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JiJi Can Talk! An Oral Language Strategy Guide for Blended Learning Math Classrooms Using ST Math

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JIJI CAN TALK!

AN ORAL LANGUAGE STRATEGY GUIDE FOR BLENDED LEARNING MATH CLASSROOMS USING ST MATH

by

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for the degree of Master of Arts in English as a Second Language.

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TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER ONE: INTRODUCTION

"Students at all grades can listen to or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments."

"Mathematically proficient students try to communicate precisely to others."

"In the elementary grades, students give carefully formulated explanations to each other."

"By the time they reach high school they (students) have learned to examine claims and make explicit use of definitions."

The 2010 Common Core Practice Standards (CCPS) for Mathematics indicate a shift in mathematics education from memorization or formula-focused learning to a more balanced approach that coordinates conceptual understanding and procedural fluency in an effort to develop mathematically proficient students (Common Core Practice Standards, 2010). Students are increasingly asked to explain the "why" in math and construct viable arguments. This emphasis on the language of math is a challenge for all students but for English as a Second Language (ESL) learners, or English Learners (ELs) (Moschkovich, 1999), this shift means language and math must be taught together. More language instruction in the math content area is essential for academic success with these new standards (Rebora, 2014).

The Common Core State Standards (CCSS) and the Common Core Practice Standards (CCPS) are affecting schools, students and teachers everywhere. Additionally, student demographics are changing how schools look in America. In the last decade, the English Learner (EL) population in the nation's public schools has increased by 51% and ELs now constitute 10.8 percent of U.S. students (NCTM, 2010). New standards and demographics are specifically changing the math classroom for students and teachers in dramatic ways. Teachers are being asked to change their practice and change the way they teach math. The National Council of the Teaching of Mathematics (NCTM) advocates support of ELs in the math classroom and sets guidelines to hold teachers accountable for ELs' performance in the classroom by claiming that support for ELs in math must meet current expectations for *all* students and ensure that ELs are provided with equitable opportunities to learn the same rigorous mathematics content as their English-speaking peers (National Council on the Teaching of Mathematics, 2013). This is followed by recommendations to 1) support student engagement, 2) design instructional strategies to meet language needs, 3) provide classroom discussion supports to encourage negotiation of meaning and 4) aim to lessen the language complexity of the math work without reducing the rigor of the mathematics (National Council on the Teaching of Mathematics, 2013). These are necessary changes or modifications to current math teaching, but how teachers and schools meet these challenges remains elusive. Tools, resources and content are essential and needed for EL success in the new math classroom.

Why I love math…and language

With every challenge there is opportunity! In my own teaching and work in the educational system, I observe opportunities for oral language in the math classroom for not only ELs but also native English speakers. However, mathematics thinking and learning needs scaffolding for students to orally produce language and thinking that Common Core expects. In the classroom, this increase in the language rigor of math classrooms presents great opportunities for peer interaction across language proficiency levels and content abilities to discuss math concepts.

My love of math developed at a very young age. Fostered by a tendency to be accurate and rewarded by teacher praise for my correct answers, math became an area of academic success and pride. Math was all about the answers for me and since I had them most of the time, I felt very successful. This love of math continued until I reached the last year of my high school career when I took Calculus. Math changed for me at that time and I struggled to understand because I lacked a conceptual understanding of math. I was forced to think about the math and explain my process and this proved difficult because I had never been expected to do this. Luckily, I remain strong in my math understanding and have always loved teaching math to students in elementary school. My experience teaching elementary math goes back fifteen years and over time my practice has evolved from speed and accuracy pedagogical practice to more of a focus on justification, explanation and reasoning. This pedagogical shift for me came when I discovered the language opportunities math offered in the classroom.

Seven years ago I moved to Minneapolis from Portland, Oregon and started working in Minneapolis Public Schools at Lyndale Elementary School. Lyndale exposed me to significant numbers of ELs for the first time in my career. Presented with training on ESL instructional strategies, specifically Sheltered Instruction Observation Protocol (SIOP) (Echevarria, Vogt, & Short, 2004), I learned how to incorporate language objectives into my practice. In SIOP, every lesson pairs a language objective with a content objective. In addition, other guidelines are set in place to help teachers meet ELs' instructional needs. In math, this revolutionized my practice from only focusing on the answer in math and allowed me to see the value in process and language usage to explain thinking. Using language objectives, employing sentence starters, designing word work activities, and creating visuals in my practice allowed me to see the value and necessity of language in math to support content understanding for ELs. This work with language and math inspired me to pursue an ESL teaching license and ultimately a Masters of Arts in ESL. This capstone merges my passion for language teaching and my love of math into an *Oral Language Strategy Guide for the Blended Learning EL Math Classroom Using ST Math,* an online math program used with nearly a million students across the country and in over twenty schools in Minneapolis.

As an elementary and ESL certified Math Specialist in a school with a culturally diverse population, I always look for connections between math and language. My position as a Math Specialist with an ESL license puts me in a unique position to affect change for ELs in my building and possibly in the district. Most elementary ESL teachers in Minneapolis are working in the content area of science and there are not a lot of ESL positions that support math directly at the elementary level. Additionally, those

ESL teachers who could support elementary ELs in math lack content knowledge or resources to effectively instruct in math. Therefore, as an advocate for ELs, I have been able to find a position that affords me the opportunity to work in the content area I love and support the learners that motivate my practice. This is why I am well qualified and motivated to create an *Oral Language Strategy Guide for Blended Learning Math Classrooms with ELs Using ST Math*. I will refer to this document as the *Strategy Guide* for reading convenience.

Three Questions that Changed My Teaching

While teaching as 3rd grade classroom teacher at Lyndale Elementary in Minneapolis years ago, I had the opportunity to experience a unique program, Visual Thinking Strategies (VTS). Commonly referred to as VTS, this curriculum program fosters critical thinking and oral language for students around art with the goal of transfer of those critical thinking skills to other content areas (Housen, 2002). My classroom hosted a docent from the Minneapolis Institute of Art (MIA) who came in monthly and displayed artwork to spark whole class conversations. The lessons and curriculum are sequenced and the art carefully chosen to build critical thinking skills (Housen, 2002). VTS, developed by Abigail Housen in the 1990s as a strategy to increase critical thinking skills using visual art and simple questioning, turned out to be a huge success in my classroom of native and non-native English speakers. I observed students who normally don't speak in class communicating about art in a deep and meaningful way. This included many of my EL students who were usually hesitant to talk in class.

Here is how VTS works. Students are presented with a piece of artwork on the Interactive White Board (IWB) and go through a recursive, three-step process of

questioning and evidence-based rationalization. Housen, who developed VTS as a result of her doctoral research at Harvard, created the VTS curriculum to increase students' aesthetic thought and critical thinking skills (Housen, 2002). Docents or teachers ask basic questions of students as the selected piece of art is displayed on the whiteboard.

- What is going on in this picture?
- What do you see that makes you say that?
- What more can you find?

Students respond to these questions and the docent or teacher leader will point to the area of focus on the screen and paraphrase or recast the student response. VTS leaders ensure that all students are involved in the discussion, listen to others, and build on the connections being made with the art. In this process, students are encouraged to look carefully at the art, talk about what they observe, back up their ideas with visual evidence from the artwork or their own background knowledge. Students listen to others' points of view and discuss multiple interpretations while building on or challenging the ideas presented by their peers (Franco, 2014).

Housen's (2002) "simple" process struck me as a great support for my ELs. I discovered that imagery and visuals associated with open-ended questions could push students to create their own meanings based on their current background knowledge, thus creating a powerful tool for constructivist teaching and learning. My students, ELs included, transformed into oral communicators who not only thought about their responses but also found evidence to support their output. The use of quality visual images assisted students in finding their evidence and supporting their claims using the visual evidence. This was a task that proved too difficult in other areas of my instruction

such as math computation and independent reading. Although the students' language output during VTS, ELs especially, was not perfect or even academic, the docent's use of recasting and the possibility for academic language integration was evident. VTS intrigued me and I wondered if I could achieve this level of discussion in my math classroom.

Discourse, discovery and oral production are important to the success of students in math (Kang 1995; Moschkovich, 1999). With my visiting docent's assistance, VTS definitively increased the oral language production and critical thinking in my classroom around the artwork presented, but it was still only at the student's individual language proficiency level and limited to those discussions. Could I use this strategy as an integrated part of social studies, science, or even math? Could other teachers apply this to their classroom content?

I was especially interested in applying this strategy to math instruction because I found it hard for students to explain their thinking in math. I began using the VTS strategy with pictures and images related to social studies and science. The strategy was valuable and assisted in positive whole group discussion, but discussion in math remained elusive. Instruction primarily lacked effective and motivating visuals to support math content learning. Then I met a virtual, animated penguin named JiJi.

My experience with ST Math

JiJi is the animated character in ST Math, an inquiry-based, online math program where students solve math puzzles to achieve content mastery. Students manipulate images on the screen and are expected to get JiJi, the penguin, across the screen. When students achieve this goal, JiJi runs across and an audible "ding" indicates puzzle

completion. Figure one shows how JiJi gets across the screen in a game comparing number value.

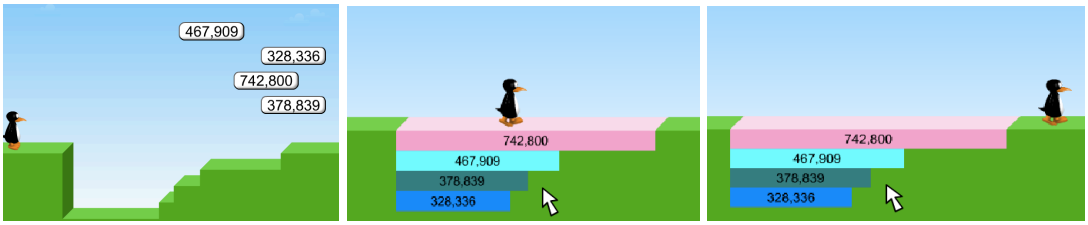


Figure 1. Example puzzle from ST Math

According to founder/CEO Dr. Matthew Peterson (2011), MIND Research has created a video game that "breaks all math content down to getting a little penguin across the screen." ST Math, or Spatial Temporal Math, is an online math program that uses visual cues, manipulatives and animation to provide students with mathematical instruction and feedback while they work to solve puzzles at grade level standards (Mind Research, 1997). Students play the games of ST Math and examine the animation as they complete mathematical puzzles specifically designed to teach students grade level conceptual understanding of math. ST Math uses no audible words to instruct students on mathematical concepts; therefore, oral language skills do not act as a barrier to access the content while students interact with the program. Dr. Peterson claimed in a 2011 TED Talk that this omission of language combined with visual animation inspires kids to talk about the math. Peterson (2011) expressed "by creating a language free approach we can actually improve language proficiency."

My first experience with ST Math was as a parent of a Lyndale student. My daughter was a fourth grader and her classroom used ST Math during the initial pilot year in Minneapolis. She and other classmates worked through the games and developed incredible skill at understanding the math involved. Whether students fail or succeed at a

level, the game displays animation to show the student why they were right or wrong with visual cues. Students then use this visual feedback to try again and master the level with another attempt. I enjoyed seeing the visual and conceptual nature of the program challenge my child and others to achieve in math class. It must be noted that my child was not an EL, but I could see the math involved in the program and was impressed with its visual animation support of math content. The program appeared a perfect link for language and math content with ELs. Then, I got a job with JiJi.

My family and I moved to Philadelphia, PA for a couple of years and I worked as an Education Consultant for ST Math in the Northeast region of the United States. I supported schools implementing ST Math, delivered Professional Development, modeled lessons using ST Math, co-planned with teachers and helped modify the program to meet the needs of schools using ST Math. My two-year tenure with ST Math was heavily influenced by my experience as an elementary educator and specifically by my passion for EL learning in math classrooms. EL learning was at the forefront of what I intended to achieve within the organization. This guided my work as an Education Consultant with Mind Research Institute.

In supporting nearly a hundred schools in Pennsylvania, New York and New Jersey, consistent patterns emerged with schools with large amount of ELs. First, educational leaders and teachers loved the ST Math program and could see the value of the games and their connection to the math standards. Second, schools would use ST Math with their low level ELs because the students could play the games and puzzles without the barrier of language. Schools identified ST Math as a way for their EL students to access math content. Finally, a troubling pattern emerged for students and

teachers who used ST Math classrooms. Teachers expected ST Math to do all the work and it was unclear how to support their students' use of language or how to support them with the math content while using the program. ELs would play the games, master the content, yet still have deficiencies in explaining their math thinking. It became imperative to help teachers adjust their teaching, build lessons that incorporated oral and academic language into their use of ST Math, and still maintain the discovery nature of the program.

The absence of words in ST Math is a unique feature that creates interest from EL teachers and school leaders. Students are expected to complete the puzzles without the aid of concrete verbal direction. By removing the language barrier for students accessing math content, ST Math forces students to make sense of problems (puzzles), take risks in their learning (click without accuracy) and persevere in problem solving (multiple attempts) in the absence of oral or written instruction. The independent and inquiry nature of ST Math is its strength, but evidence indicates that ELs do benefit from verbal guidance while using these types of discovery-based math games (Moreno & Durán, 2004). Research also shows consistent links to language and understanding that are essential for students to internalize their math learning by expressing and explaining using their own words (Alt, Arizmendi & Beal, 2014). Language plays a role in math learning so it must have a role with students who achieve in ST Math.

The experiences of my own daughter, the work with teachers in the classroom using ST Math and my own research on how math understanding and language work forced me to question if Dr. Peterson's claim that a language free approach could improve language proficiency. Research is telling us that is not the case, and oral

language can enhance or improve cognition (Swain, 2004). Could language support, visual thinking strategies and EL oral language production tools in combination with ST Math develop math content knowledge and language proficiency simultaneously? That question helped clarify that an *Oral Language Strategy Guide* was a necessary tool to fill a gap for students and teachers using ST Math in their blended learning math classrooms.

Primary aims and the guiding question

The primary aim of this capstone is to answer the question *How can a strategy guide be produced to support oral language development in the blended learning math classroom that uses ST Math?* By using a modified VTS strategy, incorporating a language station into Guided Math (defined below) and creating an environment for structured talk to become paramount in the math classroom, this *Strategy Guide* will support students who are ELs but also work for classroom teachers with native English-speaking students as well. The *Strategy Guide* is intended for use in inclusive classrooms but could also be easily modified or adjusted to work one-on-one, in small groups, or to support a pull out EL math class. A secondary aim of the paper is to demonstrate a pathway for EL support in the math classroom. By focusing on language in a math classroom I aim to demonstrate how EL teacher support in math can be effective for student progress in their language acquisition when the math instruction is provided by the technology with the language instruction provided by the ESL or classroom teacher.

This paper combines math, language, EL instructional pedagogy, visual thinking and technology by combining the use of second language acquisition (SLA) strategies, visual thinking strategies (VTS), and quality interactive gaming technology into an *Oral Language Strategy Guide* for the blended learning math classroom using ST Math. This

guide and the motivation to produce it developed from a pedagogical belief that students from different language proficiencies and backgrounds can succeed in the same math classroom with effective language support. This *Strategy Guide* maintains the rigor of mathematics necessary for grade level success and builds rigorous use of oral language to create a math community where peer interaction, validation of claims with evidence and a focus on thinking are primary instead of a typical over-emphasis placed on accuracy and speed in many math classrooms.

Summary/Preview

This chapter highlighted the background for the creation of an *Oral Language Strategy Guide* for supplemental support in blended learning classrooms using ST Math. The chapter discusses one specific strategy that has demonstrated critical thinking and language around discussion of art images. This *Oral Language Strategy Guide* applies VTS to ST Math with a modified version of that strategy being used to support students using the program. Although this modification is a major component of the guide, other strategies and activities also effectively supplement the blended learning math classroom that uses ST Math by increasing student oral language output.

Additionally, the reader receives a background discussion of the pedagogical basis of ST Math and how the games may benefit ELs based on the lack of language involved in the program. Although there is little research to back the claim by ST Math developer Dr. Matthew Peterson made at a TED Talk in 2011 that "a language free approach can actually improve language skills," there is evidence that visuals and gaming can increase student talk (Peterson, 2011). *Can an oral language strategy guide be created to help support and build on Dr. Peterson's claim about language?* No research

supports a claim that language can be learned without oral language use. Finally, my primary purpose in this chapter is to tell my story as an educator and give the reader a background of my experience, rationale and underlying purpose for the creation of an *Oral Language Strategy Guide for Blended Learning Math Classrooms Using ST Math.*

Chapter two examines the research surrounding the challenges and opportunities math language present to ELs. Chapter two defines blended learning and explains how math classrooms are using technology to teach math content, freeing teachers to teach language around the math content. The chapter also addresses technology as a motivator in EL classrooms and the effects new technologies have on EL achievement. In addition, the chapter examines how verbal guidance and interaction support students using discovery-based technological games in math. The ultimate goal is to set forth a research background demonstrating a unique need for the development of an *Oral Language Strategy Guide* for use in blended learning math classrooms using ST Math.

Chapter three describes the methodology used to create the *Oral Language Strategy Guide.* The reader is informed of the process involved with creating strategies and structures that will support oral language between peers, whole class or one on one intervention using ST Math as a part of that blended learning environment. Chapter three outlines how lessons and strategies are reviewed, demonstrated, and published. Each strategy's efficacy in EL practice is explained along with their connection to the recommendations of Judit Moschkovich (2013), who recently published the *Principles of Math Instruction for English Language Learners (ELLs).* These principles act as a general guide for the creation of materials used in the *Oral Language Strategy Guide*.

Finally, chapter three lays out a timetable for the strategy guide's development and completion.

Chapter four is dedicated to the Ora*l Language Strategy Guide*. This chapter features organized and researched strategies for implementation in the blended learning math classroom that uses ST Math with ELs. The chapter is formatted with the intention of publication on the Internet as a set of strategies, lessons and activities for active use in Minneapolis classrooms if teachers choose to do so. The *Strategy Guide* will also be published as a pamphlet for use in Minneapolis math classrooms to support the effective development of oral language in classrooms that use ST Math. Chapter five allows for reflection on the development process for the *Oral Language Strategy Guide*, how that process was affected by research, learning from professional feedback and individual metacognition about what works for students.

