since genre knowledge is embedded in the social and cultural situation, by coming to realization of genre and the notion/power of genre, it will be possible to get a better understanding of how people create and react to a particular text/film/ discourse and get affected by a culture or situation.

2.3.3 Generative aspects, addressivity, intentions and chronotopic orientations

Abbott mentions the “hard-boiled detective fiction and its cinematic counterpart, the film noir” as offspring genre of “detective classic fiction”. That connection points to the generative aspects of genres. Miller (1984) says “genres change, evolve and decay” (p.163) and Gerofsky (1996) adds there is a process where new genres arise in response to other generic forms. Likewise, Neale (1980) considers genres as “instances of repetition and difference... [because] repetition demands new. If each text within a genre were, literally, the same, there would simply not be enough difference to generate either meaning or pleasure” (p.48-50). Schryer captures the changing nature of genres in her definition of genres as “stabilized-for-now or stabilized-enough sites of social and ideological action” (1994, p. 108). The examination of “the [generative] process by which new examples of the genre are produced with reference to earlier generic forms” would help us understand the expectations, genre conventions and generic features (Gerofsky, 2012, p.10).

Generative aspect of genre suggests that each text is different than others in some unique way and genres are dynamic in nature. Schryer (2000) concurs that genre are “flexible reoccurring practices” and describes genres as “constellations of regulated, improvisational strategies with chronotopic orientations” (p.450). Chronotope, meaning place, time, values, and culture, helps researchers understand the “social and ideological action” hidden in generic forms. Schryer (2000) theorizes this Bakhtinian term as “the expression of space, time and human values” (p.451) and suggests that the time/space relation embedded in genre mirrors “the current social and cultural beliefs regarding the placement and actions of human individuals in space and time” (p.459). Therefore, examination of chronotope may reveal insights into “positioning of the

genre” in relation to current social and cultural occurrences. For example, Schryer considers a classroom space to explain the conception of chronotope where the activities of a teacher and his/her students were constrained or freed by the physical realities of the defined time/space that they occupy and these different settings affect the power, identity relations, and in return, get affected, too. Thus, the chronotopic orientations of genres address their audience in a particular way and shape their expectations.

Addressivity including intentions of the producers and the uptake of audience has been an important focus point in the genre discussion, particularly, after Bakhtin (1986) argued that every utterance is addressed to someone. Addressivity discusses how the genre addresses its audience and “how this quality shapes features of the genre and audience response it” (Gerofsky, 2012, p.6). According to Artemeva (2008) “[Bakhtin] suggests that the main inherent qualities of an utterance are its addressivity and dialogism; that is, an utterance is always directed toward an interlocutor in response to previous utterances and in anticipation of future ones” (p.163). This view considers dialogism alongside of addressivity. In the discussion of dialogism, intentions (conscious or unconscious) of producers of generic constructions and the uptake of receivers appear as two crucial elements that play important roles to shape the circumstances where genres are raised.

Genre analysis of texts provide insights into various aspects including the structural and linguistic features, chronotopic characteristics, the processes they change or transform and the unique ways they address their audience and lead to a better understanding of texts through multi-perspectival investigations. Genre analysis helps to answer the question of what a form is;

however, it may provide different perspectives to consider what a form is not (Gerofsky, 1996). The next section focuses on this issue.

2.3.4 Genre bending

Although the edges are blurry, as Tudor (2003) identifies, we can think about genre boundaries that are “less central and peripheral elements” (Gerofsky, 2012, p.7). Rhetorical genre scholar Tardy (2012) says articulating the boundaries may make it possible to understand genres better and asserts that departure from the genre convention (genre bending) might bring new perspectives and present itself as innovation.

For example, in *Chinatown* (a well-known genre bending movie), the director, Roman Polanski, “carefully controls his spectrum of hue and tone in order to give it the feel of film noir”.

However, he alters the set of elements of this very well-known film genre, “thereby making us perceive these traditional forms and images in a new way” (Cawelti, 2003, p. 244). Polanski uses golden lights especially for “the scenes that are outside the usual setting or thematic content [like the natural landscape]”. In *Chinatown* the “female antagonist” character seems to have “a neurotic fragility” and never “generates a sense of independence and courage”. Typically, she lies and the detective uncovers the lie but her deep secret regarding her past appears beyond the moral capacity of film noir films. Also, the private detective character is neither “tough” nor “heroic” as in the convention of film noir. Even the name “Gittes” or “Gits” associates “selfishness” and carries “a kind of quality very different from the pure Anglo [detective of film noir]” (p.248). Thus, *Chinatown* deliberately deviates from the basic features of a traditional

genre “in order to bring its audience to see that genre as the embodiment of an inadequate and destructive myth” (p.254).

Likewise, Strike (1984) bends the genre of coloring books. Strike, instead of asking children to color someone else's drawing, provides many creative, different activities in her "Anti-Coloring" book. By involving these distinct ideas, like changing a picture of scissors into an entirely different shape or completing a forest picture by drawing a rare species, Strike pushes the boundaries and suggests new perspectives to the coloring book genre. Strike's genre bending perspective alters the notion of the coloring book genre and attempts to force its audience (i.e., children) away from the action of coloring only giving an opportunity for drawing. As such, departing from genre conventions would be significant for thinking genres otherwise.

2.4 Summary of the chapter

This literature review explored how textbooks are analyzed in terms of their content, pedagogical intentions, textual features including language (a.k.a. *a priori*), and their use by students and teachers (a.k.a. *a tempo*). First, under the *a priori* category, an international large scale study, TIMSS, and an in-depth analysis focusing on the presentation of mathematics in textbooks were reviewed. This was followed by the exploration of the effects of language choices made in text. Second, under the *a tempo* category, a review of studies exploring textbook use in terms of how teachers interact with, draw on, refer to and are influenced by textbooks was presented. There is a gap in literature in terms of studies on worksheets which play an important role for shaping the mathematics classroom culture, and impact student learning. This literature review calls for a more comprehensive approach towards analyzing worksheets due to their complex and different

nature. After identifying this need for a holistic approach towards text analysis, genre analysis and theory were introduced. Genre analysis was identified and explored as a plausible approach to address this need, since this approach offers multiple perspectives to understand the relationships among text, teacher, student and context centered on worksheets. Therefore, it is justified to investigate worksheets in terms of their textual and contextual features to gain a deeper understanding of the nature of worksheets and their use in secondary school classrooms. This literature review provides a foundation for the current study.

Chapter 3: Methodology

Worksheets are dominant parts of mathematics education; are important curriculum materials supplementing textbooks; and impact what teachers teach and how students interact with their teacher and the subject matter (Mousley, 2003). However, there is a lack of research investigating mathematics worksheets in terms of their textual features and how teachers use them in the classrooms (Kaymakci, 2012). Given the intensive use of worksheets in mathematics education, this research attempts to explore worksheets from their textual, contextual and cultural characteristics points of view and fills an important gap.

Textbook literature provides ways to analyze text in terms of textual and contextual features (*a priori* analysis) and pedagogical use (*a tempo* analysis). Dynamic nature and use of worksheets, that are different from traditional textbooks in mathematics education, require a holistic and multiperspectival approach to investigate them. In addition to *a priori* analysis including language analysis (Morgan, 1996) and *a tempo* analysis, genre analysis (Gerofsky, 1996, 1999, 2004, 2012; Kearsley, 1997; Kearsley & Turner, 1999) is suggested as a potentially viable way to analyze texts of schooling to gain a deeper understanding of their nature.

The current study was conducted to investigate the following research questions through genre analysis of worksheets:

1. What are textual and contextual features of mathematics worksheets in secondary education?
2. How do teachers understand and use mathematics worksheets?

To investigate the nature of worksheets (Research Question 1), different forms embedded in the culture were searched to better understand the cultural recognition of worksheets and the process where worksheets arise and change. Samples were collected from research participants and the clusters of textual and contextual features of worksheets were analyzed. In order to explore teachers' understanding and use to create worksheets (Research Question 2), two semi-structured focus group discussions were held (one with four and one with three participants) where participants had the opportunity to interact with each other in the process of generating data. The data were transcribed and analyzed through emerging big ideas. The focus groups coupled with e-mail pre-and post-interviews. Pre-interviews were conducted to acquire demographic data; to gain a better understanding of how participants use worksheets while post- interviews were conducted to clarify some points raised in the focus group discussion. These interviews were conducted through email to provide participants ample time to consider questions.

Overall, there were two aspects of the data collection and analysis: The first part focused on a conceptual analysis of worksheets through genre analysis and the second part focused on an empirical analysis of how mathematical worksheets were perceived and used by teachers. In addition to eight graduate students in the Department of Curriculum and Pedagogy (EDCP) at the University of British Columbia (UBC), a retired teacher was interviewed to gain insights into the practice of worksheet use.

3.1 Participants

This study was conducted between June 2012 and October 2013 at the University of British Columbia with an approved ethics protocol (protocol #: H13-00285) to answer the research

questions. Only those who consented were included in the analysis. Pseudonyms were used in reporting to provide confidentiality. Pascal, Rambo and Anton picked these pseudonyms; however, the researcher assigned pseudonyms randomly to the remaining participants. All names or any other identifying logos of the institutions were removed from worksheets.

The participants were eight graduate students in the Department of Curriculum and Pedagogy (EDCP) at the University of British Columbia (UBC) and a retired teacher (Table 1). The participants (except Malka and Mohna) provided samples from their collection of worksheets and they were interviewed or asked questions in the focus group discussion about their practice of teaching mathematics through the use of worksheets. Malka, who is a retired teacher, didn't attend the focus group discussion nor did she provide worksheet samples; rather she was recruited to gain insights into the history of worksheets and how worksheets have been in use over time. Mohna is an international student and did not have access to her worksheets back home therefore was not able to provide worksheet samples. Due to her being abroad during the time focus groups were held, Serena did not contribute to focus group discussions either.

The main method of recruitment was an announcement made in classes where the researcher is a student. Also, e-mail announcements were sent to the graduate students at UBC in the Faculty of Education and the ones who have mathematics teaching experience at the secondary school level were invited to participate in the study. Also, the participants and the people in the researcher's network were asked to extend the announcement to their networks where the retired teacher, Malka, was connected. All the participants were informed about the nature of the study and all the aspects of their participation that is voluntary and confidential. A brief explanation of the

goals of the project was described. This was followed up with an e-mail invitation including the consent form for those who volunteered to participate.

Three male and seven female teachers within the age range 25-82 participated in the study (see Table 1). All the participants have experience teaching mathematics in secondary schools varying from two to more than ten years, except two participants, Malka and Gina. Malka was a resource teacher teaching at different grade levels and taught mathematics in various grades. Gina started her Master of Education study immediately following her undergraduate degree. During the focus groups, Gina talked primarily about her experience with worksheets as a student, which helped to gain insights into a student's perspective.

Four participants earned their undergraduate degrees from Canada, two from China, one from Belize, one from India, one from the United States of America (US). Together, these nine teachers represented their teaching/learning experience which has taken place in eight different countries and four different continents. This wide range of different experiences and insights enriched the research data and deepened focus group discussions and pre-and post-interviews.