CHAPTER TWO: LITERATURE REVIEW

This chapter presents current research regarding ELs in math classrooms to answer the question *How can an oral language strategy guide be created for the blended learning math classroom using ST Math?* By examining the works of Zwiers, Moschkovich (1999, 2004, 2007, 2013), Swain (2004) and Housen (2002), this chapter develops an understanding of how oral language can be increased and improved in the blended learning math classroom. This capstone proposes that a connection between oral language instructional strategies and online visual math curriculum could produce demonstrable results for EL students in both math content and English language development simultaneously. The research supports a connection between language learning in math and discovery-based online math games with appropriate teacher support (Moreno, 2004). EL oral production strategies are supported by quality visual imagery (Britsch, 2009) but an oral piece is absent in many blended math classrooms that utilize ST Math or other online math supplemental programs. Students play the games and complete the puzzles, but rarely engage in dialogue about the content they are completing.

Pedagogy is changing dramatically for math classrooms, and this chapter explores ideas related to the new math classroom where technology, oral discourse, peer interaction, EL support structures and language proficiency all come together to form the

blended learning math classroom. Oral language has become paramount to success in math class and students must communicate conceptual understanding of math and learn English at the same time (Moschkovich, 2015). Language and math can work together and efforts are being made to ensure this statement becomes a pedagogical reality in math classrooms across the country.

The math content area presents both challenges and opportunities for educators of ELs. Limited EL support in the elementary math classroom could be a factor in the achievement gap in math for ELs or at least in regard to EL performance on math word problems (Abedi & Lord, 2001). In blended learning environments, online programs like ST Math teach content to students for part of their instructional time (Watson, 2008), which, in theory, frees up classroom or ESL teachers to support language development and math content simultaneously. The capstone presents research on technology in the math classroom, a definition of blended learning and examples of technology's role as both a motivator and tool for EL academic and linguistic progress. It is common for ELs to interact with technology to improve language proficiency in today's classrooms (Levy, 2009). In addition, this chapter highlights effective strategies to help EL students produce oral language in the math classroom with technology as a support. Academic language and the math register are explained to demonstrate some issues affecting student use of math language accurately and effectively. Finally, chapter two outlines models of EL support in schools and suggests factors regarding why EL support is absent in math class while other content areas receive more attention.

EL Classrooms and the Language of Math

Reference to math as a universal language is common in social and educational circles, because math involves numbers and concepts instead of words and morphemes people believe everyone should be able to find common ground in math. This misconception about the language of math produces confusion concerning the achievement gap in math for our EL students. However, language learning and math learning are linked in many ways. Researchers began to look at the correlations between language learning and mathematics learning nearly thirty years ago (Borasi, 1988). Back in the early eighties Krashen (1983) began to look at how students learn English and he believed that learning was different than acquiring language. This theory of acquisition in turn allowed other researchers to find connection to math learning. The acquisition of math knowledge is not always directly taught in one context as one procedure. Borasi (1988) and others began to look at the parallels between acquiring English and acquiring math content knowledge. This initial acknowledgement of language and math spurred research in the area for the next two decades, but that research has yet to close the so-called language gap in math for ELs.

Common sense suggests math should offer an opportunity for ELs to achieve at an equitable level of success to their native speaking peers, but data refutes that assumption. NAEP (Perie, Grigg, & Donahue, 2005) has reported that the nation's fourth grade ELLs perform at a much lower level than their native English-speaking peers. Only 54% of this group achieves the basic proficiency level in math compared to 89% of native English-speaking students (Perie, Grigg, & Donahue, 2005) Ideally, ELs should perform similarly to native English speakers in math if there was truth to the universal

language myth. However, achievement in math, although a smaller gap than in reading, remains significant for ELs. The answer may lie in the language. Examine Figure 2 below to notice only one small way where confusion may lie. This example is only one of many ways in which ELs lack of language or pronunciation can affect their cognition or achievement in math.

Math language creates interesting challenges for ELs. One is the frequent use of symbols. Symbolic elements carry high amounts of semantic value in math and must be accurately interpreted for students to achieve effective oral language discourse (Zwiers, 2008). Students must interpret symbols, discern meaning, and then produce oral or written language associated with these symbols. Look at the following example:

$$25 > 12$$

"Twenty five is greater than 12."

$$2.5 < 12$$

"Two and five tenths is less than 12."

The numbers and symbols involved in those problems and the background knowledge necessary to make meaning of those two expressions is difficult for students to explain precisely. The cognitive load is low, but the language load is high. Supporting students to interpret these symbols and the conceptual understanding is paramount to their oral language development and their math achievement.

This is an example of where ST Math or other technologies could help the EL student demonstrate their math content understanding with clicks and puzzle completion. However, if we only look for mastery in the technological format and ignore the language necessary to explain, then ELs' needs are not being met. Swain (2004) developed an

output hypothesis for language development that claims students need to orally produce language around content to achieve conceptual understanding. The equations above represent an opportunity for students to develop the math language associated with comparing values of two numbers. Connecting Swain's (2004) output hypothesis to these visual online programs, there must be a component for oral language output if ELs are to achieve conceptual understanding of the content. Explanation and understanding are now expected in math classrooms. Online programs, like ST Math, that provide visual tools and manipulatives where ELs find solutions are not meeting the needs of the entire student.

Multiple meaning words also present difficulty for ELs in math. Common terms like *difference, odd, positive, plane, factor*, and *expression* have specialized meaning in math (Zwiers, 2008). ELs have background knowledge of these words from other domains. These terms already have meaning in informal areas of their language development such as at home or in social contexts. Negotiating that meaning to incorporate a new definition of the term in math class is essential for ELs but elusive to master (Barrow, 2014). Providing visuals to support meaning making is an essential support in this process. Additionally, homonyms like the ones listed below demonstrate how pronunciation and listening can affect student meaning in math. Figure 2 shows a list of common homonyms that cause issues for ELs in math.

whole – hole	eight – ate	sum – some
two – to – too	symbol – cymbal	sides – size
tenths – tents	half – have	real – reel

Figure 2. Listing of common homonyms in math (Roberts & Truxaw, 2013)

Lastly, the structure or syntax of math language, how the words are put together, presents both challenge and opportunity for ELs. The skilled math or language teacher, equipped with effective strategies or supports, can use the brevity of math talk to teach traditionally literary elements of language simultaneously within the structure of math. Schleppegrell (2007) highlights the work of M.A.K. Halliday and his groundbreaking discussion of the *mathematical register*. Halliday explained that students' everyday language plays a role in explaining math content, but these everyday words may change meaning in math, which could be a result of syntactic variation. Schleppegrell (2007) also highlighted that the math register is not necessarily adding new words to a student's vocabulary, but rather using the correct meaning of the word in the correct register. Consider a student who uses the word *bigger* to compare numbers. They are using everyday language to describe the relationship between two numbers. *Fourteen is bigger than 10*. However, this use of *bigger* is not part of the math register, because bigger can mean a different comparison than greater in value. Figure 3 shows a visual of the exact language the student is using, but the student is trying to say that 14 has more value or is greater than 10. By using *bigger* they are not precise in their math discourse.

Figure 3. Number size visual

Teachers must be able to acknowledge the math understanding of students using the word "bigger" and support construction of an accurate math register at the same time. This

type of instruction leads to better understanding of math and furthers the EL's language development.

Common Core (2010) expects students to move away from everyday language to a more mathematical structure of discussion. They must master the math register but that only comes with practice in their own everyday language (Moschkovich, 2015). Technical vocabulary, dense noun phrases, implicit logical relationships and conjunctions with specific meaning are some of the grammatical patterns students encounter in math classrooms that make it particularly difficult to talk about math in academic context (Schleppegrell, 2007).

In light of these challenges, research indicates that EL students involved in discussion around math tend to perform better over time (Valle, Waxman, Diaz, & Padrón, 2013). While planning lessons and activities math teachers must incorporate oral language strategies to allow students to experience using language to explain the math in their own words while at the same time supporting their growth towards more academic talk (Moschkovich, 2012). This language may be messy and imperfect, but as Swain (2004) and Moschkovich (2007) both claim, this messy language can lead to more conceptual understanding.

Math teachers can no longer hide behind the numbers. Active learning environments where group work, mathematical games, and pair work are a regular part of the routine allow students to grow and explain their thinking by having the space to negotiate meaning with teachers and students (Valle, Waxman, Diaz, & Padrón, 2013). Oral language supports, visual models, sentence stems, realia, and other strategies

common in ESL practice also help ensure language development in math classrooms (Echevarria, Vogt, & Short, 2004) and possibly close the achievement gap for ELs.

The focus of the modern math classroom must be on reasoning and thinking. Students can actually have negative achievement and learning outcomes when communication in math is limited to one word answers or phrases that fail to explain the process of thinking (Kang & Pham, 1995). Kang (1995) demonstrates that students need to be precise in their thinking when explaining to teachers and peers, but as Moschkovich (2012) claims in her research, precise explanation of math content does not necessarily mean students use perfect language and vocabulary. This is indicative of Halliday's ideas and the output hypothesis put forward by Swain (2000). The achievement of precise language in math does not always result in students using the specific vocabulary pre-taught in the lesson. For example, a student could explain in precise terms what a denominator is by using symbols, pictures, gestures and other words to explain the meaning to others in the classroom without ever using the word denominator. If math language focuses on that term as the standard and leaves behind the conceptual understanding of the math content objective, then opportunities for growth in both content and oral language production are missed.

These are not new pedagogical ideas. NCTM released a statement in 1991 that said, "when students…reason about mathematics, ideas and knowledge are developed collaboratively, revealing mathematics as constructed by human beings within an intellectual community (NCTM, 1991)." Math pedagogy is just finally catching up to long-standing recommendations of NCTM because of Common Core (2009). Forcing

pedagogical shift in math classrooms is something EL education has pushed for nearly three decades.

Technology, blended learning in the EL math classroom

If you have kids, teach kids or have interacted recently with kids then you possibly noticed that learning is changing before our eyes. Students are exposed to screens constantly and, according to Goodwin-Jones (2005), their mastery of technology has turned them into "digital natives." These "natives" are more comfortable with technology, computers and learning from technology than Goodwin-Jones' "digital immigrants," which include teachers and leaders in education. Another example of the changing math classroom can be seen with the implementation of more online games and technology to support student learning using technology where student have some control of their learning (Neumeier, 2005). Computers and technology have the capacity to force change in education with their influence as a powerful aid to learning math (Moreno, 2004).

Valle (2013) claimed that increasing access to and teaching students computer programming promotes student conceptual understanding and application of mathematics. Additional research demonstrates online curriculum, whiteboard technology and other gaming systems can impact math achievement and problem solving (Coyle, Yañez, & Verdú, 2010; Crawford, 2013; Lopez, 2010). Research in this area suggests that when using technology effectively students significantly increase math achievement in data interpretation and problem solving. At the same time, the technology increased the students' interest in math. Motivation in math is essential for student engagement in language learning and when technology can be combined with

language learning and math, then educational institutions are meeting the Common Core State Standards for Mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These components must work together in order to meet the needs of all learners in today's math classrooms.

Many technologies exist for students to use in math class and some are even designed specifically for ELs. One program that consistently showed up in the research was HELP Math, an online math program designed for ELs using SIOP (Echevarria, Vogt, & Short, 2004) as a guide to instruction (Demski, 2009). The program teaches math content with visuals on the screen but builds in language, syntax and vocabulary to help students learn the language as they complete the lessons (Crawford, 2013). HELP Math has seen student growth in the area of math as a result of their SIOP-modeled online curriculum, but there was no other software to judge its comparative effectiveness (Moreno & Durán, 2004). The study focused on how teacher verbal guidance impacted student growth in math in coordination with the online curriculum. Results suggest HELP Math can have positive impact on both language and math content growth, but primarily when teachers verbally guide and assist the students while students work on the curriculum (Moreno & Durán, 2004). This research concluded, "verbal guidance in addition to visual and symbolic representations helps students understand the complex arithmetic procedure better than having students discover the relationship between the multiple representations on their own" (Moreno & Durán, 2004, p. 501)

It must be noted that HELP Math is a program specifically designed for ELs. Other sites that are not using this program are still supplementing math curriculum with other online content. Some of this content may be connected to the district's curriculum,

some may be other designated supplemental online content like ST Math, while others may be only supporting content with unproven math games online that focus less on math and contain advertisements that serve as distractors for students. HELP Math is designed specifically for ELs, a rarity in the online math content area; however, with effective language supports, other programs like ST Math could help support language with little change to the content. Blended learning in the math classroom could be a structural option that supports language development and content understanding simultaneously.

Blended learning occurs when part of a student's instruction comes from teacher interaction and part of it comes from online content (Horn & Staker, 2011). Although definitions vary, blended learning should allow for self-directed learning of content in an online or technological format. Teachers may set the content structure for students in the online environment but students can move at a pace that is comfortable or appropriate for them. "Blended learning should be viewed as a pedagogical approach that combines the effectiveness and socialization opportunities of the classroom with the technologically enhanced active learning possibilities of the online environment, rather than a ratio of delivery modalities. In other words, blended learning should be approached not merely as a temporal construct, but rather as a fundamental redesign of the instructional model" (Dziuban as cited in Watson, p. 5, 2008).

Technology and games are forcing this shift and cannot be ignored in today's language learning or math content environments (Goodwin-Jones, 2005). Twitter, online games, iPhones, interactive white boards and other tools that students have access to present enormous potential to classrooms. Goodwin-Jones stated, "Interestingly there are some intriguing parallels between gaming and language learning in the use of roles,

improvisation, codes and negotiated meaning. Multiplayer games tend to encourage cooperation and communication" (p. 20, 2005). Technology is a resource that students use to discuss and communicate around and if teachers are not using these technological tools effectively in the classroom, then opportunities to connect curriculum with innovation and motivation are being missed.

For over a decade Computer Assisted Language Learning, or CALL, programs have been implemented in EL environments to help teach students syntax, vocabulary, and pronunciation with the use of computer technology in the classroom (Grgurovic, 2011). Students use the computer programs to help them learn language with and without teacher assistance. Studies show mixed results, and for our purposes only serve as background information on historical uses of technology in the language-learning environment. These CALL programs were designed to develop language skills and deliver content to EL students in a blended learning format (Grgurovic, 2011). Blended learning has been a part of the EL classroom for many years, and although this is new in math, the concept of content and language learning using technology is not new.

The blended learning discussion in education usually centers on middle and high school students. Students receive instruction at school, but then also supplement their courses with online content that allows for student control over at least part of the content (Horn & Staker, 2011). However, this *Oral Language Strategy Guide* looks at blended learning in an elementary environment. More supplemental materials are necessary to support blended learning in these environments as the model shifts down into elementary schools and students are increasingly exposed to online content.

Blended learning environments counter traditional instruction and look at learning and teaching math differently for all students. Blended learning does not only represent a new model for online learning but rather is indicative of a larger pedagogical shift from teacher-centered classrooms to a more student-centered approach. This pedagogical shift and the research done by Demski (2009) and Crawford (2013) on HELP Math both support the argument that teacher support remains essential in these blended classrooms. Much of the current discussion around this support involves math content, but as indicated by Common Core (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) teachers are expected to be simultaneous language teachers in math. An *Oral Language Strategy Guide* for ST Math is a necessary support for this component of the technology station in blended learning math classrooms. There are other programs out there to engage students in content using technology, but ST Math is unique because of its reliance on visual models instead of language.

Why ST Math

ST Math is a discovery-based math software program designed as an inquiry model of natural learning through exploration. JiJi the Penguin is the student's digital guide through mathematical content where students learn by playing a game where directions are not provided in written or oral form. ST Math is designed for all learners. The lack of language involved in the program along with the rich visual animation of math concepts allow students to take mathematical risks and receive immediate visually animated feedback on the mathematical puzzle. Aiming to develop conceptual understanding of math without the use of words or linguistic demands, MIND Research

(1997) claims ELs can learn and access the math before learning the language. This conceptual and visual understanding, according to MIND Research, can then support future language development in math (Rutherford, et al., 2010). This claim is unsupported by current research evidence, but fits with pedagogical understandings of second language development theory and practice. ELs need experience with content to talk about it.

WestEd (Wendt, Rice, & Nakamoto, 2014) conducted a study of ST Math's effect on student achievement in math in California. Using grade levels as the unit of analysis, WestEd looked at data from 463 grades in schools from 2nd through 5th. Overall, 212 schools were included in the study and WestEd compared schools and grades that had ST Math and those that did not (Wendt, Rice, & Nakamoto, 2014). The study revealed significantly higher levels of achievement on the statewide math test for those students who completed more than 50% of the content in ST Math for that particular grade level. Unfortunately, data was not available for the subgroup of ELs in California, but considering the size of the study and the fact that nearly 43% of all California public school students are designated EL (California Department of Education, 2016), it is possible that ST Math also had a positive affect on EL math scores.

Mind Research CEO's Dr. Matthew Peterson's claim (2011) that visual understanding of the conceptual mathematics in ST Math can provide stronger language skills remains unsupported, and future research on this topic is paramount for an understanding of ST Math's influence as a language tool in math. However, the results of the WestEd (2013) investigation in California suggest a possible connection between ST Math and language development in students. Language and thinking are linked and it

is clearly demonstrated that without language in place cognition is limited (Barrow, 2014). Therefore, in order for significant gains to be achieved in math, language played a role even if it was indirectly. By creating an *Oral Language Strategy Guide* to build on this connection, this language connection may result in even higher gains mathematically, but also support ELs' language development. An *Oral Language Strategy Guide* provides a bridge for these two needs.

ST Math's use of discovery-based learning and purposeful omission of language in its content represents a current online curriculum that assumes students can learn math content using a discovery method with little or no language support. This paper does not dispute that claim but rather attempts to build on ST Math's success. In EL teaching, students should not have high language demand with high cognition demand. When a student struggles with a math concept, producing language, especially a second language, to make sense of that would be extremely difficult. Ideally, teachers seek a lower cognitive demand with a higher language demand or a higher cognitive demand with a lower language demand. By utilizing the visuals effectively as language support ST Math can accomplish this goal with the proper structure and support. The *Oral Language Strategy Guide* is essential for teachers to harness that potential language and conceptual learning in math.

Moreno's (2004) and Demski's (2009) research on HELP Math, a separate online program, support some level of teacher or verbal guidance necessary to increase language functions with the online math component. ST Math has no such support built in to address language usage needs that is based on EL theory and practice. An *Oral Language Strategy Guide for the Blended Learning Math Classroom Using ST Math* is

necessary for EL students using ST Math as part of their math content if they want to learn language concurrently. Although ST Math is a drastically different program than HELP Math, they are both online content structures that could be used in blended learning math environments. Research (Moreno & Durán, 2004) on HELP Math provides a clue as to how verbal guidance or supports could also affect the language development of students using ST Math.

For blended learning to work in elementary schools, content is needed that encompasses "hundreds of hours of high-quality dynamic content aligned to standards such that students can stay powerfully engaged during the school year and across years" (Watson, p. 5, 2008). ST Math fills this need as a curriculum that delivers math content from K-12th grade. ST Math contains content for all math standards at the elementary level. Additionally, ST Math, with its extensive collection of visual supports and feedback, can support students' oral language production with strategies, lessons and activities designed to support that language growth. An *Oral Language Strategy Guide* could bridge the conceptual math content with the language of math to demonstrate understanding of concepts.

The creation of an *Oral Language Strategy Guide* is not intended to change the pedagogical foundation of ST Math to a more teacher-guided approach, but rather suggests that using positive content growth data from the WestEd (2015) research and building optional oral language supports could enhance ST Math's overall effectiveness with ELs specifically. Any program being used for math with EL students must also provide the opportunity for language proficiency growth (Moschkovich, 2012). This *Strategy Guide* supplements the blended learning classrooms using ST Math, helps

teachers and students use oral language effectively around the visuals of ST Math and accomplishes the goals set by NCTM (1991) and Moschkovich (2011).

Technology as a Tool

The use of technology in a classroom is a powerful tool that can improve instruction and enhance learning opportunities. One technological tool, the Interactive White Board (IWB), a manipulative board that acts as a white board or chalkboard for teachers that can potentially include animation, video, interactive visuals and student engagement, has been effective at improving EL content knowledge and understanding in math (Coyle, Yañez, & Verdú, 2010) In a study that measured EL achievement in math during the first year of implementing IWB technology at a large district in Texas, ELs grew in both math content and language proficiency (Lopez, 2010). Teachers were provided training on the tools involved in using the IWB and were expected to use the IWB during instruction. Results demonstrated that growth was stronger in those classrooms where the teachers were more skilled at using the IWB than in others with less skill (Lopez, 2010).

Teacher responses to surveys demonstrated a belief that the IWB was a catalyst for math discussion in their classrooms because of the accessibility of content through visual display (Coyle, Yañez, & Verdú, 2010). These discussions involved multiple speaking and listening opportunities and were important to creating language output venues for non-native speakers. The IWB can provide visual context for students that are multisensory and uses multimedia to motivate students as well (Lopez, 2010). After the first year of implementation in this district, parity was achieved between EL students in these "digital learning classrooms" and native English-speaking students in regular

classrooms (Lopez, 2010). In other words, the IWB in EL classrooms was effective for EL content growth and math discourse; however, in native English-speaking classrooms that also used the IWB technology there was a rise in proficiency and achievement as well, which ultimately results in similar gaps of achievement (Lopez, 2010).

This same research also shows that technology is not a "silver bullet" that can automatically improve teacher instruction or student performance (Lopez 2010). Evidence that technology can have negative effects on student learning is not well publicized but does exist in education. Teachers who were not skilled at using the technology did not see as many gains as those who learned to master the IWB's components (Coyle, Yañez, & Verdú, 2010). Not all technology benefits student learning and even the best tools can be misused or go unused in the classroom environment. Lopez (2010) and Coyle (2010) both highlight solely putting the tool (IWB) in the classroom does not improve outcomes for ELLs. The ST Math tool needs manipulation, application and mastery of the teacher user to become a fully effective support for students.

Using realia, visual models and other manipulatives has long been common ESL practice in language learning, and these are also mainstays in any good math classroom (Zwiers, 2008). As manipulatives and conceptual models become more digital, tools like ST Math and Interactive White Boards allow teachers and students more opportunities to manipulate visuals and experience content. The IWB and ST Math both encourage students to move items around, change pieces, manipulate shapes and highlight items. These tasks help create meaningful language experiences and discourse. The research on the IWB, one tool of math instruction, helps support the theory that mathematical

discussions using technology and discovery-based math games like ST Math could improve with proper teacher support. Lopez's (2010) research also demonstrates that as teachers practiced and increased their skilled use of the IWB, it improved their teaching and they saw better results. This increased effectiveness and usefulness of ST Math could have similar effects.

The proposed *Oral Language Strategy Guide* adds to the effectiveness of ST Math by increasing the usefulness of the tool for teachers. ST Math can be effective when used in specific ways with specific students, but it can also act as a technological babysitter for teachers as they work with small groups of students. Students play the games independent of teacher instruction or awareness and never connect their online mastery to classroom success because they don't talk about their learning. ST Math is designed to remove the language barrier for math instruction; however, that does not mean it removes all barriers to math content for EL students. By expanding ST Math's scope into other areas, such as language, teachers can connect the content of JiJi to more students by allow oral language production to be a result of the conceptual knowledge gained from the visual games the program provides. ST Math presents content visually to students in a way that teachers can't, and that use of the tool can free teachers to focus on other mathematical or language tasks. Teachers have tools of technology available to them and with ST Math they have a Swiss Army Knife, but they are using it as a can opener. This *Oral Language Strategy Guide* allows access to more parts of the ST Math tool, therefore making it more useful to teachers and students.

Oral language development in math

ESL instruction in math is at a tipping point with instructional practice finally catching up with current research and recommendations. The Practice Standards in Mathematics (2012) connect “procedural fluency” and “conceptual understanding” (CCCS, 2012). Research shows cognition is improved with language proficiency in math (Alt, 2014); therefore, better curriculum that connects language, cognition and math content is paramount for ELs in today’s learning environment.

Moreno (2004) showed that verbal guidance is essential for student understanding of math concepts presented in multiple ways. Moreno (2004) understands that discovery-based multimedia games in math are designed to instigate and direct learning through learning by failing or trial and error. By using these games the students are learning to problem solve through digitally hands on, active learning environments where they are expected to solve math puzzles. However, Moreno (2004) highlights that educators must recognize that these discovery-based environments can also lead to misconception and frustration. It is possible, maybe even probable, that students complete content in ST Math but still won’t connect the visual to the conceptual understanding. Moschkovich claims, “Any tool without a person who knows mathematics there to interact with it will not develop an English language learner’s understanding of complicated mathematical concepts" (as cited in Demski, 2009). This is why verbal guidance, targeted language intervention, and oral language discussion are essential ingredients for the overall effectiveness of ST Math for ELs. When programs ignore linguistic and language schema development in math, they ignore a part of the learning process for ELs. The

math is difficult and the language of math is difficult, but teachers must address the challenges of both to achieve content mastery. This can be a messy process.

Messy language, messy math

Swain's (2004) output hypothesis of oral language explains that students need to speak and dialogue about the content. This dialogue is both social and cognitive, pushing learners to activate more thinking as they use language to convey meaning (Swain, 2004). EL students must be expected to talk about math and explain their thinking if cognition is expected to increase, but expectations of students to talk perfectly or use academic vocabulary should be modified (Moschkovich, 2012). The expectation for students to use vocabulary, syntax or even nouns correctly in math is difficult for ELs to achieve (Zwiers, 2008). However, student use of everyday language to explain math thinking does not make their math thinking incorrect. Students must get messy with their language in order to negotiate meaning and conceptualize the math. Messy language connects to ST Math's pedagogical foundation because when students play with JiJi they are expected to make mistakes and learn from those mistakes. By producing oral language around their thinking in ST Math students are getting messy with their math and their language simultaneously. Teachers and supports should be available to help them clean it up, but if students never experience the math or the language, then true conceptual understanding will elude them.

This idea also connects back to the original research that began when Borasi (1988) and others in the language learning community saw a connection between math and language acquisition. Based on Krashen's (1983) theory of acquisition this idea around getting messy with language and helping students do the same with math while

language serves as the vehicle could bring even more light to the idea that math content can be acquired as well with the use of language to describe the math. If this is the case then ST Math can provide that visual support for students to acquire language and math content simultaneously.

Sentence stems, graphic organizers, peer interaction, manipulatives, and realia support discussion and oral language growth in ELs (Echevarria, Vogt, & Short, 2004). These are absent in too many math classrooms, but they don't have to be. One reason for this deficiency is that not enough resources exist to support the new pedagogy. Combine this with blended learning and station learning in math, and the need for resources becomes imperative if there is any hope to bridge the oral language gap for EL students. Supports for programs like ST Math in the blended learning environment to increase oral language are in demand.

Students need to process oral information about math consistently and then use oral language to express their understanding (Crawford, 2013). ST Math can help EL students express their understanding and reduce the intimidation factor of orally starting a conversation due to the visual nature of the games, motivation to complete levels and lack of language involved (Rutherford, et al., 2010). When students play ST Math and complete content they are thinking mathematically, but they may not know it or be able to express it without teacher support or some other oral language support designed specifically to capture that mathematical thinking. JiJi the Penguin can only allow students to manipulate and discover the math so much before outside explanation of the connection becomes important to understanding the process of math. This is where the procedural fluency and conceptual understanding converge. Without verbal assistance or

oral language strategies to connect understanding of visual activities, Moreno's (2010) and Freeman's (2012) research suggests that this convergence of the procedural, the conceptual and the language may or may not occur for learners.

Visual Thinking Strategies

Visual Thinking Strategies (VTS) is a curriculum developed by Abigail Housen to help students increase critical thought transfer in students using art as the vehicle for change (Housen, 2002). The curriculum is deceptively simple yet extremely effective at getting students to talk and reflect on pieces of art. The curriculum is sequenced to build critical thinking skills and transfer those skills across content areas. VTS strategically orders the art presented to students, and docents or teachers are trained to guide students through an oral discussion by citing evidence for their thinking, accessing background knowledge, building on other's ideas, and critically making judgments and inferences about the story the artist may or may not be trying to tell. The curriculum centers around three simple questions:

What is going on here?

What do you see that makes you say that?

What more can you find?

Teachers and leaders allow students to answer those questions and then acknowledge their thinking and observations by recasting what they say while pointing to their highlighted evidence for their explanation (Housen, 2002). "These questions promote extended, careful and intricate observations. They focus learners, allow choice, require learners to be active, call for reflection, invite many kinds of responses as well as change

in responses, allow group participation, and elicit responses which provide a source of information and learning for further discussion" (Housen, p.101, 2002).

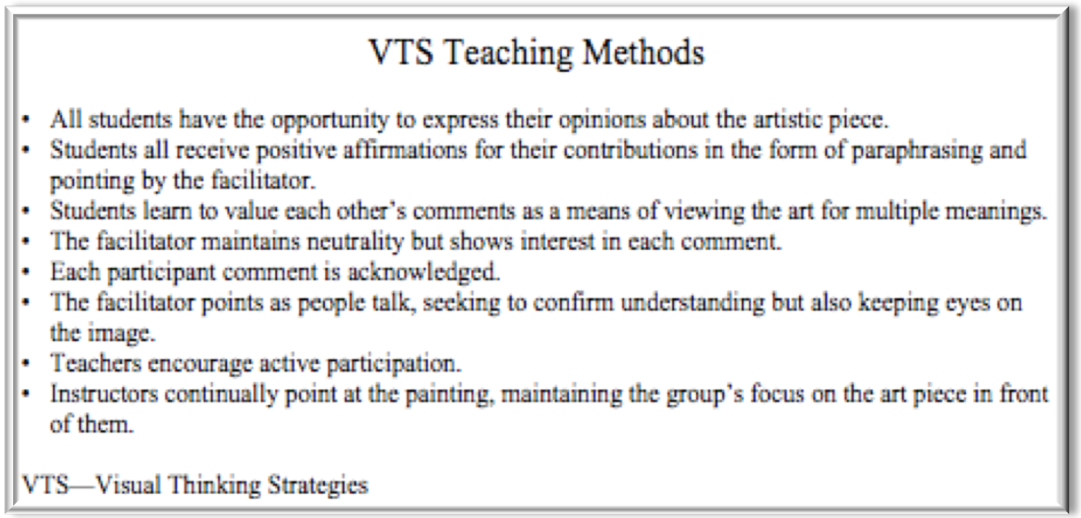


Figure 4. Description of VTS Methods

Research on VTS demonstrates the program's effectiveness at increasing critical thinking in students not only in art but other content areas as well (Housen, 2002). In a study done in Byron, MN, researchers designed and implemented a longitudinal study of two schools, one control and one experimental, in grades two and four. The study involved 52 randomly selected students in the experimental school and 47 in the control school (Housen, 2002). The study looked at numerous outcomes, but over a five-year period the primary questions were: *Could critical thinking increase as a result of VTS?* and *Would that lead to context and content transfer for those students?* (Housen, 2002) Using dialogue about content, evidentiary reasoning and material object interviews the study attempted to capture critical thinking transfer.

The results were clear for these two areas. Both the control group and the experimental group had increases in critical thought transfer over the 5-year trial, but in

both cases the experimental group had statistically significant differences demonstrating higher mean content and context transfer as a result of the VTS curriculum. This critical thinking increase was achieved and measured with oral language produced by students. The full curriculum of VTS is not available to all teachers, but the concept of simple questions to access student language and recasting student responses is a strategy commonly used in ESL environments to reduce the cognitive load and increase the language output.

Even more encouraging than the Byron, MN study was a similar study performed by Housen and VTS with students in San Antonio, TX. This study was only performed over a two-year period, but students who had access to VTS in grades 3-5 significantly outperformed students who did not in critical thinking skill development (Housen, 2010). Since the San Antonio school district has a large EL population, this data supports the theory that this strategy can work for EL students. Housen was able to conclude that speaking another primary language other than English did not interfere with VTS' ability to increase critical thinking skills or language used to measure those skills (Housen, 2007).

Finally, research on Housen's VTS demonstrated higher achievement on standardized tests with the experimental group. The data shows that a jump in test scores occurs for many students between year 1 and 2 of the implementation and those students remain above the state average at a consistent rate. This data also suggests that the content and context transfer helps students achieve on more generalizable measures of achievement, which could support larger gains for students using ST Math and VTS as a

strategy with the program. Figure 5 below shows the growth students made in the VTS program specifically after year one.

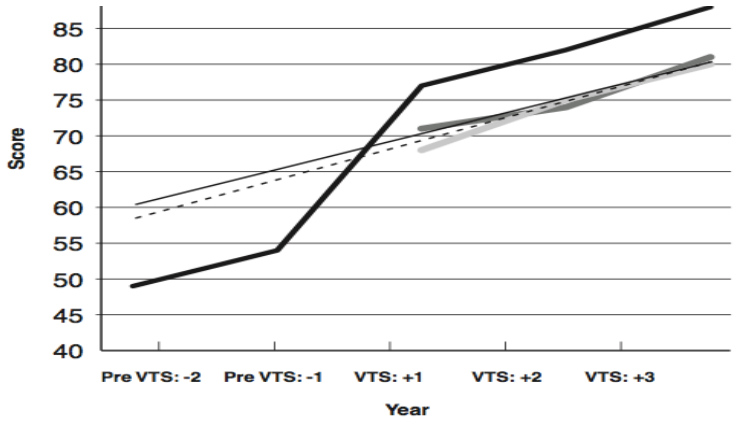


Figure 5. Pre/post VTS test scores chart

All this data points to an increase in thinking as a result of the VTS curriculum, which is promising for other applications. An assumption of this capstone is that a modified version of this VTS curriculum combined with the visuals of ST Math could significantly increase language production and thinking in EL students with proper teacher support. This is why the *Oral Language Strategy Guide* is rooted on a modified version of VTS as a primary strategy for oral language development or production in blended learning math classrooms that use ST Math.

Everyday language versus academic language

Moschkovich (2015) claims that students need to feel comfortable using everyday language when they talk about math. She suggests that students use manipulatives and visuals to support their oral language production, but that they should be talking about math even if they are not using math academic language. This claim by Moschkovich (2015) suggests that EL students must have freedom to make mistakes and examine the

nature of the math (and language) they are trying to solve without fear of grammar rules or pronunciation getting in the way. Students need simple ways to begin talking about math so they can build up to the more specific vocabulary necessary for quality math discussion. Quality supports for online content are essential to help with this process.

Investigating research around math, language and EL teaching is a difficult venture. Math has repeatedly been characterized as the universal language (Moschkovich, 1999; Barrow, 2014; Demski, 2009), but for decades ESL researchers (and teachers) avoided math and instruction in mathematics because the primary focus of Second Language Acquisition (SLA) was on literacy, language production, syntactic structure and acculturation (Borasi, & Agor, 1988). However, with the CCSS' (2010) emphasis on conceptual understanding and explanation of math concepts, a significant focus has been placed on the language of math in EL instruction and learning (Moschkovich, 2013)

ESL instructional strategies rely on the idea that the way to build oral language is through visuals and experience (Robert-Mitchell, 2013). Quality visuals provide students with the spark necessary to speak about their learning. Math visual representations and symbols are imperative for students to understand and talk about math (Aso, 2001), and it has been mentioned that realia, graphic organizers, feedback, etc. are all a part of the ESL teacher toolbox. However, in math, ESL teachers and classrooms are not as prepared for math instruction to connect with language instruction (Kareva, 2013). Since language teachers are not always as skilled in mathematics content instruction, there is a tendency for them to focus on form, grammar, vocabulary or conventions when working with students in math. This focus on correcting or perfecting the speaking before the thinking

in math discussions may not be ideal to create mathematical thinkers or speakers (Moschkovich 1999).

Findings indicate linguistic ability relates to numeracy as early as kindergarten. Kleemans (2011) research on cognitive ability, working memory and linguistic proficiency found that early numeracy skills are dependent on language development. This research was limited to K/1st graders, and it is still unclear on how this connection affects later numeracy skills. However, Kleemans (2011) was willing to conclude that since students are using working memory and phonological skills to retrieve information to count on or to solve a problem, then there is likely a connection as problems increase in complexity over the primary schooling years.