Table 1 Demography of the research participants

Participant	Gender	Undergraduate Degree	Years of Teaching Experience	Grades/ Places participants taught
Malka (Retired teacher)	F	U.S.	24	Various grades as resource teacher/ Canada, U.S.
Mohna	F	India	12	Grade 7-university /India
Serena	F	BC, Canada	10	Grade 7-university/ Canada
Pascal	M	Ontario, Canada	9	Grade 7-12/ Antigua, Ghana, Vietnam, and Korea.
Lizzie	F	China	6	Grade 7-12/ China
Chloe	F	Alberta, Canada	6	Grade 4-11/ Canada
Rambo	M	Ontario, Canada	6	Grade 7-11/UK, Canada
Anton	M	Belize	2	Grade 9-11/Belize
Gina	F	China	-	No experience

3.2 Data collection

The data were collected from online resources (culturally recognizable forms pointing to worksheets such as you tube videos, cartoons, anonymous worksheets themselves) and through

participants of this study (original worksheet samples). In addition, structured pre-and post- one-on-one interviews through e-mail correspondence and two semi-structured, audiotaped focus groups were conducted. Participants are asked for their insights into the worksheets and their practice of using worksheets. Malka's interview was also audiotaped and transcribed. The interview and focus group questions used in this study are provided in Appendix A (See p. 117-120).

3.2.1 Collection of samples including worksheets

Anonymous worksheets from websites and library archives were compiled to guide focus group discussions, and for identifying general formal features of worksheets (Gerofsky, 2012). These anonymous worksheets had diverse formalistic and contextual features as they included drill-practice questions, critical thinking questions and questions with different graphical representations.

Participants, excluding Malka and Mohna, provided 22 original middle- and high- school level worksheets (each provided 2 to 4 samples) containing 295 questions in total. These 22 original worksheets provided by the study participants were analyzed from a genre perspective and also through the linguistic perspective suggested by Morgan (1996) and implemented by Herbel-Eisenmann and Wagner (2007) and Herbel-Eisenmann (2007). The participants were asked to bring sample worksheets representing different categories: the ones that they commonly use in their practice (i.e., central to the genre), and the ones that they think are different in some aspects (i.e., in the peripheral or contrasting with the genre). Each participant (except Malka and Mohna) provided a sample from each category.

3.2.2 Focus group discussion and interviews

The reason for conducting focus groups was to provide participants an opportunity to share and test their ideas through interacting with each other, as Robinson (2012) asserts “unlike individual interviews that dislocate the person from their social context, focus group discussion creates an important space for individuals to interact with each other and so generates data and insights that would not otherwise be accessible to a researcher” (p. 392). In the preparation process, activities were planned for an hour long discussion around the major objective of understanding how teacher perceive and use worksheets in their practice. Pre-interviews were completed and participants’ worksheet samples had been collected. Open-ended questions were developed (Appendix A, p.117-120) and different worksheets were compiled for probing purpose. These choices were discussed with the supervisor, a mathematics educator and reviewed. Three days prior to the focus group discussions participant were reminded to attend. Before the discussions, a round table format was prepared, audio-recorders were checked. During the sessions, first researcher and the participants were introduced themselves, the ground rules were established to increase the participation, the goal of research was mentioned, agenda was reviewed then the questions were posed. After questions were answered, if they were not clear, confirmation was requested. Participants were given fair amount of time to participate and share their experiences, observations and ideas regarding their practice with worksheets. Immediately after sessions, notes were made, observations were written down. Then data were transcribed and were analyzed (see Figure 1 below) as in Krueger & Casey’s (2009) focus group analysis procedure through “big ideas” that emerge from the discussions (p. 16).

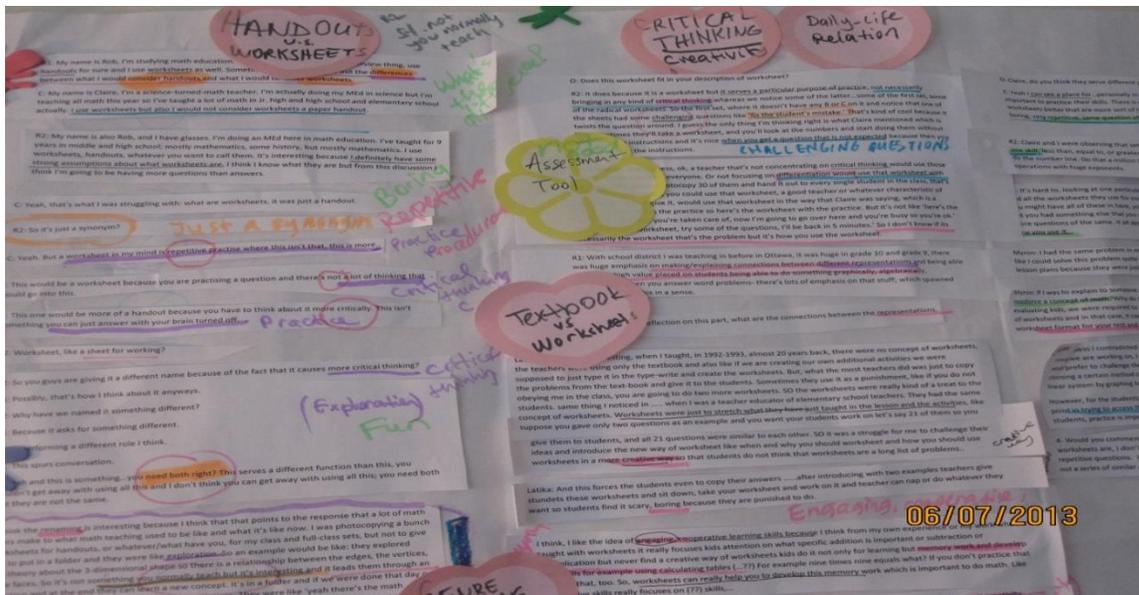


Figure 1 Interviews and focus group discussion data analysis through emerging themes

While focus group discussions were semi-structured, pre-and post-individual interviews were structured. Pre-interviews helped to gather background information about participants, how participants use worksheets; and get them start to think about worksheets and their own practice of using worksheets. Post-interviews attempted to clarify the points raised in the focus group discussions, therefore the questions were generated as follow-up questions. Although pre-interviews were standard for each participant, post-interview questions differed. Pre- and post-interviews with participants were analyzed with focus group data (Kvale & Brinkmann, 2009). Contrary to other interviews, Malka's interview questions were designed to be semi-structured since the aim was to understand the history of worksheet including how worksheets changed in time (Appendix A, p.120).

3.3 Data analysis

In order to address the first research question (what worksheets are in secondary mathematics education), the features of mathematics worksheets were explored using genre, language (section 3.3.1). In order to address the second research question (how teachers perceive and use worksheets), focus group and interview data were analyzed (section 3.3.2). Overall, this study combined genre analysis of a set of worksheets together with teachers' accounts of producing and using these texts and the methodological approach included quantitative and qualitative analysis of research data. To ensure the trustworthiness of the analysis, the interpretation of data was validated by an experienced secondary school teacher through feedback.

3.3.1 Genre analysis

Despite the wealth of genre scholarship over the last thirty years, the term *genre* itself remains fraught with confusion, competing with popular theories of genre as text type and as an artificial system of classification. Part of the confusion has to do with whether genres merely sort and classify the experiences, events, and actions they represent (and are therefore conceived of as labels or containers for meaning), or whether genres reflect, help shape, and even generate what they represent in culturally defined ways (and therefore play a critical role in meaning-making). (Bawarshi & Reiff, 2010, p. 3)

Bawarshi and Reiff's interpretation situates the genre in a contemporary perspective where it has come to be reconceptualized as a "form of cultural knowledge that conceptually frame[s] and mediate[s] how we understand and typically act within various situations" (p. 3). From this viewpoint, it becomes important to identify the existence of a specific genre through clues which

illustrate *cultural recognition* of the form that we believe exist. According to Gerofsky (2012) it is possible to trace the footprints of genres embedded in the forms of popular culture (e.g., cartoons, jokes, ads) through which it become possible to understand the cultural consensus identifying genres. Therefore, as a first step of this research, worksheets were explored if they were culturally recognizable forms and how and in what form they appeared. To do this, a web search is done through Google search engine with the term *mathematics worksheets* to identify websites, you tube videos, jokes and cartoons referring to worksheets.

The second step was to unfold formal and substantive features of worksheets that characterize worksheet genre through identifying patterns in textual data (Gerofsky, 2004). For this purpose, coding categories were created and their surrounding context was analyzed. The coding categories were defined under the themes of content, form, graphics, and linguistic features which align with the categories in the TIMSS framework (Valverde et al., 2002). Also, how worksheets address and shape students activities were considered. Nevertheless, in this study, the aim was not to quantify the formal features, on the contrary, this research drew from the idea that genre is “more than a formal entity” but “a point of connection between intention and effect” (Miller, 1984, p.153). The aim was to understand the “internal dynamic” in the form of the worksheet that shapes the creation of teachers and responses of students (p. 152). At the end of this exercise, loose criteria were established describing “common factors” or in other words, family resemblance of worksheets (Miller, 1984, p. 153). Consideration was also given to analyze worksheet samples that were “central to, peripheral to and contrasting with the genre” (Gerofsky, 2012, p. 9) to better understand the features of worksheets.

In one of her earlier studies Gerofsky's (2004) discussion of 'birds' from Rosch's (1975) work on category theory underlines the importance of this consideration. Penguins, pigeons, ostriches, robins or flamingos are all birds but some birds seem more "birdier" than the others. The Robin could be in the center of the definition of birds for North Americans; however one might claim that for Turkish people it would be the sparrow. This is an unconscious decision as a result of years of cultural exposure through stories, images and songs impacting our conception of a bird. Within the scope of this research, studying samples within the common definition of worksheets and the ones contrasting the status quo led to identify the differences among these three sets and to challenge the common understanding of worksheets.

Considering that genres may change in response to changing exigencies (Miller, 1984) while historical generic forms are intentionality or unintentionally echoed in contemporary forms (Gerofsky, 2004) this study also explored whether the forms or the pedagogical purposes of worksheets have remained steady. As such, the third step was guided by the set of questions: "What is the origin of worksheet genre?", "How did it appear?", "How did it evolve to new forms?", and "What kind of old motives are carried by the genre and impact or subvert the intentions and perceptions of this form?".

As Kvale and Brinkmann (2009) articulate interviews help with getting in-depth information and understanding the reality behind the participants' experience with their own words. As such, an interview conducted with a retired teacher, Malka, and her insights into the history of worksheets were gathered. Interview questions were open-ended and aimed at creating a conversational environment for the interviewee's natural participation (Kvale & Brinkmann, 2009). The

audiotaped interview was transcribed and analyzed for emerging themes. In addition, literature was reviewed to trace the introduction of worksheets in the schooling system through Google Scholar search engine. *The history of worksheets, the ancestry of worksheets, old worksheets* were the terms used for the search.

In summary, first worksheets were identified as culturally recognizable forms, secondly the formal and substantive features of worksheets were identified through genre analysis, thirdly marginal or contrasting worksheet samples were compared to better understand the nature of worksheet genre, and finally history of worksheet genre was attempted through conducting an interview and literature review to identify how worksheet use has changed over time.

3.3.2 Language analysis

Authors make language choices while producing text. These choices might be made unconsciously since the form of genre influences how the authors create the text. On the other hand, the choices made also influence how the readers interpret or react to the text. In other words, how the language is presented and established within the text can affect readers' making sense of it and posit the author, reader and the subject matter in a certain way. Similarly, the language of worksheet may influence the ways in which the teachers create it and the students make sense of it. Moreover, the language constructions within the genre of the text, as Herbel-Eisenmann and Wagner (2007) have suggested, create roles for the learner and determine the position of the learner in relation to the other members of classroom community and in relation to the mathematics activities. This is how Bakhtin considered a genre, where discourse is shaped, addresses its audience in a particular way and formats intentions and expectations. Therefore, in

order to understand the nature of worksheets, the role of language and its analysis should not be underestimated.