Summary

This chapter examined research and current literature to suggest that an *Oral Language Strategy Guide* for use in blended learning math classrooms that use ST Math could help EL students simultaneously achieve language proficiency and math content mastery. The chapter highlighted the success of students using ST Math as an online, supplemental math program by improving math proficiency for EL students (Rutherford, et al., 2010) and that VTS, an art-based thinking curriculum, helps EL students grow their critical thinking skills across content areas by speaking with more complexity over time about specific topics (Housen, 2007). These findings suggest that due to the visual nature of ST Math and the simple procedures involved in VTS that an *Oral Language Strategy Guide* should be produced to help ST Math and teachers meet the new oral language demands placed on EL students due to Common Core (2010). This marriage of VTS and

ST Math could have positive implications for EL students who use the program in both language development and math.

Significant time was spent on Moreno's (2004) research on verbal guidance using discovery-based multimedia math programs and Swain's (2004) work on oral language output. Although Moreno's (2004) research was not on ST Math specifically, findings suggest that students can make gains in math using online programs independent of teacher guidance, but with limited teacher guidance or verbal support those gains increase significantly and oral language production also increases for those EL students (Moreno, 2014). Swain's (2004) oral language hypothesis about how producing oral language can increase cognition was explained. By using oral language output hypothesis and the visuals of ST Math the cognitive demand of language could increase the cognition in the content area.

Looking ahead, chapter three explains the methodology of creating an *Oral Language Strategy Guide*. Chapter four presents the *Oral Language Strategy Guide for use in the Blended Learning math classroom that uses ST Math*. Strategies, lessons and activities are prepared for classroom use to help support students in math content, oral language and dialogue. Using graphic organizers, peer interaction, recasting, visual manipulatives, sentence stems and other supports the *Guide* outlines specific supports and strategies for use with ST Math in the blended learning math classroom.

Chapter five articulates reflections produced as the activities, lessons and strategies were under development. These reflections involve discussions with other educators, ideas discarded and feasibility issues that arose during production.

CHAPTER THREE: METHODOLOGY

Many opportunities for student interaction, communication, and dialogue in math are missed by teachers looking for the right answer instead of the right thinking. ST Math helps students see their thinking but does not allow them to explain that thinking orally. This gap between math thinking and language learning is why the following question must be addressed. *How can an oral language strategy guide be developed to supplement the blended learning math classroom that uses ST Math?* As outlined in chapters 1 and 2, using language, technology and visuals to support ELs during math time is essential to their overall success in math class. Chapter three examines how this strategy guide was created to support ELs' oral language development with ST Math. Using the Principles of Math Instruction for ELs (Moschkovich, 2013), a modified structure of the VTS (Housen, 2002) questioning techniques, and assumptions about EL cognition based on Swain's output hypothesis, this *Strategy Guide* blends ST Math, EL instructional supports, and blended learning models of instruction to meet the dialogue needs of the modern math classroom.

EL instruction in math has been limited and districts have avoided models where EL teachers support students in math class. This lack of guidance on how to support language in math results in reduced EL teacher proficiency in the content area, which then results in ELs with little or no language supports in math. In creating this *Oral*

Language Strategy Guide, a fundamental assumption was that ST Math could effectively teach math content while the teacher can focus on the language. This guide provides the teacher with ways to incorporate language around the math content available in ST Math.

Principles of Math Instruction

The *Principles of Math Instruction for ELLs* developed by Judit Moschkovich (2013) act as an advocacy document for EL students in math. In addition, these four principles are honored in the completion of this *Strategy Guide*.

Principles for Mathematics Instruction of ELs (Moschkovich, 2013, p. 12-13)

1. Focus on students' mathematical reasoning, not accuracy in using language.
2. Focus on mathematical practice, not language as single words or definitions.
3. Recognize the complexity of language in mathematics classrooms and support students in engaging in this complexity.
4. Treat everyday and home languages as resources not obstacles.

Throughout the development of the *Oral Language Strategy Guide*, these principles and the Common Core Standards of Mathematical Practice (2009) are consistently referenced. These two documents guided the creation of the *Oral Language Strategy Guide* for use in the blended learning math classroom that uses ST Math.

This strategy guide is different from a specific math curriculum for ELs. Designed to support teachers and classrooms at the elementary level, this guide helps both ELs and native English speakers share the learning environment. The guide assumes that all students need oral language support in math and uses ST Math to help them acquire that

language. Usefulness to the educator is paramount for this guide and teachers can take or leave what they want from the guide to use in their classrooms one time, occasionally, or consistently. All strategies must meet three criteria.

1) Strategy must encourage oral language production in students.
2) Strategy must be accessible to all students.
3) Strategy must align with the Common Core Standards for Mathematical Practice (2009) and the Principles of Mathematics Instruction for ELLs (Moschkovich, 2012)

Description of Setting

Minneapolis Public Schools is an urban school district in Minnesota and serves more than 35,000 students. Twenty four percent of the population receives ELL services currently, but many other students have been exited from ELL services. The district is comprised of 33 elementary schools, 7 middle schools and 8 high schools. All elementary schools in the district are implementing Guided Math with a blended learning component, but only 25 have access to ST Math as a resource.

Lyndale Community School in Minneapolis, MN is a public elementary school that enrolls 581 students from diverse backgrounds. Seventy percent of the students at the school qualify for free or reduced lunch, forty percent receive EL services, and five percent are homeless. The school identifies primarily with the Somali culture and has historically been a place where Somali families choose to send their students. In recent years the school has grown its white, Hispanic and other African American populations to become a truly diverse learning environment that serves PK-5th grade students.

This *Strategy Guide* is designed for the 4th and 5th grade math classrooms where 167 students use ST Math in a blended learning math environment. Students of varying abilities in both math aptitude and language proficiency all use ST Math as a technology station in Guided Math.

The expectation from the district is that all math classrooms are moving to a Guided Math model with technology as a component of instruction. All schools are using a technology station in math and 25 out of 33 elementary schools have access to ST Math for this purpose.

Like many schools in the district, access to technology remains a barrier for students at Lyndale. Getting enough iPads, computers or tablets in a classroom to implement blended learning with ST Math can be a challenge. However, the 4th and 5th grade classrooms at Lyndale should have adequate technology to implement ST Math as a station in the blended learning math classroom. The development of this *Oral Language Strategy Guide* involved no human participants directly.

Strategy Guide Rationale, Goals and Development

Chapter 2 explained why the need for simultaneous instruction of ELs in math and language is paramount for schools and educators today. This *Strategy Guide* supports teachers who use ST Math as a station in their blended learning math classrooms. ST Math is a standards-based program designed for all students, but the visual nature of the games makes it an ideal candidate to help capture oral language and explanation from EL students. The animation reduces the language load but maintains the rigor of math with the game. Factor in that technology motivates students to use their second language and this combination appears to create a unique opportunity for oral

language development in ELs. We know that technology offers opportunities for language interaction with teacher, peers and themselves about mathematical patterns, representations and concepts with the support of visual animation (Ganesh and Middleton, 2006 as cited in Crawford, 2013); however, ST Math does not currently have a language component for EL students or specific supports for this population. This *Strategy Guide* creates a resource schools and districts can use with ST Math in efforts to obtain an instructional double dip scenario where students are improving language proficiency and mathematical understanding simultaneously.

This *Strategy Guide* is primarily designed to utilize ST Math's visual animation of mathematical content as a bridge for oral language output for ELs at Lyndale School in Minneapolis. Using the model of Guided Math in a blended learning classroom, the *Oral Language Strategy Guide* helps facilitate effective discussion and conversation, or as Swain (2004) calls it, "dialogue" in math. Teachers need resources to unlock this talk in their classrooms and with this accessible *Strategy Guide*; teachers can use ST Math as a catalyst to simultaneously teach math and language.

Additionally, an essential goal of the *Strategy Guide* is to encourage ELs, native speaking students, and all students to negotiate meaning of mathematics through talking about math using both everyday and math language. Based on research presented, language learning and math thinking are tied together and the more students talk about math, the better they are able to engage in the complexities math language and content present (Alt, 2014). This *Strategy Guide* assumes that ST Math teaches the complexities of the math, while the teacher uses the strategies to help students with the complexities of the language.

Based on the guiding principle that all students, non-EL and EL, are learning math language this Guide is designed to accommodate both types of learners. Therefore an emphasis on language in the math classroom will not only increase the thinking of EL students but also raise the rigor for all students in the content area. This inclusiveness allows teachers to use the Guide more broadly and increases its usefulness in the classroom. A final goal of this guide is to support math discussions between different language proficiencies about the visuals of ST Math. By supporting both ELs and non-ELs, this *Strategy Guide* encourages discussion and rigor instead of remediation and exclusion.

The *Oral Language Strategy Guide* is formatted and structured for maximum usefulness to teachers with each activity, strategy or lesson being one page front and back. The Guide was published on a blog as I created the lessons, activities and strategies for use in the blended learning math classroom that uses ST Math. Each strategy was titled and numbered for easy reference. Using the word strategy broadly, the *Strategy Guide* highlights opportunities for teachers to teach specific lessons around big ideas in math language (i.e., the number line, sequence words, compare and contrast statements) that can be supported directly with ST Math.

Strategy Guide Usage Guidelines

The *Strategy Guide* assumes teachers include the following components in their daily math classroom:

- A short opening or mini-lesson,
- A work period with station learning
- An Interactive White Board display for whole group discussion

- Tablet type devices for student use, and
- A closing at the end of the math period.

The *Oral Language Strategy Guide* is formatted and designed to support whole group, small group, and one on one instruction. The table below shows how the Guide's activities could be used with each type of instruction. Table 1 below describes how the Guide may be used in the classroom.

Type of Instruction	Possible uses of Strategy Guide
Whole group	Openings, closings, community building activities, share outs, think alouds
Small group	Peer interaction supports, graphic organizers, partner work, cooperative game play
One on one	Interviews, journaling, language intervention support

Figure 6. Possible settings for Strategy Guide Usage

Oral language stems, graphic organizers and language objectives guide many activities to incorporate the math content into the structured use of language. As stated throughout this capstone, math classrooms should not seek only perfect language with ELs in math, but rather focus on precise math statements using students' own words in a second language (Moschkovich, 2012). Peer interaction, metacognition on their own language usage, cloze activities, peer assessment of their classmates and evidentiary writing are all a part of the *Oral Language Strategy Guide*. However, the "Notice—Think –Do" Strategy (Number 1) is the foundational support for rigorous language production for ELs at their level. The *Strategy Guide* designs activities for all EL levels of proficiency to access the everyday language of students.

Reflection Process

Creating something new and useful to many teachers in Minneapolis and possibly throughout the country is an exciting process. According to MIND Research (2015), eight hundred thousand students use ST Math as a part of their math content around the country, with about 5,000 using the program in Minneapolis Public Schools. This *Oral Language Strategy Guide*, if used effectively, provides simple and accessible benefits to many ELs and their teachers across the country.

Activities were posted on a blog available to teachers at Lyndale and other Math Specialists in Minneapolis Public Schools. Strategies and all the components (flipcharts, graphic organizers, worksheets, etc.) were posted as they were created. Teachers are able to use the activities in their classrooms and are encouraged to modify, supplement and comment on the functionality of the *Strategy Guide* in their classrooms. Designed to promote self-reflection, none of the professional feedback was used directly for the creation of this *Strategy Guide*.

The essential question remains, *How can an oral language strategy guide for use in blended learning math classrooms using ST Math be created?* This chapter attempted to show how this document supports students and teachers in whole group, small group and one on one interaction. The primary aim of this *Strategy Guide* is for ELs to be a part of a language rich environment where oral interaction is encouraged and supported. The *Strategy Guide* supports the internal and external dialogue necessary for cognition as students play the games of ST Math.

Chapter four is reserved for the development and publication of the *Oral Language Strategy Guide* and contains the actual strategies, lessons designed to improve

and promote oral language development in the blended learning math classroom using ST Math. These strategies are based on research into effective oral language strategies, background knowledge of student interactions with ST Math in a real classroom context, and personal reflections. Some strategies are generalizable to the whole math classroom while others are specific to standards for mathematical development.

Chapter 5 shares and reports on the process of creating this *Strategy Guide* by reviewing notes, ensuring each activity's alignment to the Principles of Math Instruction for ELs and monitoring the Guide's usefulness to teachers and students.

CHAPTER FOUR: CURRICULUM DEVELOPMENT

By using an *Oral Language Strategy Guide* with ST Math, JiJi acts as the math content teacher so the teacher can focus on student language development and fostering connections to build cognition. This cognition comes from the student's use of language to explain the puzzles they are completing and to develop a relationship with the online setting. The following *Oral Language Strategy Guide* supports ESL teachers and math teachers with the technological tool of ST Math by asking students to orally produce language with the support of the visual games. The guide is designed to be flexible, efficient and accessible to ensure teachers use the tool effectively for multiple purposes, such as language development, peer interaction and math vocabulary usage, rather than the singular purpose of math content mastery.

Activities and lessons in this *Strategy Guide* consistently refer back to the Visual Thinking Strategies (VTS) curriculum mentioned before, Jeff Zwiers' (2008) work on academic language strategies, NCTM (2013) publications on strategies for use with ELLs in mathematics and Judit Moschkovich's (2013) Principles of Mathematics

Instruction for ELLs from the Understanding Language group out of Stanford University. These resources are the foundation of the work contained in this *Strategy Guide*. The *Strategy Guide* begins with an open letter to teachers from myself and an open letter to students from JiJi, the main character in ST Math. Not all activities in the *Strategy Guide* involve math computation and mastery; rather they focus on students developing a relationship with ST Math and creating language to foster that relationship. Lessons and activities are compacted into one-page guides for ease of use and efficiency.

Strategy Guide Table of Contents

Letter to Teachers

Dear Teachers,

If you are reading this then you or your students already use ST Math. I hope you see a valuable tool for students to develop math content understanding, experience math concepts using visual manipulatives and persevere in their problem solving with the click of a button. However, if we simply put students on the platform and never connect the program to our classroom routines or culture, then we are missing valuable opportunities for academic and personal growth. This *Oral Language Strategy Guide* is designed to help you get your students talking (and understanding) more of what JiJi, the penguin character in ST Math, has to offer ELs with their oral language development in math.

Primarily, this *Strategy Guide* is designed to help teachers increase the use oral language in the math classroom for English Learners. Students need to talk about their math work more and ELs specifically need visual support with their oral language development. The visuals and animation of ST Math are motivating and captivating to students. I hope this strategy guide will inspire you to bring JiJi into your classroom not only as a supplement to the math curriculum or teaching you already do, but to also act as a co-teacher and motivator for your own math content teaching.

As you look through the guide, you may notice some strategies commonly used in literacy, science or social studies. You may wonder how these strategies will help your students increase their math scores. You may wonder why you can't explain the games to the students or what JiJi is doing on the screen. These strategies are all designed to stretch your understanding of what math class can be for your elementary ELs moving forward. Students need to talk about their ideas in math. This guide is here to support their math talk while using ST Math.

As you read through the guide it is important to understand that the first strategy, Notice-Think-Do, is the primary tool you will use to access student thinking. This strategy should be used frequently to instill a process for thinking in students throughout the year on ST Math and in math class. By putting simple language stems to difficult mathematical thinking the strategy is designed to help students learn how to express their thinking in math and beyond. I would use this strategy with a puzzle in ST Math once a week as a whole group for 2-4 weeks before trying any other strategy.

Additionally, I have created short videos of each strategy that allow you to hear me explain the strategy and how it may work in a classroom. I did not receive permission to use the strategies on students, but from my own personal experience using ST Math in my classroom, as a math teacher in elementary schools, and as a certified EL teacher. These experiences guided the creation of each strategy.

Please feel free to modify, improve, change and alter lessons and activities to increase student talk, teacher effectiveness and oral language development. My secondary goal is to inspire teachers to use ST Math and JiJi as a content connector. By motivating students through the use of technology and increasing perseverance by encouraging effort and mistakes over memorization and accuracy, we can create young mathematical thinkers who explain their thinking and develop deep understanding and mastery of math.

Sincerely,

Billy Menz
Strategy Guide Developer

Letter to Students

Dear Students,

I am so excited for another year of math learning with you, and hope that you can help me get back to Antarctica. I am very lost and need you to get me back home by solving sometimes difficult, sometimes easy, math puzzles. I want you to know that I know there will be times when it seems too hard to get me to the next level, but that is when I need you to work your hardest and think about what the pictures are showing you. Your perseverance will help me travel the world and get back to my cold home of Antarctica. I know you can do it.

Let me tell you a little about the puzzles and what you may need to know. First, I don't get upset when you make a mistake or fail to get me to the next level right away. It is really easy for me to start over and try again and when you have to redo a puzzle, I know you are learning just a little more each time, which makes me really happy. See, I want to get home, but I really want you to learn math too and sometimes that takes more time in certain places.

Next, when you are doing the puzzles, think about what you are thinking and use paper to help you record information. You should have a JiJi Journal to help you put things on paper instead of trying to hold everything in your head. This also will help you explain games to your teacher, your parents and your friends. I know it is fun to solve the puzzles on the screen but the pencil is still the best problem-solving tool.

Also, when you are playing the games and get stuck on a level, just remember that you are not alone. Everyone gets stuck sometimes! Just look at me; I can't even find my way home. When you get stuck, it is important to try different things over and over. You may even want to go back a level and see how you solved something a little easier. When you make mistakes and get stuck, you are at the edge of learning something new. This is how you get me home and how you learn to get to the top of the mountain. Sometimes you may need help, but always try your best before you ask your teacher or a friend for help getting past a puzzle.

Lastly, please have fun playing the games and enjoy trying difficult puzzles. The reason I am lost is because I challenged myself to travel, but now I am stuck and need your help. Please help me by playing my math games and learn something along the way. Good luck this year and please get me home!

Your friend,

JiJi the Penguin

Ways to Play ST Math

Independent

This is the most common way that kids play ST Math. Students log in using their passwords and play the next set of games (content) in their syllabus as organized by the teacher's class. Students work to move up levels by mastering the content through puzzle completion. When they fail a puzzle, ST Math animates corrective feedback and encourages them to keep trying until they can get the puzzle completed. Sometimes this can take multiple attempts, and student perseverance is tested as they become more frustrated. Students get a report at the end of a session regarding their progress.

Whole Group Play

Teachers have the ability to use any game, puzzle or level of ST Math through their Teacher Login. Teachers can select games that introduce concepts, build connections between classroom math and JiJi math, or highlight a common misconception students have while playing the games. During whole group play, teachers and students interact with the games and can orally explain their thinking with the whole classroom. This is a great way to open or close a math session and helps develop a community of thinkers around ST Math. Modeling using think-alouds and showing students how mistakes can further understanding are important when playing ST Math as a whole group. During whole group play it is helpful to use "Teacher Mode" for pause and play options that allow instruction using the animation at multiple speeds.

Small Group Play

Sometimes a teacher may want to lead a small group around ST Math to either help students who are struggling or support student thinking. This allows the teacher to clearly focus attention to the visuals and examine student talk around the content. When a teacher leads a small group around ST Math, they are actively connecting classroom content to the games of ST Math. In a blended learning math classroom it is common for students to rotate through different stations, and ST Math is a great station for independent play or teacher support. Many of the strategies in this guide are intended for use in small groups to support oral language around math content.

Partner Play

This element of ST Math is not commonly publicized because it is important for students to develop their own understanding of math concepts in ST Math. However, if properly administered, getting students to play the games of ST Math collaboratively and talk about the math involved is beneficial for student cognition in math and for language development. Peer to peer communication is important for students to create meaning and develop thinking around math. This strategy is directly highlighted in the guide to clarify its usage and purpose.

NOTE: Partner play should be used while students are either working on previously completed content or in "Test Drive" mode on content above or below their current grade.

Oral Language

Strategy Guide

for

Blended Learning Math Classrooms Using ST Math

by William Menz

Strategy 1

Notice Think Do

SWBAT justify their math thinking using sentence stems and a graphic organizer to create mathematical statements about ST Math puzzles for oral discourse practice.

Based on Visual Thinking Strategies (VTS) by Abigail Housen (1997), this strategy increases oral language output while reducing the cognitive thinking load. "Notice, Think, Do" is a thinking tool for students to use while playing ST Math and a language tool for processing through that thinking. This strategy is the foundation of each additional element of this Guide. Notice, Think, Do is a simplistic language framework for complex mathematical thinking and reasoning. This strategy is the foundation of the Oral Language Strategy Guide.

Teacher Action

- select a game for whole class instruction OR
- identify student for one on one conversation
- pose questions below to student(s)

What do you NOTICE on the screen?
What do you THINK is going on in the puzzle?
What do you plan to DO?

- recast student statements and highlight the evidence on the screen
- support student language usage by allowing animation to give feedback
- continue to question for understanding and thinking

Student Action

- utilize sentence stems to partner share or teacher share notice statements, thinking and plan to solve the puzzle
- write what they see on the screen and begin to keenly observe clues to solve visual puzzles using graphic organizer
- provide evidence of thinking using pictures on the screen and what they know about math
- orally share mathematical statements with a partner or group
- be willing to take a risk with oral language and learning
- get messy with the math and the language

Partner Play		Small Group Instruction		One on One Intervention	✓	Whole Group Instruction	✓

Notes and modifications: This strategy can be applied to many aspects of the curriculum and could be used as an oral language assessment for students using the rubric following the strategies.

I notice…	
I think… I wonder…	
I plan to… I am going to…	
Mathematical Statement	In this puzzle I noticed… SO I thought… And I decided to…

NOTICE 	THINK 	DO 

Name_____ Date_____

Game/Objective Name: _____Grade Level_____

Student Learning Objective:_____

I NOTICE…. **SO…**	I THINK… **SO…**
I AM GOING TO…	**Mathematical Statement**

Strategy 2	Picture Password Stories	SWBAT create a fictional story of their ST Math password images and orally practice telling their story with a partner, teacher or group.

In ST Math students are taught a unique 13 character picture password to access their individual game sequence. Instead of memorizing a sequence of numbers and letters students are taught to recognize images, and ST Math creates a visual imprint. Students interact with these images each time they log in to ST Math by clicking their sequence. Utilizing the images to support student storytelling builds motivation and connection to ST Math and provides an oral language opportunity that ELs can repeatedly practice as they log in to ST Math.

Teacher Action

- provide time for students to complete their password games (45 minutes)
- ensure students can consistently log into ST Math with their password.
- display stmath.com and click on JiJi.
- model orally telling a story as you choose an image for each screen
- pass out the password recording sheet and ensure students record images
- display story board and explain that students will now cut out their images and put them on the board to help tell a story and they must stay in order.
- monitor student story creation and record student oral stories

Student Action

- students MUST first learn their picture password
- highlight their unique images on the password recording sheet.
- cut out all 13 images that represent the student's password
- organize images onto the JiJi Story Board in a way that helps tell a story or orally share about the images.
- practice telling story to a partner, in writing or to a group.
- self-assess their use of oral language to tell their story and keep practicing each time they log into ST Math.
- listen to a partner's story

Partner Play	✓	Small Group Instruction	✓	One on One Intervention	✓	Whole Group Instruction	✓

Notes and modifications: Level 1 and 2 ELs can orally share single words or simple sentences for story. Students can create new JiJi stories each year they play the games since they keep the same password each year. Students could retell each other's stories.

JiJi Story Board

Put images here to help you tell your story. Start with your animal picture to make your own character for the story. The sentence stems can help you tell your story.

Main Character   **Story Title**			

Once upon a time there was a _____named ….

He or she WANTED…

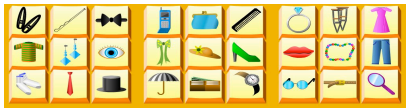
BUT something _____ happened and….

SO _____ had to … AND THEN…

IN THE END…

Student Name _____**Class**_____**Curriculum**_____

1



Write a story about your JiJi Password to help you remember your pictures.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

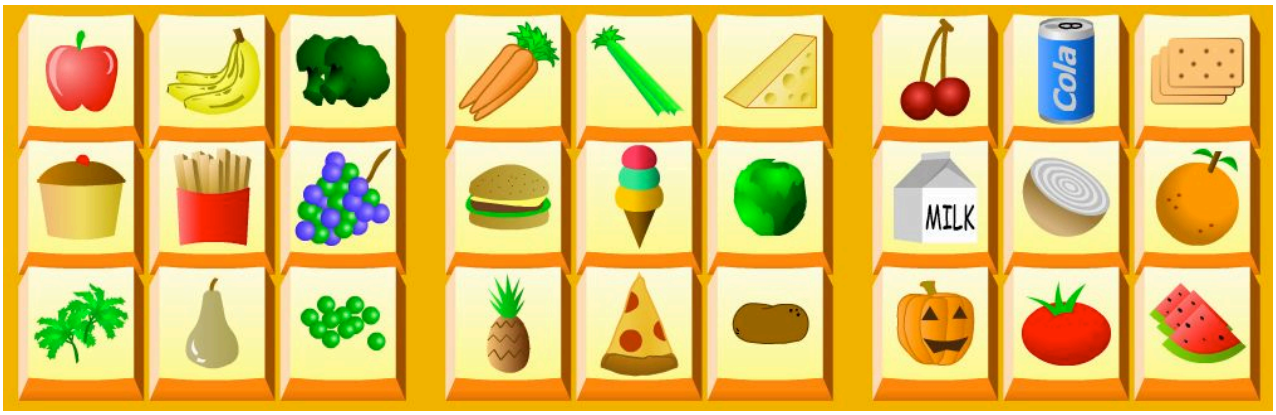
_____

_____

2

Password Cutouts Pages
Screens 1-3

Students should cut out only their password image and put it on the JiJi Story Board page.




A B C D E F G H I
J K L M N O P Q R
S T U V W X Y Z &


1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18
19 20 21 22 23 24 25 26 27


YIELD
SPEED LIMIT 25

Password Cutouts Pages
Screens 8-10

Password Cutouts Pages
Screens 11-13

Strategy 3

Oral Number Line

SWBAT interpret number lines in ST Math with sentence stems using oral or written language to describe the animated feedback of the game.

The number line is a consistent part of the ST Math curriculum at different grade levels and is one of the few concepts that continues throughout the primary years and changes over the years in focus and function. Additionally, number line understanding is paramount to developing strong conceptual math understanding and number sense. This strategy is an opportunity for students to orally share number line language while they play ST Math or in classroom interactions that involve number line concepts.

Teacher Action

- using *Teacher Mode*, select a number line game for small group instruction OR
- recognize a student struggling with a number line game in ST Math
- provide number line sheet to students and ask them to label the beginning and end of each number line.
- ask, "How do the marks help you interpret or read the number line?"
- have students label each tally mark on the number line or the ones they know.
- encourage students to share how this may help them play the games

Student Action

- examine the number line that they are playing in ST Math using notice statements
- record beginning and ending for each number line on the worksheet
- label individually or with a partner each tally they can
- use sentence stems to discuss with group or teacher what they are doing on the number line
- use math words in number line discussion
- transfer understanding from the number line sheet to the ST Math game

Partner Play		Small Group Instruction	✓	One on One Intervention	✓	Whole Group Instruction	

Notes and modifications: Teacher led small group is ideal for this strategy and much of the work can be done on the Number Line Sheets. Great for students struggling to connect the number line games to other math they do in the class. Number lines help ELs visualize and orally explain number sense in math so use this strategy is used to connect classroom number line work with ST Math games.

Whole, Blank Number Line

Half Number Line

Three Interval Number Line

Four Interval Number Line

Ten Interval Number Line

Whole, Blank Number Line

Whole, Blank Number Line

Whole, Blank Number Line

Whole, Blank Number Line

Whole, Blank Number Line

Number Line Sentence Stems or Script

I see the number line and know that….

When I see this number line, I wonder…

This number line is different than…
because…

If the beginning of the number line is _____ and the end is _____, then half way must be_____.

If I think about the middle of the number line, then …

If I know that half way is _____, then half of that part would be_____

If I break the number line up into _____ parts, then each interval would be…

On this number line, JiJi is showing me that…

Other math words to help with discussion:

greater than, less than, interval, groups, jumps, close to, near, the same as

Strategy 4	What's that number? Where's that number?	SWBAT recite numbers orally from visual animation and identify their location using directional and/or comparative language structure.

Orally producing numbers helps students name digit location, conceptualize place value and label abstract math content. For ELs this is not always common practice. ELs may be able to place a number or order a set of numbers, but reciting the number 15,234 orally represents cognitive challenge. Habitually saying the numbers on the ST Math screen helps students internalize place value concepts and gain oral language practice. "Where is that number?" challenges students to think that numbers have a place. Designed as a quick support that holds students orally accountable in ST Math, this strategy supports cognition using the language of number.

Teacher Action

- Pose question to students as they play the puzzle, "What's that number?"
- Allow wait time for student to share their number orally
- Teacher or partner poses the question, "Where's that number?"
- Allow misunderstanding for students and present directional words to help students describe number location
- Teacher or partner agree or disagree with student.
- Teacher has students complete sheet if written product is desired.

Student Action

- Orally produce the number, any number they see on the screen.
- Students then write the number in words that they hear their partner, teacher or themselves say orally.
- Students orally tell where the number is on the screen or compare the number to another visual on the screen.
- Use the sentence stems to describe their number's location
- Relate number to other numbers or items on the screen, in the room or in the world around them.

Partner Play	✓	Small Group Instruction		One on One Intervention	✓	Whole Group Instruction	

Notes and modifications: Use this strategy anywhere in math and get students to habitually locate numbers not physically but numerically. Students should be able to describe a number's relationship to other numbers.

What's that number?

Digits	
Words	
Image	

Digits	Words	Image

Where's that number?

The number _____ is **before…**

The number _____ is **after…**

The number _____ is **in between…**

The number _____ is **greater than…**

The number _____ is less than…

Other Positional Words to use

around	upside down	through	between	top
bottom	above	below	up	down
outside	inside	in	out	front
behind	over	under	on	off
next to	beside	left	right	beginning
middle	end	near	far	start
finish				

How's that number

The number _____ is smaller than… because….

The number _____ is larger than… because….

The number _____ is greater than… because….

The number _____ is less than… because….

Strategy 5

Partner Play

SWBAT collaborate with a partner while playing the games of ST Math by speaking and listening using target math vocabulary in discussions.

ST Math helps students master math content through interactive puzzle completion. Teachers encourage individual game play, but kids naturally want to discuss what they do on the games, compare their thinking and help their peers understand misconceptions. This intrinsic motivation to orally discuss the games presents an opportunity for student growth in math content knowledge and language development. This strategy increases talk and maintains ST Math's mastery foundation of puzzle completion and inquiry development.

Teacher Action

- Select content or objective for students to work on collaboratively
- Log in to ST Math Test Drive and select the objective or games for students to partner play together or have students play "green" content together on their devices. (*Green content is math work the students have already done individually.)*
- Select target vocabulary for students to use during the partner play time and record on the Partner Play Term Sheet.
- Listen for student use of target vocabulary while playing the games of ST Math.

Student Action

- Work with a partner or group to complete puzzles in ST Math.
- Read the target vocabulary out loud with your partner.
- Alternate puzzle work and explain to your partner what you are doing using Notice-Think-Do and target vocabulary
- Check off words you hear your partner use during discussion.
- Complete the Partner Play Collaboration Sheet and share with your partner.
- Review your partner or group's evaluation of your work as a collaborator today.

Partner Play	✓	**Small Group Instruction**	✓	**One on One Intervention**		**Whole Group Instruction**	

Notes and modifications: This could be a great strategy for a volunteer or intervention specialist to use while working on specific math content with students who need extra motivation and attention to puzzle completion and mastery. This could also serve as an oral language interview tool where students are striving to use more math language.

Partner Play Collaboration Sheet

Show what you worked on today with pictures or numbers or diagrams.

Grade your partner on your work together today in your JiJi Partner Play.

My partner today was _____.

My partner was helpful today.	4	3	2	1
My partner was focused today.	4	3	2	1
My partner used math language today.	4	3	2	1

Today we discussed ….

I would like to tell my partner…

Partner Play Word/Term Sheet

Directions: As you play the games of ST Math today, your goal is to use math language together as you play. Use the sheet below and put a checkmark each time you hear the words or math terms during your partner play today. Be mathematicians together!

				*I heard this word*			
				*I heard this word*			
				*I heard this word*			
				*I heard this word*			

Strategy 6	Shape Up with Venn Diagrams	SWBAT compare and contrast different shapes, concepts or numbers orally with a partner using a Venn Diagram to support their thinking.

Venn Diagrams have been used to support student language since the late 1800s, but this tool is underutilized in math classrooms. Venn Diagrams are used to compare and contrast topics and also look at items to identify obvious and not so obvious similarities. For this strategy, students specifically compare 2D and/or 3D shapes using math or everyday language. An additional Venn is provided for teachers to identify concepts and use language structures appropriate for comparative math talk.

Teacher Action

- Select content that allows comparative language in ST Math. This example uses shapes or quadrilaterals.
- Display shape puzzles or other comparative puzzle to the whole group.
- Review the purpose of a Venn Diagram and activate background knowledge.
- Complete the Venn Diagram sheet about shapes to demonstrate how to compare two shapes.
- Allow students time to work in Partner Play on Geometry games or with physical shapes with the Venn.

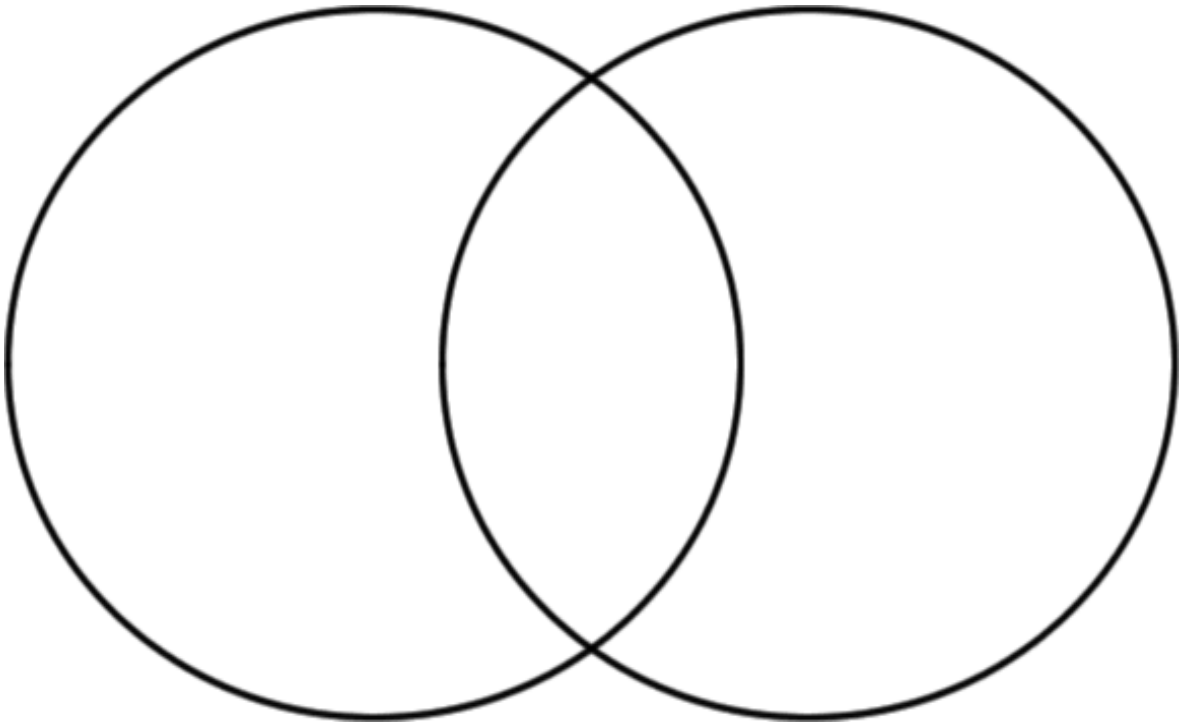
Student Action

- Label the Venn Diagram with the target shapes or concepts in math.
- List all things that are unique about the different concepts or shapes from what you see in ST Math.
- List the similarities in the center.
- With a partner or in your group, orally share the paragraph below the Venn by using your ideas in the Venn to support your language usage.
- Listen to your partner or group share their own paragraphs.
- Use target vocabulary

Partner Play		Small Group Instruction	✔	One on One Intervention		Whole Group Instruction	✔

Notes and modifications: Teacher can change the content by adding new vocabulary and identify two concepts that may need comparison. Teacher could even compare equations done in ST Math with those done on paper. There are many opportunities to compare and contrast in math class, and this is designed to be a connector for use in ST Math.