In this study, Morgan's (1996) mathematical text analysis method as it is elaborated in literature review chapter (section 2.1.3) was implemented to understand the language features of mathematics worksheets. The aim was to better understand the context where the worksheets were produced and consumed, and the relationships among author, reader and subject matter were constructed. As Morgan (1996) proposed interpersonal function, which focuses social relations, ideational function, which explains the portrayal of agency in the process of mathematisation, and textual function, which centers on the kind of message is given regarding doing mathematics in the whole text, were examined. To understand interpersonal, ideational and textual metafunctions of worksheets, this study traced the use of imperatives, pronouns and modality (Herbel-Eisenmann & Wagner; 2007) and Herbel-Eisenmann (2007) in their examination of mathematics textbooks.

According to Morgan (1996), the examination of personal pronouns not only help us to understand "author's personal involvement with the activity portrayed in the text" but also indicates how the reader is expected to be involved in the activity as well (p.5). Through analysis of the use of imperatives and modality, the relations constructed among author (teacher), readers (students) and subject matter of the text (mathematics) can be perceived because these forms indicate how the reader and the author are addressed "in the responsibility for the construction of the mathematics argument" (p. 6). As Morgan (1996) proposes the absence of first or second

pronouns shadow the human involvement with mathematics and distances both mathematics and the author from the reader.

Rotman's (1988) study claims that imperatives indicate how text involves the students in the process of construction of mathematics depending on the use two different types: "inclusive imperatives" such as explain, consider, compare, predict, prove, etc. invite the students to think; and "exclusive imperatives" which requires "scribbling" through less sophisticated mathematics and have more commanding voice such as write, draw, find and calculate (as in Herbel-Eisenmann, 2007, p. 350). Doing mathematics requires both. As in Herbel-Eisenmann and Wagner (2007) and Herbel-Eisenmann (2007) imperatives were treated as inclusive and exclusive and the relation they address between the counterparts of the community is considered. Herbel-Eisenmann and Wagner (2007) concluded that there should be a balance between scribbling and thinking demands in the text.

According to Herbel-Eisenmann and Wagner (2007), modality reveals the role of actors in relation to mathematics and indicates probability, certainty or uncertainty. In this study, modality was identified in modal auxiliary verbs such as must, can, could, will, etc. and text that may suggest absolute certainty (e.g. must, will) and text that may suggest uncertainty (e.g. might, may) were distinguished per Rowland's (1995) perspective of the use of hedges. Rowland articulates that the use of hedges - the words that may suggest uncertainty - may open for further interpretations and possibilities for students (Rowland, 1995, pp. 328-330).

In short, through the analysis of interpersonal, ideational and textual metafunctions the language

choices made in the worksheets were examined and the following issues were attempted to be addressed: How the social relation between teachers and students is situated and positioned in the worksheets, how mathematics appears in the background of the worksheets and what is assumed as doing mathematics (Morgan, 1996). In the word level analysis, imperatives, pronouns, and modality were inspected (Herbel-Eisenmann & Wagner, 2007; Herbel-Eisenmann, 2007).

3.3.3 Focus groups

In order to explore teachers' intentions, motivations and perceptions of worksheets, focus groups were conducted. These allowed participants with an opportunity to share test and generate ideas through interaction. Audiotaped and transcribed focus group data are analyzed as in Krueger & Casey 's (2009) focus group analysis procedure suggested where the researcher "needs to consider many different aspects of the focus group and its participants' responses, including words the participants use in the discussion, context, internal consistency of the participants' views, frequency of comments, degree of agreement on a topic, intensity of feeling toward a topic, specificity of responses, and "big ideas" that emerge from the discussion" (p.16).

Emerging themes were grouped under categories such as features of worksheets, the way teachers use worksheets, how they criticize worksheets and how they imagine different possibilities. The comments of participants were compiled under these categories to demonstrate specific examples. Excerpts were referred to in the results section, as relevant. Before and after focus group discussions, participants were individually interviewed. During these interviews and focus group discussions, the aim was to gain insights about teachers' intentions of creating worksheets.

In short, grounded in genre theory, this research was adapted from Gerofsky's (1999,2004, 2012) pedagogical genre analysis method and blended it with Morgan's (1996) language analysis and methods to look for patterns of features constituting worksheet genre and was informed by teachers' insights (Krueger & Casey, 2009).

3.4 Limitations

The participants of this study were graduate students in EDCP who are being exposed to new educational ideas. This may present itself as a limitation since they may be biased towards use of worksheets compared to general teacher population. Having said that, the study focused on participants' prior experience rather than their current experience that may have eliminated this potential bias. It would be interesting to run the same analysis focusing on a given grade level and/or a topic to gain further insights. In the process of language analysis I could not use word processor because some worksheets were in different formats. Therefore, I counted words manually, which may have led to some minor errors due to language analysis made through this information. Another limitation was language; some of the worksheets were not in languages spoken by the researcher. One of the research participants, Gina, assisted in the translation of these worksheets. Finally, due to the limited literature on this evolving research field, working with a theory (i.e. genre theory) was not trivial and required careful thought and creativity in the analysis.

3.5 Summary of the chapter

In this chapter, the research procedures including recruitment of participants, data collection, data analysis, confidentiality issues and limitations were presented.

The investigation throughout this research focused on two core questions:

1. What are textual and contextual features of mathematics worksheets in secondary education?
2. How do teachers understand and use mathematics worksheets?

To answer the first research question exploring the characteristics of worksheets, different forms embedded in the culture were searched on the web and how worksheets embedded in these forms were analyzed. In addition, original worksheet samples that were collected from research participants were analyzed to constitute the constellation of features of worksheets through the genre analysis (Gerofsky, 1999, 2004, 2012) and language analysis (Morgan, 1996).

In order to answer the second research question dealing with teachers' perceptions and motivations to create worksheets and the ways teachers use worksheets, participants were invited to focus group discussions. Two semi-structured focus group discussions were held (one with four and one with three participants). In the following chapter, the results will be reported.

Chapter 4: Results

In this chapter, the study findings that were based on the genre and language analyses of worksheets and the focus group and pre-and post-interview analyses will be presented. The former set of analyses attempts to provide insights into clusters of features that constitute worksheets. The latter set attempts to reveal teachers' intentions and motivations of using worksheets.

The findings of each analysis are presented in separate sections where the answers to the research questions were explored. The core research questions were:

1. 1. What are textual and contextual features of mathematics worksheets in secondary education?
2. How do teachers understand and use mathematics worksheets?

4.1 Genre analysis findings

4.1.1 Evidence of existence

A search of a word phrase “mathematics worksheets” in Google search engine revealed 4,410,000 documents (Retrieved on May 14, 2013 at 11:34pm). When "worksheet" and "mathematics" were typed separately 5,030,000 documents appeared (Retrieved on August 11, 2013 at 8:11am). Google search for Turkish mathematics worksheets which is done with the term “matematik calisma kagitlari” revealed 445,000 documents (Retrieved on September 14, 2013 at 11:58pm) and German mathematics worksheet search with the terms “mathematic arbeitsblatt” revealed 823,000 documents (Retrieved on September 14, 2013 at 11:58pm) while Chinese mathematics worksheet search with the term “数学随堂小试卷” revealed 2,110,000

documents. There are numerous printable worksheets for mathematics, along with other subject areas that are available for free (e.g. www.ixl.com, www.math-drills.com). If one chooses to pay, then there is an option to modify worksheets for his/her own class. There are also worksheet generator websites that provide opportunity for creating one's own worksheets in many different formats (e.g. <http://www.tefl.net/worksheet-generator/>, <http://www.schoolhousetech.com/Math/>) such as matching worksheets, scrambled words worksheets and sorting worksheets. Among the mathematics worksheets the most common form is traditional rows of similar calculation or rows of problems worksheets. There are also rows of geometry questions worksheets where, for example, students are required to find the third angle of a triangle. There are also different forms; for instance, riddle worksheets where students are asked to make the calculations and write the right answers in required boxes which tell a riddle.

There are also many YouTube videos related to mathematics worksheets. The YouTube video search done with the term *mathematics worksheets* revealed 3900 videos (Retrieved on October 11, 2013 at 8:11am). In the majority of these videos there are lectures where a teacher is filmed while solving a particular worksheet. While these lesson videos usually target students, there are others that target teachers. For instance, in some of the videos there are tutorials for teachers to use different worksheet generator programs. There are also some commercial videos to promote a particular worksheet generator website. For example, a video made by a website proposes printable worksheets and videos showing a teacher solving the worksheets alongside ("Your Teacher", n.p.).

The YouTube search also revealed videos filmed for educational or/and research purposes including perceptions of worksheets. One example is a pre-service students' project video: In this video teacher candidates interview anonymous people and ask them what their least favorite subject was when they were in school (Zhang, 2012). One interviewee mentions about how mechanical use of worksheets without supportive explanations did not help in learning mathematics.

Another example for educational research YouTube videos is originally from The *Research Ideas* website critiquing compartmentalization of math curriculum and worksheets as being tools to pursue this view (Gadanidis, 2013). The main idea of this video is mentioned as looking for alternative ways to provide students a better mathematical experience rather than having them solve simple, unrelated problems like the ones some worksheets have. In the video, two scripts play consecutively. The video on the left side draws from a mathematics class dominated by the use of worksheets, while the video on the right side focuses on a mathematics class where students are encouraged to explore patterns and to use multiple representations. The video on the left side shows a student bringing home a series of worksheets as homework and she mentions about how hard mathematics is. In the parents advisory meeting the teacher mentions about this student's disinterest and offers more worksheets for her to improve her skills. On the right side, to the contrary, a teacher gives the student a chance to explore mathematics ideas through multiple representations and in this parents' advisory meeting the teacher's comments were totally different than the first scenario and she mentions how this student is paying attention to mathematics class .

In addition to videos, there are cartoons about worksheets. One example is found on the Teacher Planet website (“Teacher Planet”, n.p.). Teacher Planet website provides a wide range of teaching materials that include lesson plans, rubrics, and worksheets, cartoons and quotes. The cartoons are available under the theme of “humor” for teachers to read and possibly share with students.

Overall, then, the accumulation of these mini examples of worksheets provides ample evidence that indeed the worksheet is a culturally recognizable form.

4.1.2 Family resemblance of worksheets

In this study, the original worksheets collected from participants were closely examined and family resemblances were identified for characterization of worksheet genre. These were considered under the themes of content and formalistic features, physical features and linguistic features. These features were traced in the data worksheets back and forth. These elements were regular across the worksheet data and were identified as common factors that constitute the essence of worksheets as culturally-recognizable forms (e.g. Figure 2).

Grade 9 Math	Name _____	ID: 6
Multiplying Rationals	Date _____	Period _____
Find each product.		
1) $\left(-3\frac{1}{2}\right)\left(\frac{5}{3}\right)$	2) $\left(-\frac{1}{2}\right)\left(-\frac{11}{6}\right)$	
3) $\left(\frac{1}{7}\right)\left(-\frac{1}{6}\right)$	4) $\left(-\frac{5}{6}\right)\left(-\frac{5}{6}\right)$	
5) $\left(-2\frac{1}{4}\right)\left(-\frac{6}{7}\right)$	6) $\left(-\frac{2}{5}\right)\left(-\frac{3}{2}\right)$	

Figure 2 Rambo's worksheet sample (courtesy of Rambo)

An examination of all worksheets revealed common characteristics as follows:

1. Form

- a. A page full of a series of mathematics questions.
- b. Being organized into columns and rows.
- c. Having a title (including usually the topic, sometimes grade level and rarely the name of the institute).
- d. Including different forms like puzzles, games or riddles but presenting questions more than providing information.
- e. One type fits all without any variation (no different worksheets for individual students)
- f. Requiring completion.