Shape #1_____ Shape #2_____
Image Image

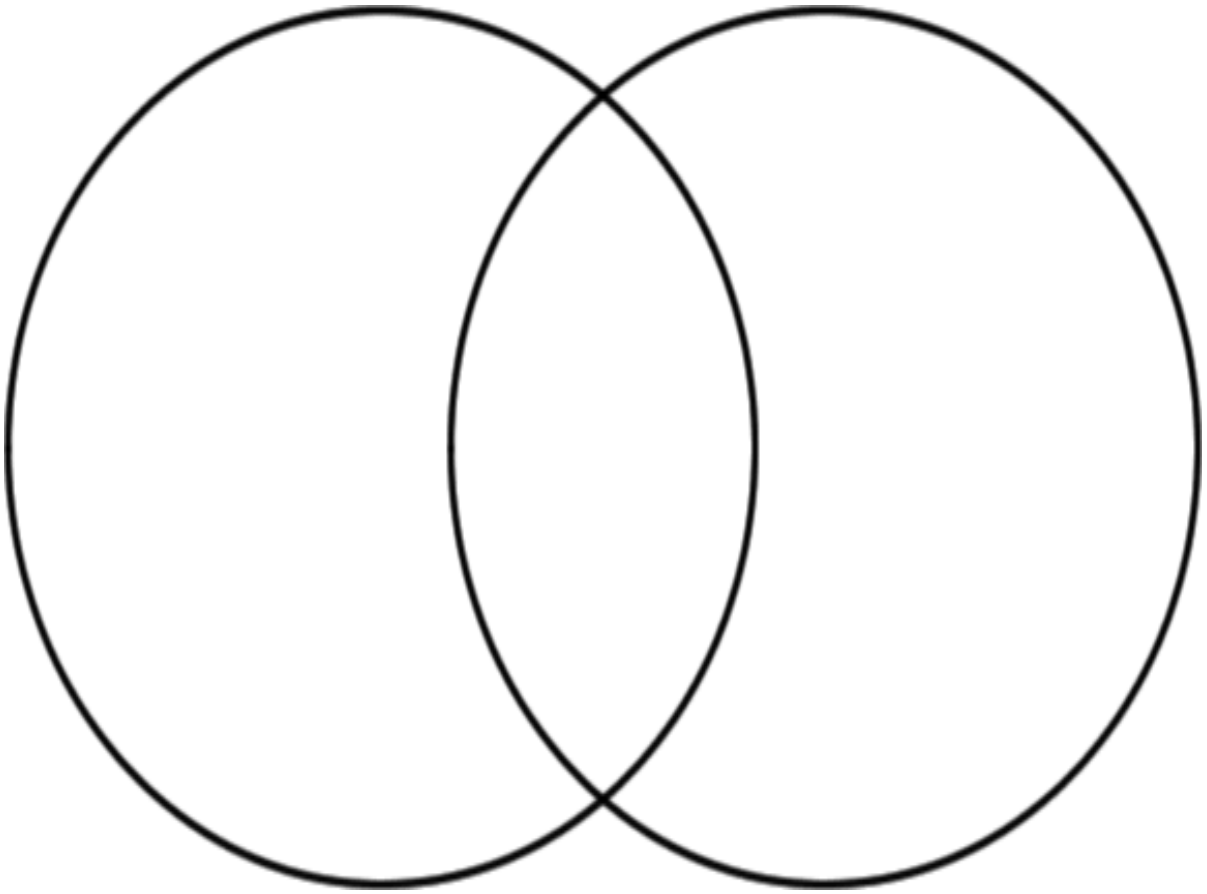


I am comparing a _____ and a _____.
I noticed both of these shapes _____ and both _____. They are also different because _____ while the _____ has _____. I/We can tell these two shapes apart because_____.

Lesson Vocabulary

Compare	Obtuse	Equal	Measure
Different	Angle	Unequal	Curved
Similar	Acute angle	Tilted	Vertex
Right angle	Length	Side	Intersect

_____ _____

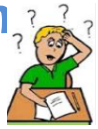


I am comparing a _____ and a _____.
I noticed both of these _____ and both _____. They are also different because _____ while the _____ has _____. I/We can tell these two _____ apart because_____.

Math words to use:

Strategy 7

Oh, that's how the algorithm works!



SWBAT use sequence words to explain math procedures with the visual animation supports of ST Math.

Math presents formulas, procedures and systems to students at all levels. Students are expected to complete a procedure to solve a subtraction equation, multiply fractions, do long division and countless others. For ELs the procedures of math present a great opportunity to teach sequence words in a context that also builds content understanding. By using ST Math to support students' oral language development around procedural talk, teachers can also help students internalize and conceptualize the math procedure.

Teacher Action

- Identify a procedure game in ST Math for play with the class. These are games that mimic the standard algorithms for addition, subtraction, multiplication or division.
- Organize curriculum to have students play the objective using the identified procedure or present the game to the whole class using Test Drive.
- Allow students to play the game and experience the procedure as a class.
- Model completion of graphic organizer and use it to orally explain the procedure.
- Listen to student language describing the procedure using the shared graphic organizer

Student Action

- Play an algorithm game and follow the Notice, Think, Do protocol to help make connections between ST Math and the procedure they use to solve equations.
- Complete the graphic organizer to help them explain the steps or clicks involved using words, numbers or pictures. *(Each click is a step)*
- Share their steps orally with a partner using the pictures of ST Math or the pictures on their organizer to assist them in speaking with a partner.
- Write the algorithm procedure on the We tell JiJi page while using sequence words in their writing.

Partner Play		**Small Group Instruction**	✔	**One on One Intervention**		**Whole Group Instruction**	✔

Notes and modifications: For Level 1-2 ELs have students work with stronger language students who could support explanation of their procedure. Students can draw what they do after each "click" in the algorithmic puzzle as each click represents a step in the procedure. For Level 4-6 ELs this activity could serve as a procedural assessment.

Name(s) _____Date_____

JiJi shows us HOW TO…

Content Objective_____

Directions: In the boxes below, draw pictures, write equations, use words, etc. to show the steps used to solve the math procedure above.

EQUATION or NUMBER SENTENCE to solve:

FIRST	SECOND	NEXT
AFTER THAT	THEN	FINALLY

Name_____ Date_____

We tell JiJi HOW TO…

If you want to solve the equation _____,
let me tell you what to do…

FIRST, _____

SECOND,_____

NEXT, _____

AFTER THAT,_____

THEN,_____

IN ADDITION, _____

FINALLY,_____

Lesson Vocabulary

Strategy 8

Hurdle Club

SWBAT use reflective talk to describe perseverance in problem solving using sentence stems and a graphic organizer.

In ST Math students are expected to struggle and fail at levels during the course of their play. This is also expected in math, learning and life. This strategy is designed to support ELs as they struggle with the math content, but also support a classroom culture that encourages and celebrates perseverance. When students consistently fail a puzzle in ST Math, it becomes a hurdle. This strategy helps students see hurdles as necessary and desired. Our ELs struggle to use language in class and make tiny mistakes, but they are overcoming hurdles. The Hurdle Club supports a belief in struggle, which creates a classroom culture to build EL proficiency.

Teacher Action

- Be aware of students who may be struggling and experiencing hurdles.
- Model system of perseverance by sharing Stuck Page and Reflection Sheet so students know hurdle process.
- Actively monitor any stuck journal pages and provide assistance with peer, volunteer or one-one.
- Observe student play the game and seek understanding of misconception.
- Help as minimally as possible but don't miss instructional moments to get student over a hurdle.
- Celebrate students who pass hurdles.

Student Action

- Play game and notice struggle with content
- Complete a "Stuck" page with peer, individually or teacher.
- Turn stuck sheet into Teacher box.
- Continue playing and examining the game. Replay previous levels.
- Get assistance from a teacher or peer with the puzzle. Mouse control always remains with the player.
- Pass the hurdle and level. Feel awesome.
- Complete a Hurdle Club Reflection Sheet and share with class how you persevered in your problem solving.

Partner Play		Small Group Instruction		One on One Intervention	✓	Whole Group Instruction	✓

Notes and modifications: In your math classroom, set up a place where you can put up student names as they get into the Hurdle Club. Celebrate the struggle students overcome in ST Math as much as the progress they make regarding curriculum completion.

JiJi Journal
I'm stuck!

Name: _____
Current Objective: _____
Game: _____ Level: _____
Date: _____

Use pictures, words, and equations in the boxes below to think through the puzzle.

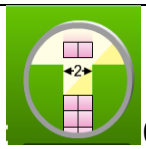
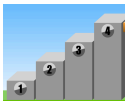
What I learned in the previous games/levels:	**I have already tried...**
What does JiJi show me when I try my answer?	**I am struggling with...**

MIND Research Institute ED-ST-008-150707

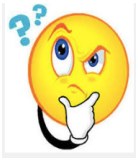
ST Math teachers can access this sheet from the Teacher Resource Site at trs.stmath.com.

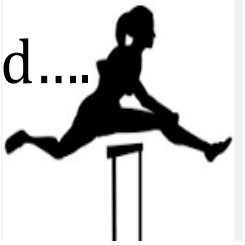
Hurdle Club Reflection Sheet

ST Math Player Name _____Class_____Grade_____

Date 	 Game	Objective 	Level 

I played this game about _____times.

 I really struggled to understand….



Use pictures, words or images to describe …

I used to think…	*Now I think…*

Strategy 9

Dear JiJi,

SWBAT write a friendly letter to a math teacher and reflect on their learning of specific content.

Letter writing connects people to each other. Encouraging students to write letters to a fictional character who helps them learn in math is a non threatening way to access math thinking, attitudes and creativity in student understanding. This activity is outside of the usual "box" that math class involves and forces students to interact with their math language in a unique and purposeful way.

Teacher Action

- Introduce letter writing genre to the class (previous lesson)
- Ask students to share a letter with JiJi about their current progress in ST Math or about the math puzzles.
- Brainstorm with students words that may be good to use in a letter to JiJi or a math teacher.
- Write a letter to JiJi as a class to model how to provide evidence of your argument to persuade JiJi.
- Send letters to ST Math or record student's feedback to JiJi about the games of ST Math.

Student Action

- Help teacher and class compose a letter to JiJi about math.
- Use vocabulary and sentence stems to write a letter to JiJi and then give it to a partner. Other student writes back or responds orally.
- Listen to partner's read letters from the class or letter from JiJi that responds to the feedback.
- Self assess on the writing of the letter for specific criteria.
- Mail letter to ST Math or send video file to JiJi

Partner Play	✓	Small Group Instruction		One on One Intervention		Whole Group Instruction	✓

Notes and modifications: Following a unit of instruction, letters can be a good language assessment of student learning. Level 1s and/or 2s can use the model letter to help them participate orally in the written language task. Teachers could make a letter to JiJi part of quarterly or unit reflections that allow teachers to see or hear different modes of content understanding besides mastery of puzzles or procedures.

Date_____

Dear JiJi,

Let me tell you about _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Sincerely,

_____

Self Checklist – Check a 3, 2 or 1 for your self assessment. 3 is the highest.							
I used math words in my letter to JiJi.		I respected JiJi's feelings in my letter.		I used evidence for my arguments.		I challenged myself and/or JiJi in this letter.	
3		3		3		3	
2		2		2		2	
1		1		1		1	

Date_____

Dear Mathematician _____,

Thank you for your letter about _____ _____I enjoy hearing from students and wanted to let you know that_____

_____

_____

_____

_____

_____

_____

_____

Sincerely,
JiJi the Penguin

Self Checklist – Check a 3, 2 or 1 for your self assessment. 3 is the highest.							
I used math words in my letter.		I respected my partner's feelings in my letter.		I used evidence for my math arguments.		I challenged my thinking in this letter.	
3		3		3		3	
2		2		2		2	
1		1		1		1	

Strategy 10

What's the Math?

SWBAT orally share connections between the games of ST Math, the real world, their classroom math work and life from a graphic organizer.

When students play ST Math, they do not always or consistently make connections to their own lives or the content being taught during teacher instruction. This is especially true with younger grades. ST Math addresses multiple learning modalities, but it is important, if not imperative, to help ELs see the connection clearly between what their teacher or parents are telling them and what ST Math is showing them. This strategy helps students see those connections and eventually look for them on their own.

Teacher Action

- Consistently ask the question, "What's the Math?" of students as they play the games.
- Reorder content in ST Math throughout the year to align with what students are being taught in math. This helps students make connections to the classroom.
- Encourage students to bring JiJi home and tell some words they use in math with their home language.
- Model completing the "What's the Math?" graphic organizer for teacher's connection.

Student Action

- Recognize that ST Math is not just a game they play but math around them.
- Choose a game they have played that reminds them of something in school, their life or the world.
- Review the game and complete the graphic organizer.
- Share their work orally with a partner, teacher or the group and listen to others share their connections.
- Practice telling story to a partner, in writing or to a group.
- Work with a parent to complete the Math in my language sheet.

Partner Play	✓	Small Group Instruction		One on One Intervention		Whole Group Instruction	✓

Notes and modifications: Ask this question in line, outside on the playground, in Gym, at Art, etc. Asking them as they play the games of ST Math connects their math learning in JiJi to the classroom, but asking them everywhere expands their math world.



What's the Math?

Building connections to life, school and the world with JiJi.

What game are you playing in ST Math?_____

Draw or write how the game connects to your life, schoolwork or the world.

Connection to	This game(s) in ST Math remind me of...
School 	
Home or Life 	
The World 	

Name_____ Home Language_____

Homework - ***Math in my world***

Directions: Create a math story about JiJi in your world, at your house or in your native country. Include math in your story, but also include things about your family, culture or traditions. You can share your story with the group.

Strategy 11

JiJi Math Theater

SWBAT work with a group or a partner to create a skit about content completed in ST Math by physically performing in front of the class.

This strategy is designed to be an activity that can include all learners by grouping students strategically. Students with proficient language ability can work with those still developing and all can have a role. JiJi Math Theater encourages students to be creative while also demonstrating some level of math content understanding. When students complete an objective or unit, they can use physical communication and oral language to tell a story about their learning in that unit or objective. Student groups are held accountable to the rubric and must ensure that all have a voice in the performance.

Teacher Action

- Identify students who have mastered a common objective in ST Math.
- Strategically partner students with different level ELs and native speakers.
- Provide students with a storyboard to plan out their physical performance.
- Ask students to develop a list of math words and language that they feel will need to be a part of their performance.
- Provide students with the time and space to create a creative performance around math content and look for creativity and oral language.
- Highlight student understanding with feedback following the performance.

Student Action

- Include all members of the group in the creation and presentation of the performance.
- Ask for input from all members of the group and make sure to create a script so people understand their roles.
- Complete the story board as a group and make sure the story matches the content focus for the performance.
- Make sure each student in the group has a role and that they use at least one targeted math term in their oral language.
- Perform for the class, self assess and peer assess using criteria chart.

Partner Play	✓	Small Group Instruction	✓	One on One Intervention		Whole Group Instruction	

Notes and modifications: A great modification would be to have a pre-developed script of a content area theater. This way the teacher could assign roles and the students could act out those roles, which could make it easier for ELs to be involved.

Math Theater Script

Title of Performance:

Group Members:

ST Math Objective performing:_____Grade_____

Math Words to use in script (list 5-10 words related to objective played):

Big Ideas from the Objective:

Member Roles:

(Begin script on back if needed)

Math Theater Rubric/Assessment

Directions: Please grade your group or another's group using a 4 point scale for how well you think the group met the criteria. Circle if it is a peer or self assessment.

My name is_____

This is a peer / self assessment

4 is excellent 3 is good 2 is okay 1 is poor.

Criteria	1	2	3	4
All group members were involved and used at least one math word.				
Performance demonstrated understanding of the math content.				
The performance helped me understand the unit better.				
Group was creative, worked well together and challenged themselves.				
TOTAL SCORE				

I really liked when…

The performance could have been better if…

Strategy 12

Making a JiJi Dictionary

SWBAT create meaning for math content vocabulary and make connections to ST Math visuals while orally sharing their personal definitions with classmates.

ELs need to make meaning of math content vocabulary for themselves instead being provided definitions that lack context. This strategy uses a modified Frayer Model to create meaning of math terms using the visuals of ST Math, their own background knowledge and their classmates' background knowledge of the targeted vocabulary. The visual supports of ST Math provide ELs with examples and experience that is interactive and provides visual feedback. By interacting with their peers about these words, the terms become alive and active in the room.

Teacher Action

- Create a book of the graphic organizer so students can keep a dictionary of JiJi words.
- During whole group, put up a word that can be defined by ST Math, students, etc. Put up a JiJi game that shows this word.
- Have students write their own images or definitions of the word.
- Students then walk around to find another's definition.
- Student pairs decide what is a picture or image JiJi shows to represent this vocabulary word.
- Repeat with another word.

Student Action

- Write down teacher provided term or identify a math word for JiJi dictionary.
- Create a definition for the word and a quick image or symbol for the word.
- Ask another student what they think the word means and record on your graphic organizer.
- With your partner discuss how JiJi or ST Math demonstrates this term.
- Use the word with your partner in a sentence.
- Identify a new word for your JiJi Dictionary and repeat the above steps finding a new partner.

Partner Play	✓	Small Group Instruction		One on One Intervention		Whole Group Instruction	✓

Notes and modifications: Print multiple pages of the graphic organizer for a book. As students play ST Math, encourage them to create terms with JiJi images. Write down the terms before hand and have students move to different partners for each term.

Math term (include symbol and/or image)	My definition of the word is…
Another student's definition is…	JiJi picture

Math term (include symbol and/or image)	My definition of the word is…
Another student's definition is…	JiJi picture

CHAPTER FIVE: REFLECTIONS

This chapter helps the reader understand my own process of reflection throughout the development of this curriculum capstone project. The project changed numerous times and during the research major modifications to the original design became necessary. Along the way it was important to maintain a focus on mathematics instruction using ST Math.

The Capstone Process

This capstone represents a culmination of learning throughout the last three years of my professional and academic career. The inspiration to work on a capstone project linking Visual Thinking Strategies, ST Math and ESL instruction developed when I first heard Dr. Matthew Peterson, CEO of MIND Research and creator of ST Math, claimed in a June, 2011 TED Talk (Peterson, 2011) that "a language free approach (to math instruction) could actually improve language proficiency." Investigating and in some ways disproving that statement motivated my research on how oral language, math

thinking and ST Math are connected. Peterson's claim may be founded on the fact that students cognitively understand the math and they want to talk about it, but that is not a language free approach. He went on to say that the visuals spark talk, which in a math classroom is essential for deep understanding. This Oral Language Strategy Guide represents a tool to facilitate the claim by Peterson. ST Math's omission of language in its program is not improving language proficiency, but its inspiration and motivation to produce language in students helps support language usage. This Strategy Guide can bridge the gap and help guide student talk about math while using ST Math.

My work as an Education Consultant with ST Math, my commitment to academic study in ESL education at Hamline University and my experience as a classroom teacher and Math Specialist in Minneapolis with ELs uniquely qualified me to investigate this claim and discover how language can play a role in ST Math for ELs. Originally, this capstone was designed to test one of the twelve strategies in the *Oral Language Strategy Guide.* "Notice, Think, Do", the anchor strategy of the guide, was the subject of my original question, *Can a visual thinking strategy used with ST Math increase the oral language output of EL students exposed to the strategy over a six week period?* That question guided my initial draft of this capstone project and much of my research for nearly a year and a half. However, classroom research proved unattainable in both my previous location, Philadelphia Public Schools, and in my home district, Minneapolis Public Schools. New research regulations for larger districts restricted access to students for studies at the master's level.

In response to this roadblock, I contemplated using other classrooms in smaller districts but ultimately decided, with the help of my research adviser, to create a more

comprehensive set of strategies around ST Math designed to increase oral language proficiency for EL students. Therefore, instead of testing the efficacy of a single strategy, this *Guide* presents twelve strategies specifically designed to increase oral language output for ELs in the blended learning math classroom that uses ST Math as the online content provider.

Strategy Guide Creation

As I began to create the strategies for this guide and looked more closely at the ST Math program, the Minnesota State Standards in Math (2007), and possible language objectives, I realized that the primary goal of this guide is oral language development. Considering this goal, I concluded that not all of my strategies needed to be directly aligned with a specific math standard, but could be more related to visual thinking strategies, motivation, perseverance, or metacognition. As a result, not all strategies in this guide look like math work.

Visual Thinking Strategies was an essential influence on this capstone work and without Housen's (2002) curriculum and subsequent research on the effectiveness of critical thinking, transfer would not exist. Using different strategies from the guide, especially the Notice-Think-Do, and knowing that accessing student thinking with simple questions to build evidential thinking not only can help with current content but overall thinking is motivating for teachers to observe. Hearing students talk about math using visual thinking allows the teacher to question and push students for conceptual understanding of math where they are in control of the conversation. Moreno's (2004) research on verbal assistance built on this idea that students can control their learning in an online game, but there must be some adult interaction to build strong connections to

the math content. Without a strategy guide to supplement oral language usage in ST Math, according to Moreno's (2004) research on HELP Math, a separate online program, connections will not develop as strong in students. This connection between observational data utilizing VTS and seeing it in action and research with online content in math strengthened my resolve to build strategies that could connect this thinking for ELs.

Usefulness was also a challenge. In the *Strategy Guide* I attempt to use clear and concise language for teachers to understand each strategy's purpose and process efficiently. It is imperative not to lose teachers in the words before they see the value of the objectives and strategies. Inspiring creativity in teachers who use ST Math to develop language and discourse remains a priority of the guide. If this guide can help teachers access student language and oral discussion and open new understandings about how students think, then teachers will see its usefulness. As a result math thinking and language can be explored, investigated and supported within the math environment, therefore increasing opportunity and structure for ELs to speak up in math class.

The structure of math language and the difficulty it can present to students is an opportunity for teachers to utilize that misunderstanding as an opportunity for growth in language and mathematics simultaneously. Academic language is a tool that students must acquire in math for achievement in secondary math classrooms (Zwiers, 2008). Building this language in elementary classrooms helps ELs be successful later in their math learning. Zwiers (2008) work on academic language challenged my work to consider expanding oral language from simple production strategies to more developed

strategies where students are encouraged to use academic vocabulary as they talk about the games of ST Math.

Finally, curriculum or focus within the guide's content presented a different challenge. There were many different directions that I could have taken with this *Guide*, but from the beginning I knew the foundation of the *Oral Language Strategy Guide* would be Notice – Think – Do (Strategy 1). The question remained, *how would other strategies, lessons or activities branch off from that foundational element?* While creating the additional eleven strategies contained in this guide, my attention focused on oral communication and the recommendations presented in the Principles of Math Instruction for ELs (Moschkovich, 2012). It was imperative that the rigor of mathematics remain while increasing oral language supports simultaneously. In developing strategy options I referred back to my own foundation in language objectives as a part of math instruction.

The guide could have been an organized set of lessons designed specifically for certain games in ST Math that bring out oral language. However, Notice-Think-Do was a strategy that could be broadly applied to nearly every game, puzzle or content area of ST Math. The desire for other strategies to include broad application to multiple standards or strands in mathematics, different grade level content, and be accessible to a variety of language proficiencies was paramount. For this reason, strategies are incorporated for application across the math standards for the primary and early intermediate years. In addition, only language objectives, not math content objectives, are presented with the strategies since the math content objective is secondary to the goal of this particular

guide. Finally, the math objective is variable with the application of the strategy due to their broad usability and application.

For this reason, the strategies involve minimal math content understanding but focus more on connections to ST Math as a language motivator, perseverance tool and visual support for thinking across the content areas. Picture Password Stories (Strategy 2) represents a creative outlet for students to own their password in ST Math and develop a connection to the game that is focused on language and storytelling. This purposeful input of writing, language and storytelling into the math class is intended to help ELs see math not only about the numbers but also about the stories in the numbers. My own experience with ELs in math demonstrates that they are more connected to content when there is a story involved. These stories could have a number or math focus but the objective is related to storytelling around JiJi or ST Math and not math content.

Additionally, The Hurdle Club (Strategy 8) focuses attention on how students persevere in their problem solving and that in math class mistakes are common and necessary for learning. This strategy highlights and supports student thinking through expressing how they overcame something that was challenging or difficult. By encouraging metacognitive thinking, The Hurdle Club can not only change student outcomes in math but also help them overcome barriers in their language learning. Celebrating and supporting students to take risks, try new things and learn from their mistakes is imperative for EL development. These are the soft skills ELs need to become proficient in English. Struggle is important for ELs to build language skills because without oral language mistakes in their dialogue they will not grow in their usage of English (Swain, 2000).

Finally, during the creation of the *Oral Language Strategy Guide* I attempted to identify language tasks important for math discourse. In my current role as Math Specialist at Lyndale Elementary School, language stations in the blended learning math class have helped students talk more about the math they are doing in class with classmates, partners, and the group. My work to create these stations in the math classroom has helped me create these strategies for ST Math. This guide is a reflection of my knowledge of elementary math content, my graduate learning in ESL best practice, and my experience creating language opportunities for ELs and native speakers in math class. The *Oral Language Strategy Guide* represents a collection of my own knowledge, learning, creativity and reflection.

The role of verbal guidance was detailed in chapter two with Moreno's (2004) research on its role with technology programs. In the guide we see multiple strategies, Notice-Think-Do, Hurdle Club, What's that Number, What's the Math, and Oral Number Line where teacher or adult interaction is important to help students connect what they do in ST Math to how number or math works outside of the online component. Moschkovich (2013) clearly explains, as do the Principles of Math Instruction for ELs (2013), that students should use language to communicate in math. Partner Play, Math Theater and Notice-Think-Do help provide students with structure but also freedom to navigate mathematical content using a combination of everyday English and academic language. These strategies attempt to meet the expectations set forth by Moschkovich and the National Council of Teachers of Mathematics (1991) in regard to EL teaching in math.

Additionally, as the strategies were being developed I considered and used SIOP as a model for creating language objectives for each item. SIOP presents teachers with an outline and strategy to focus on vocabulary and language development within the content areas (Echevarria, Vogt & Short, 2004) to make it comprehensible for ELs. The inclusion of a specific language objective adheres to this model and the use of graphic organizers, visual manipulatives and background knowledge in the activities helps support ELs. Strategy 10, Making a JiJi Dictionary, helps students make sense of visual models to explain academic language. Strategy 6, Shape Up with Venns, uses graphic organizers to support comparative language structures and Strategy 2, Picture Password Stories, helps students utilize their own background knowledge to create math stories about the images presented as part of their picture password.

Strategy Guide Format

In developing this *Strategy Guide* one of the primary goals was to be simple and efficient for teachers to use. I was not interested in developing full lesson plans for math content with language objectives accompanying each lesson. There are too many lessons to choose from and that task appeared unattainable and unrealistic. My goal was to create oral language tasks or strategies for ST Math that could be applied to many of the games and a broad range of math content across the elementary grades.

For this reason, readers will notice a one-page descriptor containing a language objective, a brief rationale of the strategy, teacher actions, student actions and possible modifications for the proposed strategy. The language objectives are chosen for both their relevance to math discussion and appeal to other content or syntactic structures that students encounter across the math content area. The rationale gives some background

and also discusses the possible importance to overall math and language proficiency. The teacher and student action sections are brief directions that both should do in order to successfully implement and apply the strategy. Finally, the notes and modifications section can help teachers envision other uses of the strategy that may not be readily apparent. It is the author's hope that the strategies contained both instruct and inspire teachers using ST Math with ELs. The design of the guide is intended to be an entry point for teachers not an endpoint, and these strategies represent the tip of what is possible for ST Math as a tool with ELs.

Following an edit session with my peer reviewer, he suggested that each of the graphic organizers provide a completed example. The work samples help the teacher see what language is desired and also allow the guide to act as an evaluation tool. However, since the examples are not from actual student work, these examples are not in student context but rather a prediction of what students may say or write in their work. By using the guide, teachers may be able to modify student expectations from what they see from student generated work samples.

It is important to keep in mind that the strategies presented work on both ends of the academic spectrum for teachers aiming to differentiate for their ELs and native speaking students. On the one hand, the oral language strategies help struggling students in the math content work through the puzzles in a more systematic way with peers, teachers or language production as a support for building understanding. However, for students experiencing little struggle with the games and puzzles of ST Math, the Guide also works to build a deeper understanding of the math using language. In more advanced ELs the strategies can help "slow down" a learner and encourage them to look

for more details in the puzzle's connection to broader math understanding. Strategies like Notice-Think-Do, What's that Number, What's the Math, and Math Theater assist students who skillfully pass the levels of the games easily with the rigor of explaining how the math relates to the real world, other math learning or separate content areas.

Teacher Training and Strategy Guide Delivery

As the guide was being developed, I realized that usefulness of the strategies relied on teacher understanding of oral language and ST Math. This guide is not intended to be used by teachers brand new to ST Math. They may be able to experiment with some of the strategies early on, but some knowledge of ST Math's pedagogy and structure is essential to effective use of the Guide. Sometimes teachers may use ST Math in the classroom and have ELs in their math class but have very little knowledge of how oral language and ST Math can connect to their overall math classroom. Since one of the goals of the *Strategy Guide* was to be brief, broad and easy to use, I could not spend a lot of written words explaining the strategy to teachers. I wondered how could I deliver training to teachers on how to use the strategies in the shortest time possible with the greatest understanding.

Video tutorials were the answer and could give the guide a technological training aspect that teachers or parents could utilize and re-watch for clarification. As a result, each strategy and graphic organizer set is linked to a short, five-minute video tutorial for teachers, administrators or parents to understand how to effectively introduce or utilize the strategy. This tweak to the original methodology also put a personal element into the document for my own colleagues at Lyndale School and in Minneapolis. This mode of delivery and training allows for the greatest impact with the least amount of resources.

Each strategy and graphic organizer set can be found on the Lyndale Math Page at https://sites.google.com/a/mpls.k12.mn.us/lyndale-math-world/math-videos/oral-language-strategy-guide along with a short video tutorial of each strategy.

Usage and Purpose

The *Oral Language Strategy Guide* was created for my own personal use in classrooms with ELs who use ST Math consistently in their classrooms. The strategies include math language structures that are common in mathematical discussion for elementary students and represent an opportunity for teachers to access oral language and thinking in students. One purpose was to help teachers bring student misconceptions to the forefront of their class because if teachers don't hear a misconception, then they don't know it exists in students. Many times I have observed students play the games of ST Math and demonstrate high level math thinking but when asked to explain what they are doing or, as in the strategy "What's the Math?" were unable to connect their game mastery to their explanation. Students' inability to produce language around their math thinking creates misconceptions even if the math appears correct.

The Common Core State and Practice Standards (2012) emphasis on conceptual understanding and explanation of math thinking made the creation of this *Oral Language Strategy Guide* in ST Math imperative for ELs. My experience in schools with ST Math as an Education Consultant demonstrated that many teachers who use ST Math allow students to play the games and master the content but rarely connect their thinking to oral language or explanation. This is not true for all teachers and schools, but even the schools and classrooms where these connections were being established between ST Math, language and conceptual understanding, the teachers were uncertain of how to

bring that language out in students with ST Math. ST Math provided a few suggestions but not enough variety to keep kids talking and motivated to discuss math all year. By creating a set of strategies that focus on specific oral language objectives to support the rigorous math content found in ST Math, I hope to inspire more creativity and a sense of freedom for teachers to use ST Math not only as a content supplement but also as a tool for oral language development in EL and native speaking students.

Limitations

The *Oral Language Strategy Guide* has a limited scope because of issues regarding the ST Math product. Mind Research Institute has copyright of ST Math and their development teams must approve materials created for public use. This limitation prevents me from publishing the materials on a broad scale unless I obtain approval from Mind Research and ST Math, which is not currently part of the plan.

Additionally, teachers are limited with their use of the strategy guide because of time and ability to integrate content areas. Some schools will not see the value of increasing language discourse in the math class around ST Math. For this reason, teacher use will change by their comfort with the ST Math program, the functions of the program teachers have mastered and the teacher's comfort with inquiry-based questioning in math class where the right answer is not the primary goal of the student interaction.

Finally, students ultimately choose whether or not to use oral language, apply content vocabulary, take risks with their math and language learning and engage in focused dialogue with their peers. With these activities I hope to inspire and promote oral language discourse in the math content area, but all classrooms are ultimately limited

by students' willingness to participate. The strategies intend to increase the applicability of ST Math to the Common Core math classroom.

It should be noted that teachers can monitor student use of oral language in ST Math without these strategies. Students work well with routines and these are designed to help teachers set routines and rituals around language usage and ST Math. Although it is important to utilize the strategies that work best for the students in a classroom, it is also important not to overuse the strategies. The graphic organizers allow teachers to foster thinking and language but are not the end product for each activity. The product of each strategy is the discourse, discussion and oral output that students produce. This is limited to student level, classroom demographics, and teacher style.

Future implications

It is my hope that staff in my building and possibly other staff in the Minneapolis Public Schools use these strategies. By publishing them locally on our school intranet, the *Oral Language Strategy Guide* will be made available to teachers in my building and the videos will support their implementation as they attempt strategies that work for them and connect to their teaching style. However, if the Strategy Guide is successful and teachers see oral language opportunity grow in their math classrooms, then the Guide will be promoted as an option in the Minneapolis School District to support academic vocabulary. In addition, it is important for me to share the Guide with colleagues at MIND Research in an effort to inspire those professionals with more opportunity to expand the scope of ST Math and its effect on student learning and achievement.

The path of research and curriculum creation in the area of technology, math and language learning is too broad to predict, but as other technologies become solidified in

delivering math content to students then supplements will need to address language use with these programs. The challenges of the Common Core in mathematics duly allows ELs an opportunity to grow and teachers to grow with them. These standards are forcing teachers to use language structures and increase the talk in math due to the recommendations of NCTM and the newer standards (Hakuta, Santos & Fang, 2013). Hakuta (2013) looks at these new requirements as an opportunity to bring more resources and common teacher skills to the content areas regarding EL teaching. This researcher believes that supports for online programs already exist, but it is the hope that these supports begin to act more fluidly and flexibly while adhering to EL teaching principles. In my opinion, no support that we provide for ELs will improve language, vocabulary or academic discourse unless we increase the oral language output of ELs in this content area. That is the goal of this capstone and could serve as a springboard for other online curriculum supports to build off. If anything, this capstone project will create an impetus for Mind Research and ST Math to look at these oral language supports more closely and possibly even adopt them for their own use.

Finally, one interesting idea for use of these strategies comes from a project based on screencasting to explain thinking in math. Wilson Vazquez (2014), in a capstone that outlines a project where students explain complex math procedures with the aide of screencasting technology could be a part of an assessment procedure using these strategies. In Vazquez's (2014) research, she demonstrates that using technology to prepare and plan math communication can have a positive effect on student use of academic language and oral output in ELs. This example could connect to students

describing the animation produced by ST Math when students complete a puzzle correctly or incorrectly.

Dissemination

Now that the Oral Language Strategy Guide is complete and video tutorials of the strategies are available online for teachers to access, dissemination can occur in multiple forms. First, this capstone will be shared with other ST Math teachers at Lyndale School and parents via the linked web page published earlier in the chapter. I also plan to share the guide with other math specialists in the Minneapolis School District at an organized professional development session. In addition, I have submitted a proposal for the NCTM regional conference in Duluth, Minnesota in April 2017. Finally, following publication on the Hamline Digital Commons, I will be submitting my Oral Language Strategy Guide to the Education Department at MIND Research to see if there is any interest in developing content specifically for ELs who use ST Math.

Final Thoughts

The creation of these strategies and this capstone has humbled me as a teacher and an academic. The work involved in delivering and creating content that is meaningful, aligned and applicable to ELs is challenging. ELs get stuck in their understanding and can lose some motivation to take risks with their learning. I feel this capstone taught me about perseverance and allows me to relate better to my EL students who struggle with language and content each day in our schools. This struggle needs to be supported and I appreciate all the support I received while working on this capstone project. It should be noted that I have not fully used all the strategies in this Guide to full effectiveness but rather see these as things I use everyday and strategies I have yet to perfect. I continue to

create new systems to develop oral language using ST Math and as this capstone process has shown me, fluidity is a strength and not a weakness in a language classroom. Be on the lookout for more to come as new ideas and strategies present themselves.