2. Content

- a. Having the questions that the teacher sets up/chooses.
- b. Having answers that the teacher already knows.

- c. Requiring students to solve all the questions.
- d. Asking more than telling.
- e. Starting with easiest question and ending with more difficult ones.
- f. Dealing with one particular topic.
- g. Emphasizing certain skills.
- h. Having a selection of questions that are commonly in use.

3. Graphics

- a. No or few graphics.
- b. Visual displays with few words.
- c. No or little use of different representations together such as graphs, numbers and illustration.

4. Linguistic

- a. Use of simple symbolic statements.
- b. Use of imperatives such as find, calculate, divide etc.
- c. Use of sentence phrases such as fill in the blanks, solve the following equation etc.

5. How worksheets address teachers and students and shape students' actions?

- a. Teachers set the worksheets.
- b. Teachers ask the questions.
- c. Teachers know the answers.
- d. Students are supposed to solve the questions.
- e. Students are required to complete the whole worksheet.
- f. Each student is supposed to have his/her own copy of worksheet and solve it individually.
- g. The actions of students are linear and monotonous as they repeat the same task that is getting the pen and paper and start solving worksheet problems until the worksheet is completed.

4.1.3 Comparison of central to, peripheral to and contrasting with the genre

The original worksheets collected from participants within the common definition of worksheets, along with the ones on the boundaries and the ones contrasting the status quo were compared.

Participants self-identified their own worksheets as marginal or not. Through comparison, the differences among the three sets of worksheets were identified. For example, in the figures below (Figure 3, Figure 4, Figure 5), Pascal and Chloe's worksheet samples are presented as central to, peripheral to and contrasting with the genre. In Chloe's samples, the one on the left is central to genre, providing practice questions for fluency and accuracy, as Chloe stated. The one on the right is peripheral, focusing on skill practice but is asking for different activities such as sketching, using number line or reasoning. In Pascal's samples, the one above is central to genre as it focuses on skill practice with repetitive questions and the one in the middle is peripheral to genre since it requires pattern recognition while the one below is contrasting with the genre as it is personalized in the sense that everyone doing the worksheet is required to use his/her birthday year and thus in a way acts as a co-producer of the question. Moreover, this worksheet is more open-ended as it gives chance to everyone to use different strategies.

<p>(Chloe-CENTRAL TO)</p> <p>Simplifying Radicals</p> <p>1. Write each radical in simplest form, if possible.</p> <p>a) $\sqrt{8}$ b) $\sqrt{12}$ c) $\sqrt{32}$ d) $\sqrt{18}$ e) $\sqrt{48}$</p> <p>2. Express each entire radical as an equivalent mixed radical.</p> <p>a) $\sqrt{180}$ b) $\sqrt{108}$ c) $\sqrt[3]{750}$ d) $\sqrt[3]{81}$</p> <p>3. Write each mixed radical as an entire radical.</p> <p>a) $5\sqrt{2}$ b) $6\sqrt{3}$ c) $4\sqrt{6}$ d) $2\sqrt[3]{3}$ f) $4\sqrt[3]{2}$ g) $5\sqrt[3]{2}$ h) $2\sqrt[3]{3}$ i) $3\sqrt[3]{2}$ j) $4\sqrt[3]{4}$</p> <p>4. Express each mixed radical as an equivalent entire radical.</p> <p>a) $4\sqrt{5}$ b) $3\sqrt{4}$</p>	<p>(Chloe-PERIPHERAL TO)</p> <p>Classifying Numbers Worksheet</p> <p>4. Sketch a number line for each irrational number and label its approximate location. Explain your reasoning.</p> <p>a) $\sqrt{5}$ b) $\sqrt[3]{12}$ c) $\sqrt[4]{25}$ d) $\sqrt[3]{-12}$</p> <p>5. Use a number line to order these numbers from least to greatest. Identify which numbers are irrational and which are rational.</p> <p>$\frac{-14}{5}, \frac{123}{99}, -2, \sqrt[3]{-10}, \sqrt{4}$</p> <p>6. Which of the following statements are true? For a statement that is false, provide examples to explain why you believe it to be so.</p> <ul style="list-style-type: none"> • All natural numbers are integers. • All integers are rational numbers. • All whole numbers are natural numbers. • All irrational numbers are roots.
--	---

Figure 3 Chloe’s central to and peripheral to worksheet samples (courtesy of Chloe)

Overall, then, the worksheet samples demonstrated different forms, content, graphical and linguistics features among the category of central to, peripheral to and contrasting with categories. In the marginal forms, more variety in content and graphic features is observed. While the marginal ones included more pattern recognition, reasoning, critical thinking questions, the worksheet samples central to genre were dominated by plug-and-chug questions (e.g. Rambo, Chloe, and Pascal’s worksheet samples-Figures 2, 3, 4, & 5). In other words, the

former ones included more open-ended questions rather than straight-forward and mechanical questions. Although not apparent in the examples, Figures 2-5, it is important to note that in the marginal worksheets there were more daily life referrals. In addition, there were more use of graphics and more complex language structures were used.

(Pascal-CENTRAL TO)

Calculate

<p>1. $\frac{9}{20} + \frac{8}{20} =$</p>	<p>2. $\frac{4}{5} - \frac{11}{30} =$</p>
<p>3. $\frac{2}{3} + \frac{1}{4} =$</p>	<p>4. $\frac{3}{7} - \frac{2}{5} =$</p>

(Pascal-PERIPHERAL TO)

Can you decipher this number system?

A)

	+		=	
---	---	---	---	--

B)

	+		=	
---	---	---	---	--

Figure 4 Excerpts from Pascal's central to and peripheral to worksheet sample (courtesy of Pascal)

(Pascal-CONTRARY WITH)

Birth Year Puzzle

Year =

Name =

0 =	25 =	50 =	75 =
1 =	26 =	51 =	76 =
2 =	27 =	52 =	77 =
3 =	28 =	53 =	78 =
4 =	29 =	54 =	79 =
5 =	30 =	55 =	80 =
6 =	31 =	56 =	81 =
7 =	32 =	57 =	82 =
8 =	33 =	58 =	83 =
9 =	34 =	59 =	84 =
10 =	35 =	60 =	85 =
11 =	36 =	61 =	86 =
12 =	37 =	62 =	87 =
13 =	38 =	63 =	88 =
14 =	39 =	64 =	89 =
15 =	40 =	65 =	90 =
16 =	41 =	66 =	91 =
17 =	42 =	67 =	92 =
18 =	43 =	68 =	93 =
19 =	44 =	69 =	94 =
20 =	45 =	70 =	95 =
21 =	46 =	71 =	96 =
22 =	47 =	72 =	97 =
23 =	48 =	73 =	98 =
24 =	49 =	74 =	99 =

100 =

Figure 5 Excerpts from Pascal's contrary with worksheet sample (courtesy of Pascal)

4.1.4 History of worksheets

For this inquiry, insights into the history of worksheets were gathered through an interview with one participant. Malka is a retired teacher, from Hamilton, Ontario, who taught from 1952 to 1954, took a break to raise her children for twenty-two years, and then went back to teaching from 1976 to 1995. She was involved in the education system for almost a half a century as an elementary school teacher, as a resource teacher and as a parent of three children. In her interview she talked about her experience with worksheets during these 43 years of school

involvement. Mainly she drew from her work with students with special needs as a resource teacher in her reading and writing classrooms; however, her insights shed light into our understanding of mathematics worksheets and their history.

Malka identified worksheets as “a supplementary type of thing” and she cautioned about handing out worksheets and leaving students all alone. Rather she valued teachers’ involvement in the process of solving worksheets and helping the students ‘individually’. She said,

Worksheets would [not] be the be-all, end-all; they would just be one tool of many. It was very important to get the kids to use the material that they learned, that was another avenue of learning. You can’t just listen, you have to participate, you have to use it, and a worksheet might be one tool, writing might be another tool, getting together in a group and answering questions and discussing would be another. Another way would be to, perhaps, use art as a tool to interpret what it was you were learning. I could go on and on and on. So worksheets were not the be-all, end-all of teaching; they shouldn’t be.

Malka was also cautious about using worksheets all the time for everyone. While she mentioned that she was photocopying “a whole set” of worksheets for the class, she mentioned that if any of the students needed a different worksheet then she would make them. She also mentioned worksheets as formative assessment tools as “they were useful, the children had to use what they were taught and that had to be translated to solving problems on paper. They were one of many tools but it was a good work tool [...] helped me see whether the child understood what was taught”.

Another thought was revolved around her comments on ditto machines and mimeographs. Malka talked about her experience with “copying technologies” associated with worksheets from the 1930s to 1990s. She recalled herself copying the questions from the blackboard as a student in the 1930 and 1940s, then using ditto and mimeograph machines in the 1950s and 1960s and photocopies in the remainder of teaching practice from the 1970s to 1990s and coupling photocopy machines with computers after the 1980s.

Through Malka’s experience, one might wonder whether the use of worksheets first started in language classes to address students’ individual needs such as reinforcing a particular skill and then became widespread in other subjects such as mathematics. Malka mentioned this: "when I was working individually with a child in improving his reading ability, then the practice worksheets using some of the vocabulary ... helped me see whether the child understood what was taught". It is curious to know that while worksheets were created and used for addressing one or a few students’ necessities at the beginning, when the copying technology became available and easily accessible, particularly after sixties, teachers started making “a whole set” for the class and then worksheets become ubiquitous in mathematics classroom. However, there is no history of mathematics that traces the introduction of worksheets within our knowledge.

In the interview, Malka brought up worksheets a couple of times as tools to reinforce learning through practice skills and told about one of her students who was from Hungary, waiting to be registered in an ESL class and who “had a fundamental knowledge”. She commented “worksheets were helpful for him because I could give him worksheets or a workbook in that area and he could work through when he wasn’t with me and then bring it in and we could check

it over and so on. In that case, the repetition was good for him”. However, she said another student was in need of working with “story boards, pictures, all hands-on things because she learned better that way”. Thus, she was careful about not using worksheets with everyone in the same way. She valued diverse teaching tools and methods in mathematics. She said “for math we try to use as many concrete examples as much as possible. When children learn, they have to learn how to focus and listen but they have to be able to use what they learned. Even at a very early age, [...] they learn higher mathematical skills with objects and later they translate it into the numbers and so on”.

She concluded that, “worksheets have a place, but first you have to have a really good teacher; a teacher who understands how to teach, but understands and is interested in the child, empathetic to the child, and understands what the problem is to go about solving it. That’s why I enjoyed teaching because it was always a challenge and I had all kinds of challenging situations”.

Malka’s perspective then invites us to think about our practices of using worksheets. One might feel that worksheets are becoming boring and teaching through worksheets is becoming ineffective because many teachers may fail to realize that worksheets were originally intended to use for a particular reason for a particular person, rather than used all the time for everyone. Educators’ good intentions for the use of worksheets may be subverted by the changing technology as it became available. If this is the case, it gives us reason to consider, how the development of a paperless office machines-digital copier machines (Bodenheimer & Grumbach, 2003) will affect the use of worksheets and also the teaching and learning of mathematics. There is a need for further research in this area.

A literature review of the history of worksheets revealed the oldest article using the term worksheet as *Individual Work in Plane Geometry* by Zant (1930). Zant used the term worksheet as a sheet of paper where he assigned textbook questions for students. Another scholar, Horst (1936) used the term worksheet for the sheet where he had written his work within a table including rows and columns. Interestingly, the publications mentioning worksheets were on a rise in the 1960's when ditto machines became very common in school life and the photocopier started to enter schools, making copying even easier. In 1963, Potamkin used the term worksheet for the same purpose as Zant, that is to assign homework questions from the textbook. However, she also used this term when she needed to prepare a paper assignment for students regarding a topic which was not included in the textbook, which corresponds to a current meaning of worksheets. In her later practice, Potamkin used worksheets to encourage personalized learning.

Worksheets have more than a century-long history and their increasing use started with the presence of duplicator machines in the schooling system (Dunn, 2012). The copying technology has been available since 1800's; however, stencil duplicating machine or mimeograph machine technology became available in schools in the 1900's. Until photocopying machines became available, mimeographs have been commonly used for almost forty years until the 1970's (Dunn, 2012).

There are other articles, from the sixties which mention worksheets. For example Burns (1964) uses the term worksheet as a sheet where he asked fill in the blanks questions to teach the Mayan number system. In 1967, Roberts and Bloom (1967) published a paper which addressed worksheets and workbooks as efficient "formal" teaching tools and mentioned a teaching

development program at kindergarten level focusing on the use of teaching materials like worksheets and workbooks. From this literature review Potamkin's emphasis on individual's necessities through differentiating teaching associates to Malka's experience. It is curious how the technology used (ditto machines-spirit duplicator technology became common in schools) affected use of worksheets in mathematics classrooms.

4.2 Language analysis findings

The language of worksheets may influence the ways in which the teachers create them and the students make sense of them, which, in turn affects teaching and learning of mathematics (Morgan, 1996). Therefore, in this phase of analysis, the language used in the worksheets was considered. Word, sentence, and question selections were counted. Their functions were also interpreted (Morgan, 1996) and discussed in the last chapter. These language constructions within the genre of the text create roles for the learner and determine the position of the learner in relation to the other members of classroom community and in relation to the mathematics activities (Herbel-Eisenmann & Wagner, 2005). In this sense, interpersonal, ideational, and textual metafunctions were studied in order to understand the formatting power of language encapsulated in worksheet genre (Morgan, 1996) through the analysis of imperatives, pronouns, and modality (Herbel-Eisenmann, 2007). Table 3, presented in Appendix B, summarizes the frequency of pronouns, imperatives, modality and questions across the worksheet data.

4.2.1 Imperatives

The most frequently occurring linguistic form in the full data set studied was imperatives (i.e. see Figure 6). Taking into consideration Rotman's (1988) study, inclusive and exclusive imperatives

were examined separately (as in Table 3, Appendix B, p. 121-127). There were 139 imperative embedded forms observed in 22 original worksheets and in 295 questions provided by participants. There were 17 inclusive and 121 exclusive imperatives, indicating that the exclusive imperatives were used seven times more as compared to inclusive imperatives within the common and uncommon categories (See Table 2).

Table 2 Inclusive and exclusive imperatives in the worksheet samples

Inclusive Imperatives		Exclusive Imperatives	
TOTAL: 17		TOTAL: 121	
Common (# of times)	Uncommon (# of times)	Common (# of times)	Uncommon (# of times)
“Show” (3)	“Perform” (1)	“Find” (15)	“Draw”(3)
“Develop a strategy”(3)	“Decipher”(1)	“Calculate” (14)	“Divide”(3)
“Explain”(2)	“Make a conjecture”(1);	“Write/ down”(9)	“(Re)-Evaluate” (3)
“Describe”(2)	“Investigate”(1)	“Express”(8)	“Use” (2)
	“Model”(1);	“Determine”(8)	“Give answer”(1)
	“Create”(1)	“Solve” (7)	“Read”(2)
	“Apply”(1)	“Graph”(6)	“Look”(1)
		“Answer” (6)	“Tell”(1)
		“Simplify” (5)	“Complete”(2)
		“Fill” (5)	“Classify”(2);
		“Reduce” (5)	“Sketch”(2);
		“Get the answer” (4)	“Name” (1)
		“Record”(4)	“Order”(1)“
			“Check”(1)

先化简，再求值，已知 $a = 1$, $b = -\frac{1}{3}$ ，求多项式 $(a^3 - 2b^3) + 2\left(ab^2 - \frac{1}{2}a^2b\right) - 2(ab^2 - b^3)$ 的值

First (simplify this polynomial expression, if $a = 1$, $b = -\frac{1}{3}$, what is the answer?)

化简 (求值) $2(x^2y + xy^2) - 2(x^2y - x) - 2xy^2 - 2y$ 的值，其中 $x = -2$, $y = 2$

First (simplify this expression, if $x = -2$, $y = 2$, what is the answer?)

解方程 (solve) the equation: $4 - 3(2 - x) = 5x$

解方程 (solve) the equation: $\frac{2x - 1}{3} = \frac{x + 2}{2} + 1$

Figure 6 An example of imperative examination based on an excerpt from Gina's worksheet sample

(Courtesy of Gina) (Translation is made by the participant herself)

4.2.2 Pronouns

In the 22 original worksheets, a small number of pronoun usages were found (i.e. see Figure 7). Overall among the 25 pronouns, only two of them were first person plural pronouns (we), 17 of them were second person pronouns, and 8 of them were third person pronouns. There were no first person singular pronoun usages at all. All the third person pronouns were used in a specific word problem worksheet where, interestingly, there were no questions including first or second person pronouns.

modal verbs having strong certainty were more than the hedged words, for example, “can” occurred eleven times, while “may” occurred only twice.

According to Herbel-Eisenmann and Wagner (2005) “would, can and will” demonstrate “stronger conviction” whereas may, could and should express “weaker conviction”. The weaker modality shows less certainty. As Rowland (1995) argues being in the state of uncertainty may open space for students’ awareness, discussion, interpretation and contribution.

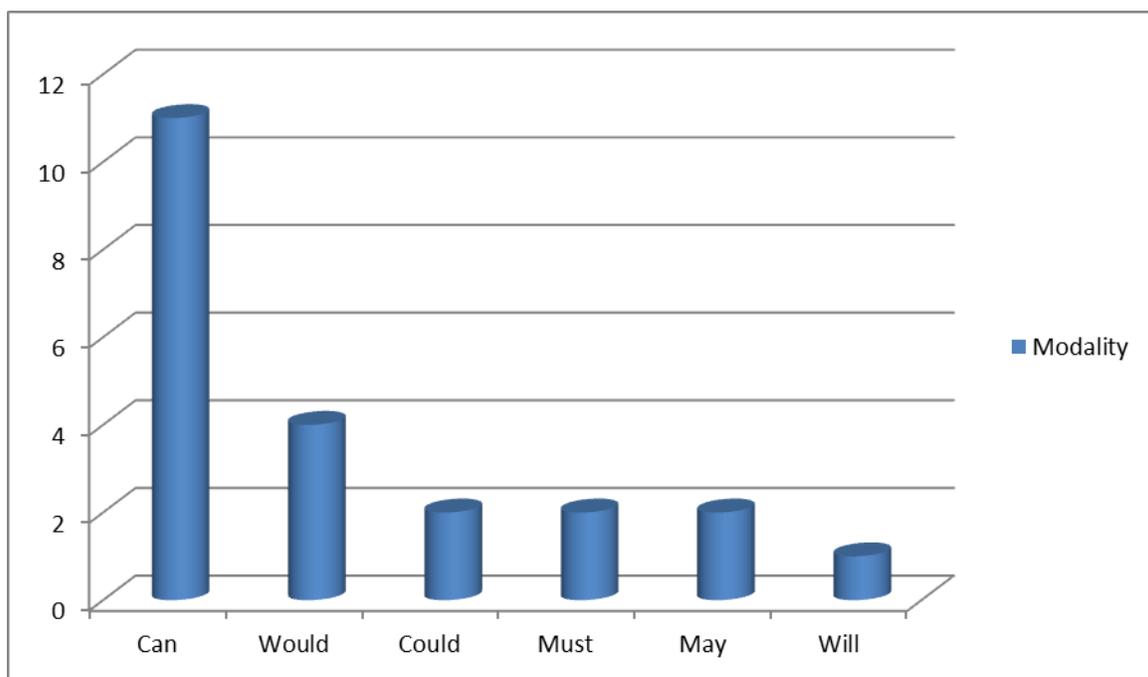


Figure 8 Frequency of modality

4.3 Teachers' understanding and use of worksheets

During focus group discussions and pre-and post-interviews, participants shared their ideas on the ways they perceive worksheets and how they use them. The findings were grouped and reported under emerging themes.

4.3.1 How teachers describe worksheets

4.3.1.1 Difference between worksheets and handouts

From the very beginning of the first group discussion, hand-outs and worksheets were in the center of the conversations. First, Rambo made the observation, “I use handouts for sure and I use worksheets as well. Sometimes it is hard to figure out the differences between what I would consider handouts and what I would consider worksheets”. Throughout the discussions, handouts were elaborated many times and the features of worksheets were clarified by examining handouts that most of the participants would not consider as worksheets. According to Rambo, handouts play a totally different role in mathematics classrooms therefore they must not be considered as worksheets. Chloe supported this idea and she said although she believes “there is a place for worksheets” in the mathematics classrooms, she preferred like to use handouts which are totally different constructions of activities. She also mentioned that her teaching or student interactions with worksheets and handouts are totally different because, Chloe said, worksheets have more repetitive questions and did not emphasize critical thinking. While addressing a “handout”, she commented as “this isn’t something you can just answer with your brain turned off” and considered worksheets as “pages with math practicing questions [where] there is not a lot of thinking would go into”. Mohna also agreed, “...worksheets are making things look boring because teachers don’t use them as a tool for critical thinking or conceptual understanding but they should be. Mostly they use for skill practice. Generally what you have already learned...” and Anton added, “practice, practice, practice...”.

Rambo defined worksheets as “a series of questions” with “single right answers” and he highlighted the “repetition” aspects of worksheets for letting students not “forget” mathematical

concepts. Mohna, Anton, Gina and Lizzy associated worksheets with acquiring fluency and accuracy and many of the participants differentiated handouts from worksheets in terms of handouts facilitating conceptual understanding, and enhancing different skills like reasoning, critical thinking and active learning.

4.3.1.2 Procedural versus computational/conceptual understanding versus skill competency

At one point, Rambo addressed a particular sheet as a worksheet because he pointed a worksheet and said “This one is very procedural; I consider worksheets to be concerned with procedures and repetition”. And he identified worksheets focusing on fluency or calculation speed rather than understanding.

Participants mentioned how they value the teaching process i.e. “doing” mathematics over the product i.e. “finding an answer”, and enforcing conceptual understanding in addition to skill competency. They also mentioned that they found worksheets inadequate since worksheets only reinforce one kind of skill development through repetitive, drill type questions and lack challenging questions which would prompt critical thinking. Although they did emphasize that worksheets are needed in their classrooms from time to time; research participants were cautious about their use of worksheets. All of them were against teaching mathematics in a linear way with the only focus on its calculational aspect.

4.3.2 How teachers use worksheets

The ways the participant teachers use worksheets varied; however, they illustrated some similarities as well. For example; Chloe said

Sometimes I use a worksheet for an exploration on a new topic, but more commonly for practice after we have gone through notes and examples as a class. Some of the classes I teach do not have textbooks (lack of school funding) so worksheets are used all the time. I think this is less beneficial to the students because they do not have the same explanations that the textbook provides them, but do not have a choice in this case. Sometimes they are used to cover topics that the textbook does not cover so I do not see them as being limiting, but it would depend on how they are being used.

She also commented “sometimes I think they are used as fillers when there is extra time”. Pascal considered this as a “break from teaching”. On the other hand, Lizzy revealed her use of worksheets as test preparation while Anton said he uses worksheets for homework and practice exercises that would help with sharpening students’ memory. Anton also acknowledged that worksheets are efficient for assessing students understanding of basic concepts but not necessarily in depth understanding unless students are asked to elaborate on their answers.

Rambo revealed that he rarely uses worksheets for drill but often constructs what he calls hand-outs that structure the activities he aims students to do, or sequences questions in a way that he thinks will help students construct their own understanding. Serena said she uses worksheets as a main tool to help students developing self-study habit, and thus the textbook becomes a complimentary material to her teaching. According to Serena worksheets helps students to test

their knowledge and provides them the opportunity of working at their pace. Serena also acknowledged that she would give worksheets that involve math drill only near the end of teaching a new math concept such as integer addition, subtraction, where she thinks math drill might be beneficial. Pascal's way of using worksheets included the practices mentioned by the other participants as he mentioned that sometimes worksheets provide scaffolding for students if they are reviewing a topic or worksheets lead students on an investigation, or sometimes worksheets are for students to work on with others and elicit discussion. Pascal said "worksheets in my class mainly free me up to circulate around the class and help students while they do the work" and also he added worksheets could be used for assigning a class a good problem, or for setting of stations or a long-term project.

Mohna, on the other hand, said "I used them to encourage group learning through guided practice and ensure individual mastery during closure and follow up". Mohna also added that worksheets can be used as either formative evaluations or summative evaluation and she commented that: "It's the technique of creating and using the worksheet that ensure their successful use not the worksheet itself because it is just a tool for learning". Therefore, for Mohna, it is the way teachers use the worksheets that makes a difference. Mohna concluded that "It is important that worksheets should be created and utilized as formative evaluations and also for encouraging hands-on, minds-on learning not just as copied text-based list of problems that are used as summative evaluations, which is often done by many teachers".

4.3.3 How teachers critique worksheets: Drill and kill, group work versus individual study

Many times, participants mentioned that they found worksheets boring by being repetitive and focusing on drill practice. Rambo described this as “drill and kill exercises”, which limit creativity and destroy cooperative learning but enhance individual study and “memory work”, as Anton says. Mohna asserted, “Why don’t you give a worksheet to a student to challenge them? Or students can create their own worksheet ... and they work in peer groups and solve their own problems”. Lizzie considered worksheets’ as hindering creativity in favour of teachers’ activities. Since most of the time, worksheets behave like a lesson plan for teachers to cover, teachers cannot think out of this pre-arranged agenda/ the form where repetitive practice was requested.

Anton stressed that “sometimes worksheets forces them to focus on getting the answer the quickest way possible sometimes at the expense of in-depth understanding”. In her interview Serena also criticized that worksheets with close-ended questions would not help teachers to learn about their students’ understanding because they would not provide the possibility for asking students to explain their understandings. Pascal added “a typo in a worksheet may cause serious problems. Sometimes even when you’re standing next to a student and clarifying things for them, they still persist that there is a problem since there is a problem with the worksheet”. Thus, the students still consider a worksheet as being more authentic because they are printed text.

Another, underlining fact that came up was that even though students might find worksheets boring and creativity killers, time-to-time they might prefer it. Rambo mentioned how sometimes

he pushed his students to work together as a group on a more challenging question; however, some students reacted negatively to them and did not want to participate in these kinds of activities. Chloe's critique of asking "question after question" in mathematics classrooms and having students overwhelmed through worksheets carried the discussion to another dimension. Rambo's mentioning about his practice of providing one question at a time led the discussion to consider alternative worksheet forms.

4.3.4 How teachers imagine different possibilities: Genre benders

As Rambo says, "there's definitely a form that...associate with what a worksheet looks like, if you play with that form, it is less worksheet-like" and by creating "less worksheet-like" forms, that this research considers as genre-benders, we may have a chance to visit the concept of worksheet thoughtfully and improve our teaching.

In the focus group discussions the following genre benders were identified and were elaborated on. Research participants' valuable insights regarding the nature of worksheets enriched the

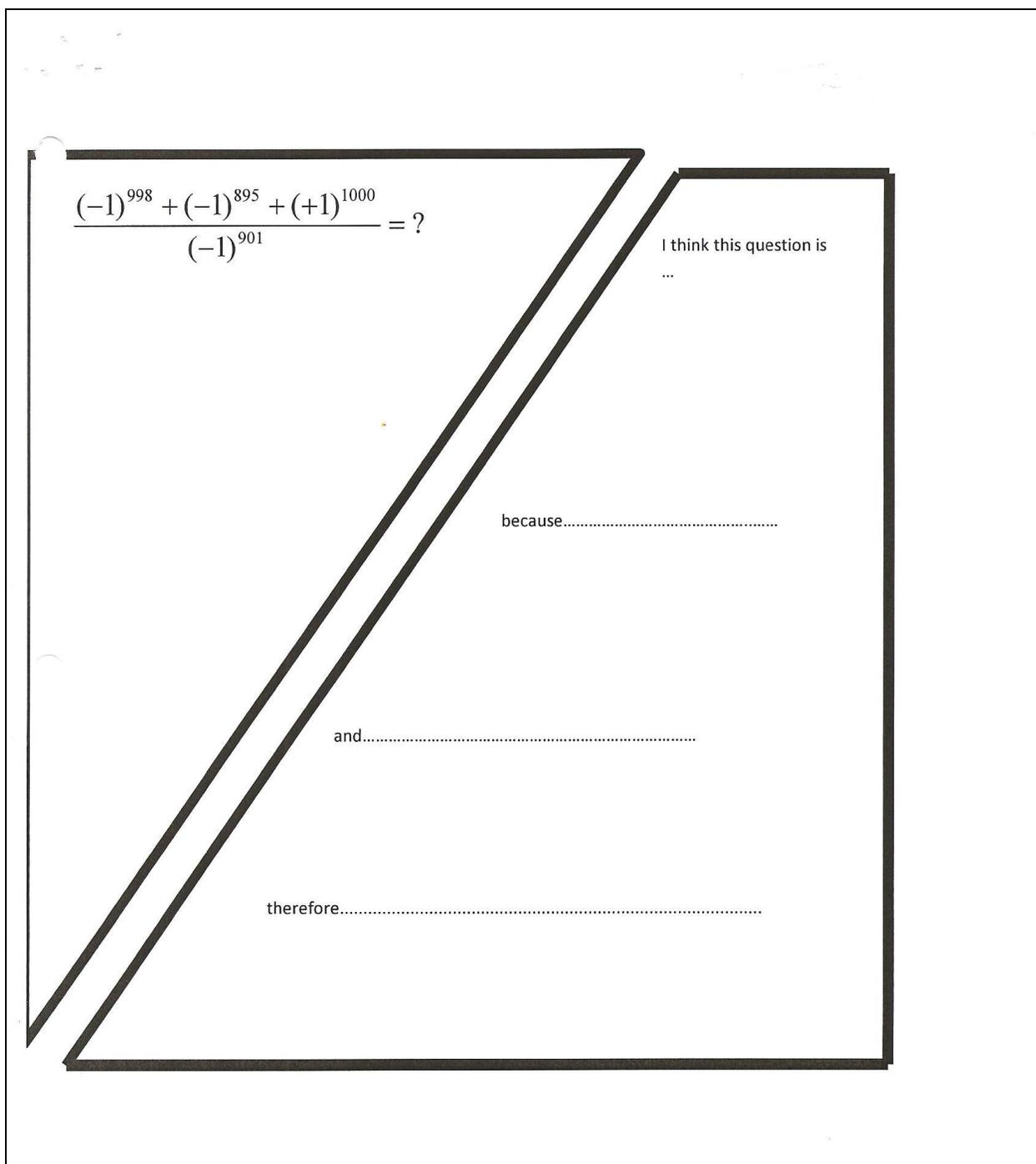


Figure 9 Genre bender sample-1

understanding of worksheet form. While discussing an anonymous worksheet where there was only one question and space for students to expand their solutions and there were also reflective questions (See Figure 9.), Rambo named it as handout because he said, “I consider worksheets to be concerned with procedures and repetition whereas this one is conceptual. If you raise one to any power, what do you get? It asks for an explanation...it’s asking students to think...”. Others agreed.

The second genre bending worksheet was about completing the worksheet by asking questions (See Figure 10). Gina liked this idea and offered a way to employ it “This is something to think about, maybe the teachers will give the worksheet to study and ask [the students]...put more questions on it and exchange with each other...”. Gina’s idea was about providing students with a chance to ask these questions to their friends so that they can talk about their solutions and questions. While analyzing this worksheet, Pascal commented “I’m assuming that, if I’m doing the worksheet on the culture of worksheets, I’m presuming that the difficulty will progress-the challenge will progress with the number. So, the first question will be easy and ...”. Here, Pascal’s words are important for acknowledging that there is a worksheet culture which requires students to act in a particular way through features of worksheets.

Rambo commented on worksheets’ sequential structure, reminding us of Lockhart’s (2009) mathematics lament where he talks about what he calls the ladder myth of mathematics. For Lockhart, you do not need to learn mathematics in “a sequence of events” but this is how we teach in schools and worksheets are used within this perspective. However, mathematics can be taught in alternative ways that allow students to figure out things as they feel they need to learn it

Adding Decimals- Complete the worksheet.

1.	9.	17. $3276.8+1.64=$
2.	10.	18.
3. $0.2 + 0.1 =$	11.	19.
4. $0.4+0.21=$	12. $102.4+1.09=$	20.
5.	13. $204.8+1.2=$	21.
6.	14. $409.6+1.31=$	22.
7. $3.2+ 0.54 =$	15. $819.2+1.42=$	23.
8. $6.4+0.65+$	16.	24.

Figure 10 Genre bender sample-2

(Small, 2012). Likewise, Chloe criticized asking question after question to students and not having time for in-depth mathematical inquiries that reminded Rambo of his practice of providing one question at a time exam, which can be considered as worksheet practice as well.

It's interesting; you mentioned the bombardment of questions. One time I actually experimented giving a test one question at a time. It was kind of annoying and a weird way to do it but I literally gave each student one question, it was a waste of paper too, but

they glued to a piece of paper when they finished it and then got the next one. So they didn't know how long it was going to be or think that they couldn't do all of it, they just did one at a time, and if they couldn't do it, I would give them the next one, just wave the white flag. It was a weird experiment that was like me doing what you said, kind of tailoring it, even my own test like changing the form a little bit. It's weird because textbooks-I don't even know the difference between textbooks and worksheets, like there is not much difference in the stuff we give.

Is this practice genre bending? First, in a worksheet you see the whole and expect to solve a certain number of questions, twenty or fifteen. But in this practice students have no clue as to how many questions they will be solving. With worksheets there is a finishing feeling; there is an end and at the end you supposedly finish your working on this particular topic. Once you completed it is done. However, with the offered practice there is no completion, at least the completion is aligned with your pace and it is not predetermined. This technique also gives teachers a chance to differentiate questions for each of the students and surprise them.

4.4 Summary of the chapter

The genre analysis of worksheets conducted in this chapter explored what worksheets are and language analysis of worksheets revealed specific language structures employed in the worksheets. The analysis of the focus group discussions showed how teachers perceive worksheets and how they use worksheets in their practice in secondary level mathematics education. In the following chapter, the results will be discussed, their implications will be presented and concluding remarks will be made.

Chapter 5: Discussions and Conclusions

5.1 Discussion

The findings reported in the previous section will be discussed below.

5.1.1 What are textual and contextual features of mathematics worksheets in secondary education?

This study was designed to explore the nature of worksheets and how teachers perceive and use them in secondary mathematics education. The data presented in this thesis demonstrated worksheets as culturally recognizable forms, their formal and substantive features, and how formalistic and language choices made in them position students and teachers. Besides, it illustrated teachers' perspectives on the use of worksheets.

The genre analysis revealed that worksheets have “typified regularities” (Miller, 1984, p.131) that conform to a certain consensus (Gerofsky, 2012) and “mediate situated symbolic actions” (Bawarshi & Reiff, 2010, p.54). The typical textual features of worksheets were identified based on the genre analysis of the original worksheets collected from the participants. The features were found to have format and context specific characteristics as listed in the results section. Briefly, they were grouped under form, content, graphics, linguistics themes and teacher and students' actions addressed by the genre. This constellation of features constituted the essence of worksheets as culturally recognizable forms. Questioning the worksheet genre form through comparing the contrasting or marginal forms led to an inquiry of clarifying the nature and generic structure of worksheet genre. As such, among the worksheets under investigation, there

were forms that were identified as central or marginal to (peripheral to and contrary with) the worksheet genre.

Differences were observed between the worksheets that were central to and marginal to the worksheet genre. For instance, worksheets that were central to genre had questions that emphasized the calculational and procedural aspects of mathematics and reinforced drill-type skill development, highlighting accuracy and speed but not reinforcing reasoning and critical thinking skills. On the other hand, marginal forms included reasoning, pattern recognition and critical thinking questions. In addition, the use of graphics and language illustrated more complex structures than the ones described as central to worksheet genre. The findings obtained by the genre analysis may have implications for improving the creation of worksheets. For example, instead of the repeated use of drill-type worksheets aiming at fluency and accuracy, teachers ought to be more purposeful to include questions that allow students to think critically.

The history of “copying technologies” associated with worksheets from 1930s to 1990s provided insights into the evolution of teacher intentions. The students’ practice of copying the questions from the blackboard in the 1930s and 1940s changed alongside the common use of ditto and mimeograph machines in the 1950s and 1960s. After 1970s, when the photocopy machines became a part of school life, particularly after 1980s coupled with computers and printers the mass production of worksheets became easier. This view provided a perspective of the intentionality use of worksheets and “making a whole set” for the class.

The linguistic analysis conducted in this study validated the assertion that language of worksheets employ exclusive imperatives significantly more than inclusive imperatives. This finding aroused questions whether worksheets tend to treat students as scribblers rather than thinkers (Herbel-Eisenmann and Wagner, 2007). This performance-based approach distances students from comparing, reasoning, explaining, and relating activities and leads them to value mathematics as a science of abstract or as a mastery of calculation but not the art, the aesthetics, the discovery or the play.

In addition, findings of this study suggested that worksheets are lacking of singular and plural first person pronouns and very limited in second person pronouns. This indicates that teachers' (or worksheet authors') own voice is lost in the worksheets, which is also supported in literature. Herbel-Eisenmann and Wagner (2007) say “[f]irst person pronouns (I and we) indicate an author’s personal involvement with the mathematics. ... authors can use the pronoun I to model an actual person doing mathematics, and can draw readers into the picture by using the pronoun we” (p.123). In a way, through the worksheets teachers detach students from themselves and “[set] a formal relationship between them” (Morgan, 1996, p.6).

The analysis of modality use in worksheets emphasized an absolutist view to mathematics as certainty is enforced through the dominant use of “can” meaning students’ imagining or interpreting other possibilities within mathematics is disregarded (Rowland, 1995). This certainty pursues a fixed curriculum and puts barriers to children’s and teachers’ imagination and creation from their own real experiences. That view is neither open to children’s own experiences and

contacts with the world nor is it an effective tool to experience real mathematics as a powerful language of the imagination.

5.1.2 How do teachers understand and use mathematics worksheets?

Teachers' intentions of the use of worksheets appeared in many different ways. Majority of them indicated using worksheets as introduction to a topic, test preparation, individual mastery, unit review, homework, developing self-study habits, or drill practice. Although the teachers participated in this study emphasized the importance of conceptual/procedural understanding in mathematics learning, they revealed their use of worksheets to foster the development of computational fluency rather than conceptual/procedural understanding. One does not need to sacrifice one way over the other. In other words, worksheets can both be used to foster conceptual/procedural understanding as well as skill enhancement if they are designed carefully.

In addition, all the participants agreed on the constraints of the current use of worksheets as killing creativity and exploration, boring and repetitive, limiting interaction and forcing students to learn in a specific way and not addressing diversity. It was also brought up that worksheets could be used for exploration of a topic, eliciting discussion or as a scaffold. This indicates the importance of how worksheets are used as well as what they include.

Stemming from the participants views, worksheets revealed a world where the students' activities are limited and that students are encouraged to circle or fill the right answers but are not provided with enough space to raise their own voice and to make their own contributions. However, this study also revealed that it is possible to think worksheets in a different way; by

coming together and sharing ideas, teachers create different possibilities for the use of worksheets.

In this context, Davis and Rinvoluceri's (1988) "Dictation" is an inspiring project. "Dictation" receives negative attention because Siskin (1989) says "it has been an anxiety-producing, authoritarian, teacher-controlled activity, with the focus on form rather than meaning" (p.486). However, Davis and Rinvoluceri reconsider this form in more than sixty different ways by transforming the form, context, focus or functions like in single word dictations, text reconstruction, the telephone dictations, computer dictations, picture dictations, story constructions or peer correction dictations. Siskin (1989) says "as I read through the book, I found myself saying 'But this isn't dictations'" (p.487) and she admits that these new forms are "marginal" and in a sense "departure" from the general depiction of dictation which convert dictation into a meaningful learning activity. Such a departure could also serve as in the way that we create worksheets or implement worksheets as follows:

- One question at a time worksheets: providing students with one question on the worksheet at each time and even if they do not find the answer, they should be provided with another one to show that they do not need to complete the whole.
- Creating worksheets with open ended questions where students need to work together as a team
- Producing worksheets where students need to raise questions
- Writing worksheets that give the answers and leave the questions open
- Providing different worksheets for everyone in the classroom
- Offering worksheets that require students' removing items rather than filling items in.

The genre analysis of worksheets helped us to clarify the form of worksheets which shape the activities in the mathematics classrooms. Genre bending led us to think this form in different ways as listed above. This perspective suggests that rather than eliminating worksheets from our practice, we can rethink about their use by considering marginal forms of worksheets - the genre benders and what they offer for improving mathematics teaching.

5.2 Conclusions

This study demonstrated that worksheets are important elements of mathematics teaching and learning and reflect teachers' intentions and teaching choices to address their students' needs. Many teachers and students use worksheets in different ways around the world. The features of worksheets, how language choices are made in worksheets and how they are used have a big impact on teaching and learning of mathematics.

This study also revealed that worksheets have mostly emphasized the procedural and calculational aspects of mathematics but not conjecturing, relating, testing or describing nature of mathematics. In addition, it revealed that the authoritative language of worksheets position students outside of mathematics community resulting in alienation. When worksheets are used to force students to learn in a specific way, and treat them as a cohort rather than individuals without addressing individual abilities, interests and needs, worksheets are considered as a hegemonic and homogenizing force. Thus, the use of worksheets could potentially put barriers to teachers' and their students' imagination and creation by closing a door towards exploration and by forcing a fixed curriculum.

However, worksheets can be conceptualized differently by converting them into forms that promote students' exploration of ideas through critical thinking and problem solving. This requires thinking outside of the box when it comes to worksheet usage in the mathematics classroom. By being aware of the constellation of features of worksheet genre, it is possible to alter or highlight some of these features to improve teaching by creating new forms and bringing a fresh look to their form and context.

In this study, genre analysis was employed in addition to language analysis, focus group and interviews to understand the textual and contextual characteristics of worksheets in secondary level mathematics education. Genre analysis provided a framework to incorporate different methods of analysis and brought a critical view that the form of worksheet could shape our actions as teachers creating the text and students reacting to text since it considers multiple dimensions ranging from formalistic features to origin.

5.3 Implications

The findings of this study may have several implications for teaching and further research involving worksheets. This study reinforces a need for practitioners to consider coming together to discuss their practices in general. More specifically, this study urges practitioners to reconsider and reinvent their use of worksheets in their mathematics classrooms since worksheets may play an important role in fostering learning. In addition, traditional worksheets may benefit from revision/reinvention to make them more effective by pushing the genre boundaries.

This study provides insights into understanding of worksheets by identifying their textual and contextual features which may be considered when creating new worksheets or revising existing ones. Such practitioner activities may be possible through Pro-D days or through workshops where ideas are discussed in a supportive environment because teachers not only need ideas to convert their worksheets in a way that aligns with their intentions but also share their way of implementing worksheets.

The genre analysis employed in this study proved to be useful in understanding content and use of worksheets in secondary level mathematics education. By combining genre analysis with other analyses such as language analysis, it was possible to bring a holistic approach to the data analysis which yielded valuable insights into our understanding of worksheets. Given that genre analysis is a dynamic method which allows incorporation of multiple perspectives to understand the forms of text that shape how producers create the text and how consumers receive and react to it, this study exemplifies an application of genre analysis within the context of worksheets in mathematics education. Stemming from this application, one may potentially use genre analysis to understand the nature of other curriculum materials such as textbooks, exams and/or students' discussions in online forums in mathematics education going through similar methodological frameworks. For example, one may be specifically interested in exploring the formalistic features embedded in the form of the material, origin of the material, its chronotopic orientation and reconsidering the form itself (genre bending). This suggested approach would be different than other analysis since it allows to understand the shaping power of the form/genre and thus encourages to ask questions of what this form is, what its origin is, what the intentions of producers are and how this form addresses its consumers. Such investigations would potentially

shed light into our understanding of the contributing factors of written text in math education.

The direct impact of such investigations would be to raise awareness of the importance of written text and to identify their role in shaping mathematics classroom culture and interactions among the members of the classroom community.

Further research may include incorporation of students' perspectives to triangulate data to support genre and language analyses. Parents' voice could also be obtained to strengthen the findings. Particularly, parents and students could provide valuable insights into our understanding of how they perceive worksheets and how they use them at home and whether teacher's intention aligns with students' and parents' uptake.

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Appendices

Appendix A

The University of British Columbia



Department of Curriculum and Pedagogy

Faculty of Education

2125 Main Mall

Vancouver, B.C. Canada V6T 1Z4

Tel: (604) 822-5422, Fax: (604) 822-

Consent Form

Title: An investigation of mathematics worksheets as a pedagogical genre in secondary school classrooms.

Principal Investigator: Dr. Susan Gerofsky, Assistant Professor, Department of Curriculum & Pedagogy, UBC, 604-822-5204.

Co-Investigator: Ozlem Deniz, M.A. Student, Department of Curriculum & Pedagogy, UBC, 778-223-5550

Secondary school mathematics teachers are invited to participate in a thesis research with a focus on investigating mathematics worksheets. The results of this study may be published in some form and/or presented publicly, but without any information that could be used to identify the participants.

Purpose: While worksheets play an important role as teaching tools, there have been very few systematic attempts to investigate these written generic constructions of schooling. This research focuses on investigating mathematics worksheet as a pedagogical genre and exploring the notion of worksheets in the secondary school classrooms. The textual & contextual analysis of these generic forms may lead a better understanding of mathematics teaching and learning practice by having the power of revealing the tacit assumptions of the field. The findings may also find applications in teacher education as well.

Study Procedures: You are invited to participate in the following activities:

- sharing 3 to 10 worksheets that you have created and/or used in your practice of teaching mathematics as examples for the project
- participating in a one hour long focus group discussion
- participating in a one hour long personal interview or participating in through an e-mail interview.

The interview session will take place after a preliminary analysis of data (text analysis and focus group discussion analysis). The focus group discussion and interview session will be held in a room (to be announced) in Neville Scarfe Education Faculty building at the University of British Columbia at a time convenient to the participant. With your permission, the focus group discussion and the interview session will be audio-recorded with a copy of the transcript provided to you upon request. It is anticipated that you would need to commit up to 2 hours total to the research study on two different days. If you decide to participate in through an e-mail interview, you will be requested to complete the interview in two weeks.

Potential Risks: There are no known risks to participate in this study.

Potential Benefits: During the focus group discussion or interviews, teachers will be involved in a reflective process; therefore you may gain valuable insights about your practice. This might help you enhance your practice for the betterment of teaching and learning in your classroom.

Confidentiality: Your confidentiality will be respected. Pseudonyms will be assigned to all participants in the research for identifying data sources and reporting of results. The results will only be used for academic publications and presentations. The data acquired will be stored in a password protected computer or a locked cabinet accessible only to the researchers for a period of five years after which all data will be destroyed. We highly encourage all participants to refrain from disclosing the contents of the focus group; however, we cannot control what other participants do with the information discussed.

Contact information: If you have any questions or desire further information about the study, feel free to contact Ozlem Deniz (researcher) by emailing ozlem.deniz@ymail.com or calling 778-223-5550 or Dr. Susan Gerofsky (principal investigator) email: susan.gerofsky@ubc.ca, telephone: 604-822-5204. If you have any concerns about your treatment or rights as a research participant, please telephone the Office of Research Services at the University of British Columbia, at 604-822-8598 or e-mail to RSIL@ors.ubc.ca.

Consent: Participation in this study is entirely voluntary. Participants may refuse to participate or withdraw from the study during the research without any consequences. A copy of transcribed audio recordings will be made available to participants for confirmation of accuracy and a report of findings upon request.

Please indicate whether you agree to participate in this research project by signing the attached Consent Form and kindly returning it to the researcher, Ozlem Deniz. Please retain the attached copy for your records.

Consent Form

RESEARCH PROJECT: An Investigation of Mathematics Worksheets as a Pedagogical Genre in Secondary School Classrooms.

I have read and retained a copy of the Consent Form and have had my concerns and questions answered to my satisfaction. I understand that in any papers, publications or presentations from this study, my identity will not be revealed. Under the conditions outlined in the Consent Form, I agree to participate in this research project as the following:

I consent to use of my mathematics worksheets that I shared with the researcher as research data.

I consent to use of my interview records as research data.

I consent to use of my focus group records as research data.

Subject Signature

Date

Printed Name of Subject signing above

Phone: _____

Address: _____

Email: _____

KEEP THIS COPY FOR YOUR RECORDS

Consent Form

RESEARCH PROJECT: An Investigation of Mathematics Worksheets as a Pedagogical Genre in Secondary School Classrooms.

RESEARCH PROJECT: An Investigation of Mathematics Worksheets as a Pedagogical Genre in Secondary School Classrooms.

I have read and retained a copy of the Consent Form and have had my concerns and questions answered to my satisfaction. I understand that in any papers, publications or presentations from this study, my identity will not be revealed. Under the conditions outlined in the Consent Form, I agree to participate in this research project as the following:

I consent to use of my mathematics worksheets that I shared with the researcher as research data.

I consent to use of my e-mail interview records as research data.

I consent to use of my focus group records as research data.

Subject Signature _____ Date _____

Printed Name of Subject signing above _____

Phone: _____

Address: _____

Email: _____

RETURN THIS COPY TO RESEARCHER

Worksheets Project

Sample Focus Group Questions

Questions will be designed as open-ended or sentence-completion types and worded in a way that they cannot be answered simply “yes” or “no”. Different types of questions will be included for engagement and exploration of the participants as follows:

1- Would you fill in the blanks below:

Mathematics worksheets are but
because Worksheets look like and
..... because Worksheets can be.....and
..... Also,.....
.....

2- Imagine yourself way back when you were an elementary school student. What are your memories about worksheets? Were they part of your school experience? What did they look like, smell like, etc.? How did you feel when the teacher gave them to you? When and how did you complete them?

3- Imagine yourself when you had just started teaching. Do you remember the first worksheets you used in your class? What changed since then?

4- Imagine you were having a conversation with someone from a very different culture where they didn't have worksheets, in math or any part of school. How would you describe what a worksheet is, what it's for, why teachers use them, and what students think about them?

5- What do you think which students like worksheets and which ones dislike? Why do you think this is the way it is? What do kids do with worksheets once they are completed? What would you like them to do with them?

6- When and how do you provide students with worksheets in your regular routine? Are they taking worksheets home as homework and completing by themselves or are they working on the worksheets as a group in school or what could be the other variations?

7- One of my colleagues compares a worksheet to a hammer as a tool and says worksheet can be misused and therefore can strike you like a hammer. How does this statement speak to you?

8- One of my other colleague claims that worksheets are not bad, good, or indifferent. It is how we use them that counts. Would you elaborate on this claim?

9- One might say that he/she uses worksheets to save time. Do you agree with this statement?

10- We are all teachers and we all use worksheets sometimes. What situations are the ones where you would consider using a worksheet? What does it accomplish in your class? Is anything lost by using worksheets?

11- What do you think that long distance education or all the educational technologies we have started to use would affect the future of worksheets?

12- How would you compare worksheets to textbooks? What are the similarities and differences between them in terms of their functions or form or content?

WORKSHEET PROJECT PRE-INTERVIEW QUESTIONS

Name:	Date of Birth/Place:
Where did you do your primary, secondary and post-secondary education?	
How long have you been teaching?	
In which schools (and which grades) have you taught so far?	
Would you a little bit tell about your daily routine in your math classes? How worksheets would fit in this picture?	
Would you write a few sentences about your ways of using worksheets?	
What situations are the ones where you would consider using a worksheet? What does it accomplish in your class? Is anything lost by using worksheets? When did you see them appropriate or not?	
Do you think other teachers use worksheets in the same way you use them? Would you elaborate a bit?	

WORKSHEET PROJECT SAMPLE POST-INTERVIEW QUESTIONS

(From Pascal's interviews)

- 1- In our focus group discussion, once you mentioned that you would not agree on providing one type of worksheet to every one of the classroom as a usual practice. Would you talk about it little bit more and would you elaborate on how this would impact the power-identity relations or interactions between the classroom community?
- 2- You also mentioned that the different education systems conceptualize and employ worksheets as a same way because “the curriculum is the same” and mathematics is a “gateway subject” for many exams. Would you explain this argument little bit more?
- 3- At one point you mentioned that “worksheets should not be used all the time because they provide too much structure for student”. Would you elaborate on this little bit, please?
- 4- How do you comment on the discussion of hand-outs and worksheets?

MATHEMATICS WORKSHEET PROJECT MALKA'S INTERVIEW QUESTIONS

- 1- When did you start teaching and for how long did you teach?
- 2- Which grade levels did you teach?
- 3- Imagine yourself way back when you were teaching. What are your memories about worksheets? Were they part of your school experience? How did you use them?
- 4- Do you remember the first worksheets you used in your class? When was it? How did you created them, how did you use them? What kind of technology did you used?
- 5- Do you think you changed your way of using worksheets during time?
- 6- How were your students' reactions to worksheets?
- 7- Do you remember how your colleagues were using them?
- 8- Do you remember anything special to mathematics teaching regarding to use of worksheets?

Appendix B

Table 3 Frequency of imperatives, pronouns and modality

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Chloe-Sample 1 Simplifying Radicals Grade 9	(12)	you (1)	Inclusive: describe (1) Exclusive: express (8); order (1); determine (1); calculate (1); write (3)	
Chloe-Sample 2 Integer tile Investigation of Algebraic Expressions Grade 9	(7)	we (1) your(2)	Inclusive: model (1); create(1) Exclusive: sketch(2); write(2);	can (1) would (1)
Chloe-Sample 3 Classification of Polynomials Grade 9	(5)		Exclusive: name (1); classify (2); write (2)	

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Chloe-Sample 4 Patterning-Hinged! No Grade	(3)	you (1)	Exclusive: draw (1); use (2); record (1); complete (1)	could (1)
Chloe TOTAL	(27)	(5)	Inclusive: (3) Exclusive: (28)	(3)
Rambo-Sample 1 Multiplying Rational Numbers	(12)		Exclusive: find (1)	
Rambo-Sample 2 Mystery Equations Grade 9-10	(6)	you (2)	Inclusive: No use Exclusive: determine (5); evaluate (1), re-evaluate (2); fill (1)	can (2)

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Rambo-Sample 3 Grade 11	(12)	You (1)	Inclusive: make a conjecture (1); investigate (1); develop a strategy (3) Exclusive: record (3); graph (5); calculate (1); find (1); write (1);	can (2); may (2); will (1)
Rambo TOTAL	(30)	(3)	Inclusive: (5) Exclusive: (21)	(7)
Pascal-Sample 1 Fractions Grade 6-8	(28)		Inclusive: explain (1) Exclusive: draw (1) calculate (5) fill in (1)	

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Pascal-Sample 2 Mayan Number System Grade 6-8	(7)	you (1)	Inclusive: decipher (1) Exclusive: solve (1)	can (1)
Pascal-Sample 3 Puzzle	(7)			
Pascal TOTAL	(42)	(1)	Inclusive: (2) Exclusive: (8)	(1)
Lizzie- Sample 1 Analytic Geometry	(7)		Exclusive: Fill (1)	Must (1)
Lizzie-Sample 2 Angles (English) Grade 10-12	(16)		Exclusive: answer(6)	
Lizzie-Sample 3 Trigonometry Grade 10-12	(24)		Exclusive: give (1); find (6); calculate (2);	

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Lizzie's	(47)	(0)	Inclusive: (0)	(1)
TOTAL			Exclusive: (16)	
Gina-Sample 1 Inequalities Grade 8	(16)		Exclusive: solve (2); reduction (2)	
Gina-Sample 2 Algebra Grade 8	(37)		Exclusive: solve (3); calculation (1); give the answer (1)	
Gina-Sample 3 Rational Numbers	(43)		Exclusive: simplify (5); get the answer (4); shorten-reduce (1)	would (1)
Gina's	(96)	(0)	Inclusive: (0)	(1)
TOTAL			Exclusive: (19)	
Anton-Sample 1 Word Problems	(10)	Third person pronoun (8)	Exclusive: find (5); calculate (4)	would (2)

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Anton-Sample2	(10)		Inclusive: perform(1) Exclusive: write (1); find (1)	
Anton-Sample3 Pythagorean Theorem Grade 8-9	(22)		Exclusive: “find”(1)	
Anton’s TOTAL	(42)	(8)	Inclusive: (1) Exclusive: (12)	(2)
Serena-Sample-1 Patterns in a Table of Variables Grade 8-9	(4)	you (2)	Inclusive: describe (1); explain (1); Exclusive: graph (1); fill in the blanks (1); tell (1); complete (1); check (1); determine (1)	can (2)

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
Serena-Sample-2 Quadratic Inequalities Grade 9	(1)		Exclusive: fill (1); solve (1)	could (1)
Serena-Sample-3 Integers Grade-8	(6)	you (7)	Inclusive: show (3); apply (1) Exclusive: draw (1); determine(1); look (1); write down (1); read (2); divide (3)	can-can't (3); must(1)
Serena TOTAL	(11)	(9)	Inclusive: (6) Exclusive: (17)	(7)

Data Information	Number of Questions	Use of Pronoun (# of times)	Use of imperatives (# of times)	Use of modality (# of times)
OVERALL TOTAL	(295) questions	(25) you(17) we (1) third person pronoun (8)	Inclusive: (17) Exclusive: (121)	(22) can(11) would(4) must(2) could(2) will(1) may(2)