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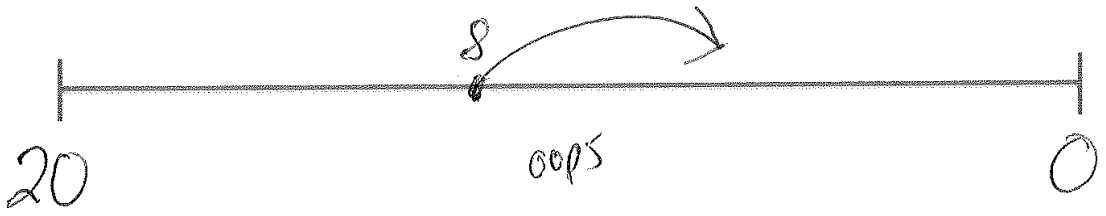
APPENDIX A: GRAPHIC ORGANIZER SAMPLES

The work samples included in this appendix are not the work of students in a classroom but rather model work created by the curriculum developer to help guide teachers' thinking around the strategies. These are possible responses or oral language that may result from using these strategies with ST Math.

I notice...	-there is a number line ⟶ -a number 263 -200 and three hundred
I think... I wonder...	that I should put 263 on the number line but I am not sure where it goes.
I plan to... I am going to...	put 263 near the half point on the line and click to see what happens
Mathematical Statement	In this puzzle I noticed... 200 and 300 on a number line SO I thought... I should put the number 263 in between them, And I decided to... put it a little more than half way to 300 because...

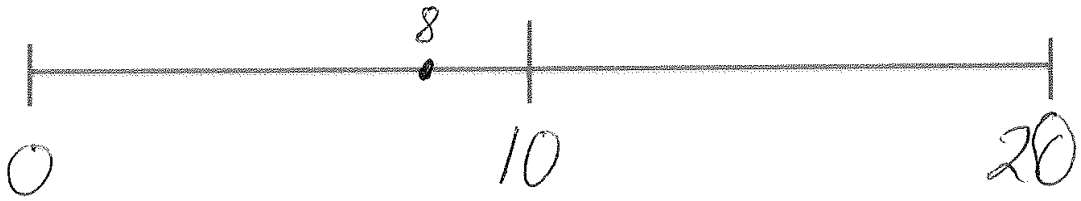
NOTICE 	THINK 	DO 
-a lot of petals on the ground -1s, 10s, 100s, 1000s at the top	-I think I click the amount I see on the ground.	I am going to click 10 because I see more than 1 but a lot less than 100.

Whole, Blank Number Line

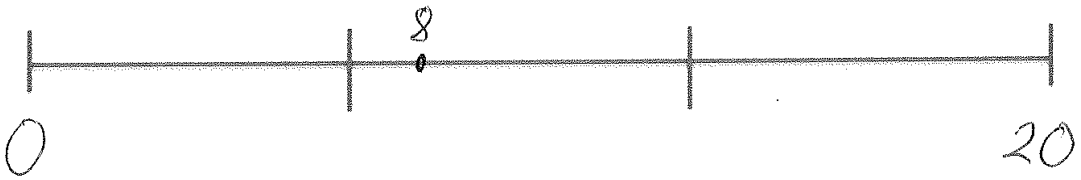


Half Number Line

Eight is before 10.

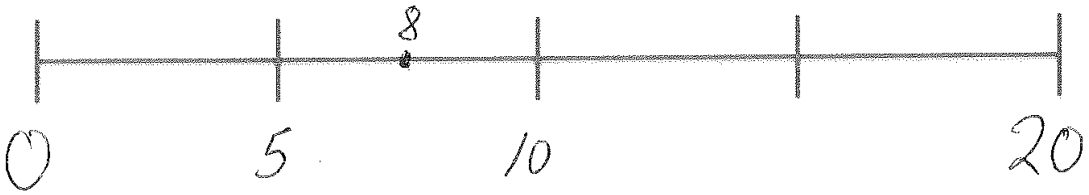


Three Interval Number Line

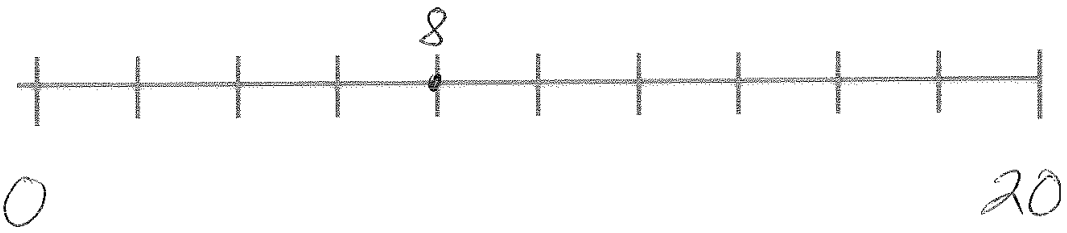


Four Interval Number Line

Eight is between 5 and 10.

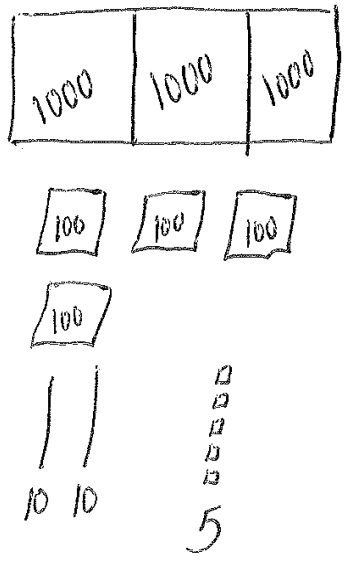


Ten Interval Number Line



What's that number?

Digits	3,425
Words	three thousand four hundred twenty five
Image	1000s 100s 10s 1s /// //// // #####

Digits	Words	Image
3000 400 20 5	three thousand four hundred twenty five	

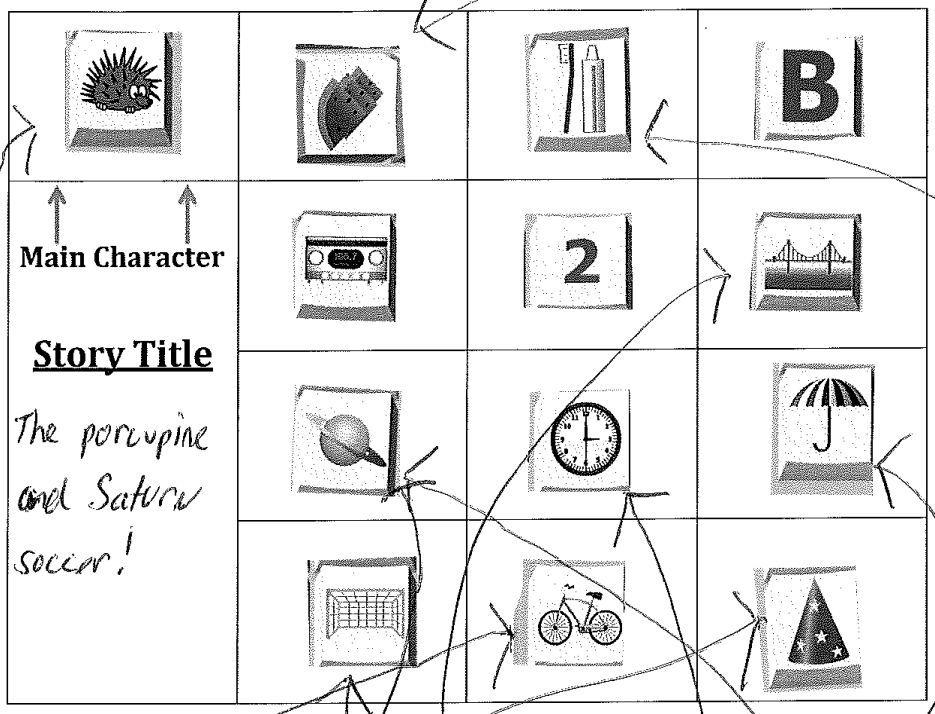
Partner Play Word/Term Sheet

Directions: As you play the games of ST Math today your goal is to use math language together as you play. Use the sheet below and put a checkmark each time you hear the words or math terms during your partner play today. Be mathematicians together!

	✓	✓		*I heard this word*	✓	✓	✓
equal				multiply			
	✓			*I heard this word*	✓	✓	
perimeter				area			
	✓	✓	✓	*I heard this word*	✓		
around				cover			
	✓	✓		*I heard this word*	✓		
add				array			

JiJi Story Board

Put images here to help you tell your story. Start with your animal picture to make your own character for the story. The sentence stems can help you tell your story.



Once upon a time there was a porcupine named ....

He or she WANTED... to eat some watermelon with her friends. She always brushed her teeth after.

BUT something crazy happened and... when she was on the Golden Gate Bridge. At 3:00 an alien came

SO when she got had to ... play AND THEN... to Saturn a soccer game before they

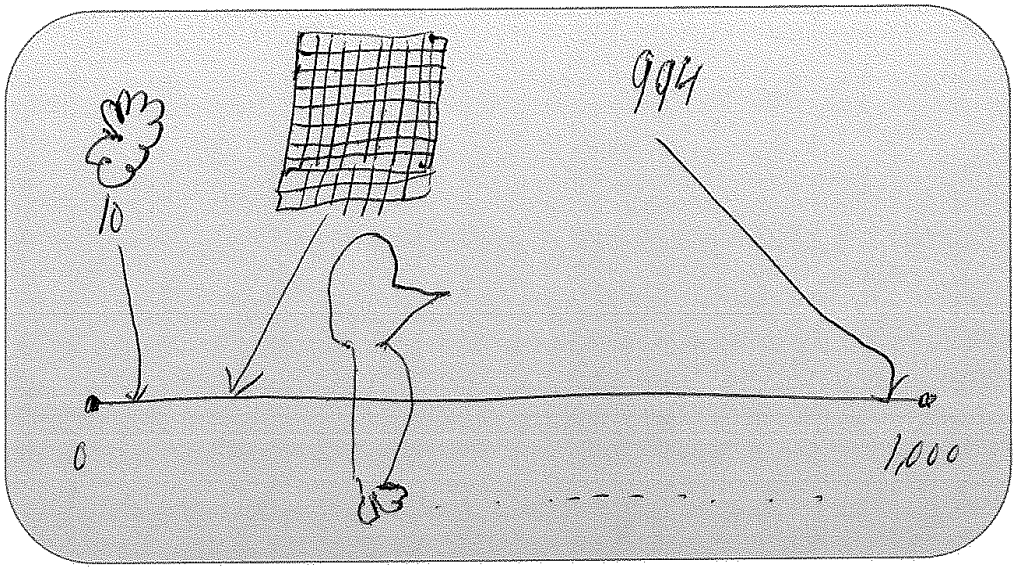
IN THE END... would let her go home. Saturn and took her away

her quills popped the ball so the aliens returned her to Earth. She on an umbrella.

rode her bike back home and her family had a party to celebrate her return.

Partner Play Collaboration Sheet

Show what you worked on today with pictures or numbers or diagrams.



Grade your partner on your work together today in your JiJi Partner Play.

My partner today was Mohamed.

			☺	☹
My partner was helpful today.	4	(3)	2	1
My partner was ~~focused~~ today.	(4)	3	2	1
My partner used math language today.	4	(3)	2	1

Today we discussed .... place value and where to put numbers on a line

I would like to tell my partner... thank you for helping me with the big numbers

Hurdle Club Reflection Sheet

ST Math Player Name Jennifer Lopez Class 224 Grade 5th

Date	Game	Objective	Level
10/16	long divide	multi-digit division	3

I played this game about 12 times.

I really struggled to understand....

Use pictures, words or images to describe ...

I used to think...	*Now I think...*
that long division only used one digit 11 12 | 264 12 14 12	that I need to break up the digit value. 22 12 | 264 -240 24 24 10 10 10 10 11....

Name_____ Date_____

We tell JiJi HOW TO...

If you want to solve the equation 796-361,
let me tell you what to do...

FIRST, I look at the equation and pictures

SECOND, subtract in the ones 6-1=5

NEXT, go to the 10s and take 90-60=30

AFTER THAT, I move to the 100s and take 700-300=400

THEN, ~~[illegible]~~ put the number together (435)

IN ADDITION, there was no borrowing in this problem.

FINALLY,_____

Lesson Vocabulary

subtract	100s	
borrow		
10s		

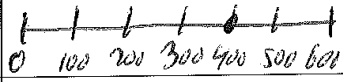
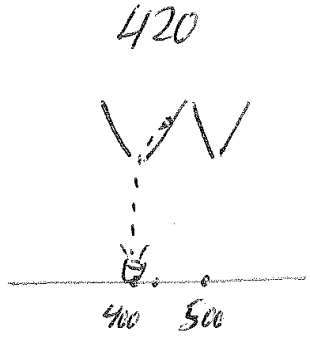
Name(s) _____ Date _____

JiJi shows us HOW TO...

Content Objective rounding 3-digit numbers

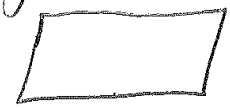
Directions: In the boxes below, draw pictures, write equations, use words, etc. to show the steps used to solve the math procedure above.

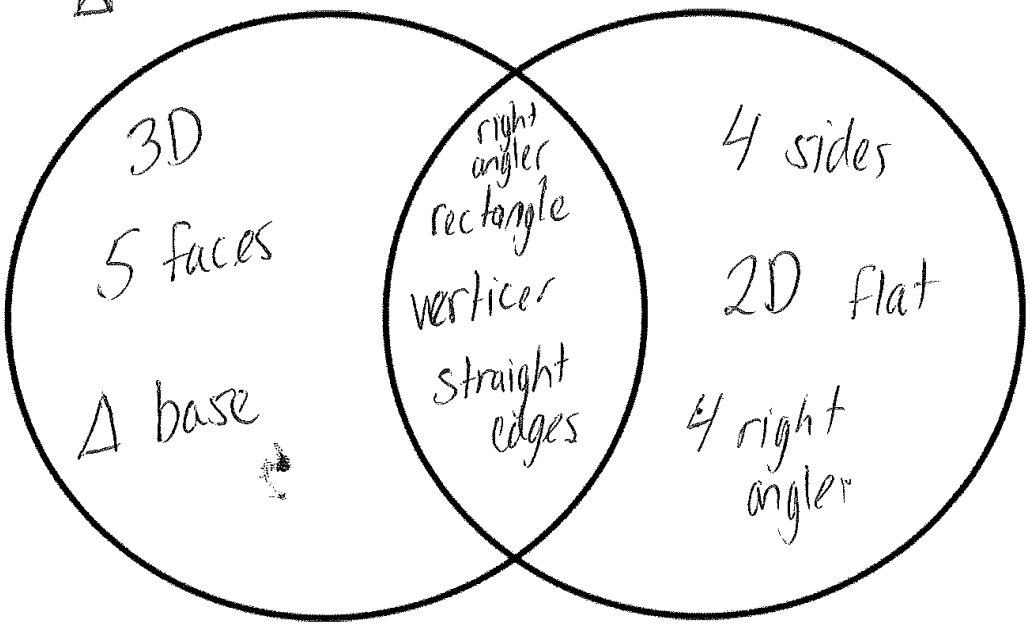
EQUATION or NUMBER SENTENCE to solve: round to nearest 100 420

FIRST	SECOND	NEXT
	click the hundred it is closest to 	watch the JiJi animation show
AFTER THAT 	**THEN** Say 420 is closer to 400 than 500.	**FINALLY** go to next ? Round 73 to nearest (10)

Shape #1 triangular prism
Image

Shape #2 rectangle
Image



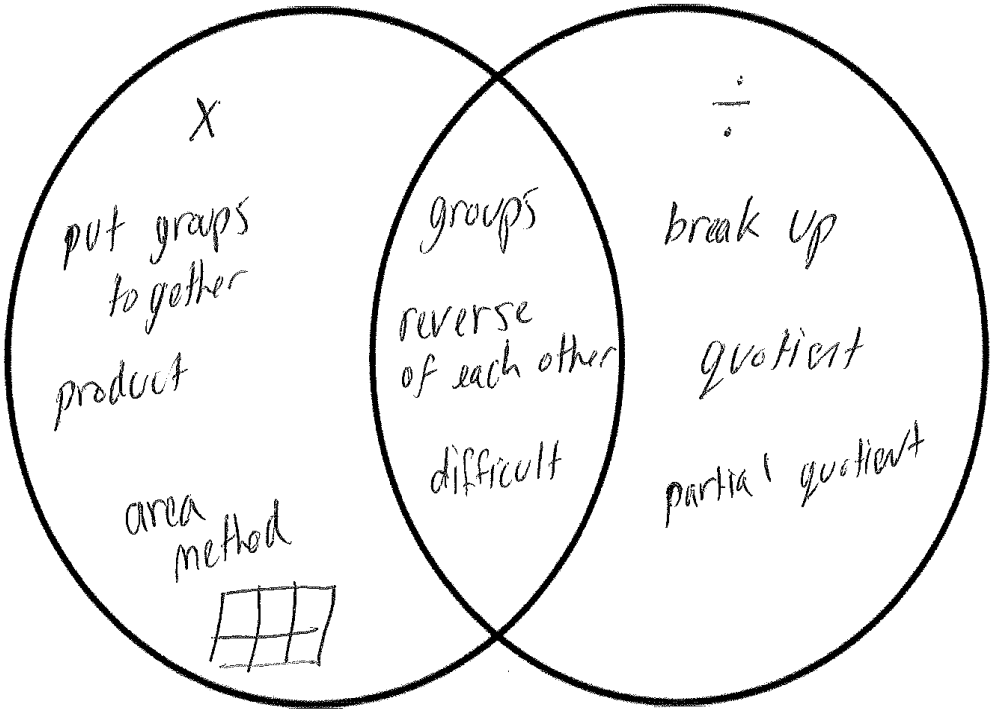


I am comparing a triangular prism and a rectangle.
I noticed both of these shapes have straight edges and both have rectangles. They are also different because one is 3D while the rectangle has 2 dimensions. I/We can tell these two shapes apart because the rectangle is flat and can't be filled up.

Lesson Vocabulary

Compare	Obtuse	Equal	Measure
Different	Angle	Unequal	Curved
Similar	Acute angle	Tilted	Vertex
Right angle	Length	Side	Intersect

multiplication division



I am comparing ~~a~~ multiplication and ~~a~~ division.
I noticed both of these use groups and both are difficult for me. They are also different because multiplication adds up while ~~the~~ division takes away ~~has~~. I/We can tell these two apart because the symbols help us.

Math words to use: