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Comprehensible Input And Output In The Math Immersion Classroom: A Professional Development Series

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COMPREHENSIBLE INPUT AND OUTPUT IN THE MATH IMMERSION CLASSROOM:

A PROFESSIONAL DEVELOPMENT SERIES

by

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DEDICATION

To my husband Jacob, for the hours spent listening to me talk about second language acquisition, the moral and technical support, and for continuing to "earn the money while I earn the degrees." To my dogs Hamilton and Malcolm, for making do with less snuggling space due to my laptop taking up so much room during this process. Lastly, to Mike Mullins for his support throughout this journey and the great "big idea" language acquisition discussions that resulted from it.

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CHAPTER ONE: INTRODUCTION

"Language is best taught when it is being used to transmit messages, not when it is explicitly taught for conscious learning."

Dr. Stephen D. Krashen, *The Natural Approach: Language Acquisition in the Classroom*

Overview

The previous quote from Dr. Stephen D. Krashen, notable linguist and author of hundreds of works on second language acquisition, is one that I have often revisited in my six years of experience teaching in an immersion school. Teachers in immersion settings can find the balance between content instruction and language instruction difficult to manage, often feeling that they need to teach considerable amounts of language before they can work more deeply with content (Martínez & Dominguez, 2018). Contrary to this belief, a developing area of research in how language skills, vocabulary knowledge in particular, can help support the development of numeracy skills in young children indicates that cognitive and/or academic skills are able to be transferred across languages (Méndez, Hammer, Lopez, & Blair, 2019).

My experience and interest in where teaching math and language intersect has led me to the research question: *What are effective comprehensible input and output strategies for teaching mathematics in the immersion classroom?* The working definition of comprehensible input is input understandable by listeners even if they do not understand all of the words or grammar structures. The purpose of this project is to cultivate a collection of strategies, presented via a professional development series, that can be implemented in mathematics lessons in immersion schools (in this case defined as a school where the majority of speakers have limited or no proficiency in the immersion language) to make input more comprehensible for students. Throughout this chapter I will discuss my personal and professional background, reasons for choosing this topic, and what I intend to do with the final product.

Personal Connection to the Research Topic

As a student in a gifted and talented elementary program in the 1990s, our class of twenty students believed we were the class of "the smart kids." I recall a lot of project-based learning and free time to explore topics that interested me, and a class where students were encouraged to try new things and take risks. We enjoyed our label of "smart" and were eager to try new concepts in all subjects. As we moved on to middle school, classes were divided up into hourly subjects, and I found myself struggling with math. My peers seemed to be faring far better, and I often suffered in silence, embarrassed to admit that I could not keep up and unsure of how to proceed. When the time came to be divided up into tracks for high school, I was disappointed to find that I had been put into the "standard" track and would not be spending time with friends in the more advanced math classes. I was also secretly relieved, however, as it was clear to me that I simply was not a "math person." As soon as I met the state requirement for high school math credits, I stopped taking math classes, choosing instead to focus on the areas where I excelled, specifically in language and music. Those classes were challenging in a fun way to me, whereas math was just a challenge I felt unable to take on.

My success in language led me to an exchange year in Germany after my high school graduation, and I was smitten with the language and the culture. I was able to utilize my four years of German as a foreign language experience from high school and truly be immersed in an area where I excelled, and after my year abroad, I decided to study German Language and Literature instead of Music, as I had previously planned. I worked my way through two more exchange programs in Austria and Germany, completed a Master's in German Language and Literature, and arrived at the realization that I wanted to teach. I wanted to be licensed in Minnesota instead of my home state of Michigan, so I moved to the Twin Cities and began working as an Educational Assistant at the Twin Cities German Immersion School with the plan of completing my K-12 German teacher's license and teaching at the high school level.

As luck would have it, a teaching position in First Grade opened up and I was asked to fill it. I quickly realized that teaching the content and language in K-6 was what appealed most to me, so I took elementary education licensure classes the first two-and-a-half years of my teaching career. As stressful as it was, the opportunity to learn so much and to apply it in my classroom, often the very next day, was invaluable.

In 2013, my first year of teaching, I participated in a multi-day professional development workshop on Cognitively Guided Instruction (CGI). CGI is defined as an approach to teaching math that takes children's mathematical and intuitive knowledge into account, and uses these things to help children develop more formal mathematical understanding (Moscardini, 2014). In this process, the mathematical knowledge is not something that one either does or does not have; instead, each student comes to the classroom with some sort of understanding, and it is the teacher's job to determine what their students know and how to help them further develop that knowledge.

Before this workshop, I assumed that students in the immersion setting would have difficulty with word problems, as using word problems involves both math and language skills they have not yet developed, so I often shied away from using word problems. Without much experience with word problems, my students were missing a valuable tool to deepen their mathematical understanding (Fennema, Carpenter, Franke, Levi, & Empson, 1999). I sought out ways to develop better word problems for students and found that many students were more eager to interact with math as a word problem than when math was just, as one student said, "numbers on a piece of paper." That student comment made me want to dive even deeper into improving my mathematical teaching practice.

In my fourth year of teaching, teachers had the opportunity to participate in book clubs during time devoted to professional development. One of the books suggested was Jo Boaler's *Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages and Innovative Teaching.* Having read Carol Dweck's *Mindset: The New Psychology of Success*, in which Dweck (2014) defines growth mindset as when students understand that their abilities can be developed, I was interested in learning more about the concept of growth mindset in the math classroom. So, I joined the club. Throughout the school year, I met with colleagues to discuss the book and collaborate on ways to implement strategies from it, learning a lot about my own mindset during the process. As a K-12 student, math skills seemed to be something one either had or did not have, and even though I was considered one of those "smart kids," I actually shied away from tasks (like math) if I felt I would not be able to experience success relatively quickly. Reflecting on it, I realized that I and so many of my "gifted and talented" classmates had fixed mindsets instead of growth mindsets. We knew what we did well and often avoided trying new things for fear of anything less than complete success, which denied us opportunities to learn from mistakes. As Boaler and Dweck (2016) point out, those very mistakes are the ones that allow our brains to make connections and grow. This is another concept I strive to bring to math lessons in my classroom.

My personal history and professional background have inspired this capstone project. My passion for language learning and language teaching have brought me to the immersion classroom, and my experience as someone who felt left behind by math teachers and for most of her life did not consider herself a “math person” has made me want to ensure that my students have a more positive math experience than I did, including being eager to try new things and understanding that mistakes are an important part of the learning process. My success in K-5 math is likely less attributable to being a "smart kid" in a gifted and talented program and more attributable to having a teacher who encouraged us to see math as more than "just numbers," connected math to our everyday lives, and reinforced the idea of exploring math without sole emphasis on getting the right answer. The switch in middle school to "just numbers" math that did not seem applicable to my life had a definite impact on my feelings about math and performance in the subject, which followed me into my teaching career.

Math Anxiety in Students and Teachers

My own math anxiety appears to be part of a trend reflected in a large study, the Programme for International Student Assessment (PISA). The PISA is a triennial survey of the reading, math, and science skills of fifteen-year olds nearing the end of their compulsory education (OECD, 2013). Over 90 countries have participated in the assessment since its start in 2000, and in addition to reporting on academic abilities, the survey results give the world a glimpse into the learning environments and student attitudes in countries who are members of or work in conjunction with the Organisation for Economic Co-operation and Development (OECD).

The results from PISA 2012 indicate that about 30% of participants felt anxiety when faced with math problems, which was associated with considerably lower scores in mathematics (OECD, 2013). It is possible that this one of the sources of this anxiety in students comes from teachers who themselves have math anxiety, given that it can affect teacher beliefs about who is a "math person" as well as teacher instructional practices (Beilock et al, 2009; Ramirez et al, 2016; Ramirez et al, 2018; Rattan et al, 2012). The results from this survey and the cited research, as well as my own experience as a student and as a teacher, indicates that both teachers and students would benefit from better professional development in math teaching methods.

Immersion Education Beginnings

In October 1963, a group of parents in St. Lambert, Quebec organized and wrote to other parents to determine whether there was interest in developing a better French instruction program for their children (Scott, 2016). There was, and that interest led to the proposal of a "language bath" experiment: all children in the proposed class would be instructed in all subjects in French through Grade 3, and in half English/half French from Grade 4 onward (2016). The experiment was successful, and it fit well into the national discussion of official languages of Canada also going on at the time.

In the mid-1960s, a commission was established to research and provide recommendations on how to develop French biculturalism and bilingualism within the Canadian province of Quebec (Dicks & Genesee, 2017). The commission recommended that Canada should have two national languages, English and French, and that children should be provided instruction in both of those official languages, given that there was enough demand in their local district (2017). As a result of these recommendations, the first official French Immersion (FI) program was established as a way to provide adequate instruction for students to achieve bilingualism (2017). These programs expanded across Quebec through the 1970s and 1980s, and are now available as schooling options across all of Canada (2017), with 409,893 students enrolled in them throughout the country as of the 2014-2015 school year.

Immersion Education in the United States

Multilingual communities in the United States have existed side by side since before it was officially a country, thanks to both the languages of Native Americans and to waves of immigrants who came from across the world (Dicks & Genesee, 2017). In the "melting pot" of people from all over the world, linguistic assimilation (i.e. learning to speak English) was to many people the key to "becoming" American. The concept was voiced by President Theodore Roosevelt himself in 1907:

> "We have room for but one language in this country, and that is the English language, for we intend to see that the crucible turns our people out as Americans, of American nationality, and not as dwellers in a polyglot boarding house." (as cited in Dicks & Genesee, 2017)

The history of language instruction in the United States, including foreign language, bilingual education, and immersion education, reflects tensions that have been seen throughout the history of the nation. In the early 20th century, few or no resources were provided for students who did not speak English, and those students were often held back until they understood enough English to also understand the content of lessons (Bybee, Henderson &

Hinojosa, 2014). The concept of "English only" policies was seen throughout the 20th Century, including the Reagan administration's campaign against bilingual education in the 1980s and the bill put forth in the House of Representatives in 1996 to designate English as the "official" language of the United States, barring other languages from being used by government agencies and in official documents (Dicks & Genesee, 2017). That bill did not pass the Senate, but the English-only movement continues as a part of a wave of anti-immigrant sentiment in areas of the United States (Agudo, 2018). While English is not the official language, children of immigrants who learn English are less likely to speak their native language as time goes on (Kaur, 2018). Proponents of English argue that having an official language would save the government money on translation and document printing costs as well as encourage non-native English speakers to speak English (Agudo, 2018). However, a study by Stanford University found that non-native English-speaking students performed better both linguistically and academically when placed in dual-language immersion programs that allowed them to process and discuss in their native language, as opposed to those students who were placed in English-only programs and expected to "sink or swim" (Myers, 2014).

Given the history of the United States, as well as its size, it is understandable that its relationship with language learning is different when compared to other countries across the world. In the United States, most students begin learning a world language around age fourteen and continue doing so for a school year. According to the Asia Society (2009), this is in stark contrast to twenty-one of the other twenty-four industrialized countries in the world, where most students begin learning a second language in their elementary school years and do so for a longer period of time.

An area where language learning in the United States is growing, reported by the Center for Applied Linguistics (2011), is immersion education. Lenker and Rhodes (2007) define three different types of immersion education. Total, or one-way, immersion is a program in which students in kindergarten through second grade are instructed in the target language (TL), with instruction in English increasing to 20%-50% in third through sixth grade, depending on the school. Partial immersion is defined as 50% of instruction in the TL, with literacy instruction either in English, in the TL, or in both simultaneously. A third type, two-way or two-way bilingual immersion, uses both English and another TL for instruction.

Since first being introduced in the United States in 1971, immersion programs have spread across the country as a way to introduce second languages to children at a young age. The number of immersion schools has increased from three in 1971 to 448 as of 2011, according to the Center for Applied Linguistics (2011), with 38 states and the District of Columbia having at least one immersion school within their borders. Additionally, 33 U.S. states now offer a "Seal of Biliteracy" for high school graduates who can demonstrate proficiency in two or more languages (Agudo, 2018).

Benefits of Immersion Education

Benefits of immersion education, as summarized by Fortune (2012), are many. Among them include high levels of proficiency in both English and the TL, a range of well-developed cognitive skills, and the ability to communicate better with people from a wide range of backgrounds. Fortune acknowledges that students:

> ... in one-way immersion programs where English may not be introduced until grades 2–5, show evidence of a temporary lag in specific English language skills such as

> spelling, capitalization, punctuation, word knowledge, and word discrimination. That said, these studies also find that within a year or two after instruction in English language arts begins, the lag disappears. There were no long-term negative repercussions to English language or literacy development. (Fortune, 2012, p. 9-10)

Results from studies examining the link between academic achievement and immersion education, highlighted by Dorner (2016), found that immersion students tend to outperform their English-only peers across multiple subjects.

Challenges of Immersion Education

Dorner's (2016) work also highlights areas of concern in immersion education, including inequality of access across the U.S., limited high-quality curricular resources, few immersion teacher preparation programs, the aforementioned "English-only" movements, and a lack of structure that engages parents and community of minoritized families. Fortune's research (2012) describes staffing concerns in more detail, indicating that finding appropriately licensed, experienced teachers who are proficient in the TL is a challenge. In addition to these concerns is the balancing act that immersion teachers feel every day in trying to teach content, language, and literacy development. Fortune adds that differences in student abilities, language proficiency, learning style, and potential special needs can grow when occurring in a second language.

My Experience Teaching Math in the Immersion Setting

As an immersion teacher, adapting non-English language math curriculum to the state standards where my school is located is often very time-consuming but necessary, as the level of language (and sometimes cultural knowledge) is often too difficult for non-native students to access in its original form. There are often many multisyllabic words on one page, which can overwhelm non-native emergent readers and prevent them from working with the content.

Additionally, some topics are covered in different grades in the TL. Examples in my U.S. state include the topic of rocks starting in first grade, a topic which is generally taught in Germany starting in third grade. Economics concepts (including goods, services, consumers, producers, and opportunity cost) are taught in my state beginning in second grade, while the topic is spread across second, third, and fourth grade in much of Germany.

Lastly, teaching materials in the TL can differ greatly from those used in the immersion setting. In my experience visiting many German elementary school classrooms, students are given much more independence in their classwork from a younger age. This independence is difficult to provide students in the immersion setting who do not understand what certain words mean and are not yet literate enough to look them up on their own.

It is my intent to develop a collection of strategies that immersion teachers can implement in their own classrooms, no matter what the language, to help their students develop both their mathematical and language skills. Additionally, I would like to share this research with other immersion and dual-language teachers at language educator conferences. Given the increase in immersion education programs in the United States, opportunities to share this research seem to be increasing. Collaborating with other professionals in my field will further strengthen my practice as a math teacher, which will in turn have a positive effect on my students, my colleagues, and myself.

Summary

By completing this capstone project, I hope to answer the question *What are effective comprehensible input and output strategies for teaching mathematics in the immersion classroom?* Chapter One is a description of how my experiences with math as a student, as well as my experiences with math and a second language as an adult, have inspired me to make my classroom one where students can enjoy and celebrate mathematics. Chapter Two will be a literature analysis including the topics second language acquisition, immersion education, mathematics instruction, and math anxiety. Chapter Three will describe the professional development series aimed at immersion teachers in grades K-3. Lastly, Chapter Four will provide thoughts on the research process, the project itself, and the capstone journey.

CHAPTER TWO: REVIEW OF THE RESEARCH LITERATURE

Introduction

As a teacher in an immersion classroom, I strive to provide a classroom environment where both second language learning and mathematics are seen by students as areas where they can experience success. Accomplishing this in the subject of math in the early elementary immersion setting can be difficult, as K-3 students often have not had enough exposure to the Target Language (TL) to use it to discuss their mathematical reasoning with each other. In this case, the TL is defined as the language that the students are learning.

Rather than prevent students from discussing their mathematical ideas, I have tended to teach the main lesson in the TL and allowed the students to talk with each other in English. While students are discussing and working with each other, I have checked in on groups and discussed ideas with them, rephrasing and summarizing their ideas in the TL. This has worked to a point, but my desire to better support students in both learning the TL and mathematics concepts, as well as keep them in the TL longer, has led to my research topic: *What are effective input and output strategies for teaching mathematics in the K-2 immersion classroom?*

The first section will summarize Dr. Stephen Krashen's five main hypotheses of second language acquisition (SLA). Researching these hypotheses helped me better understand best practices in second language acquisition and helped define the collection of strategies in Chapter Four of this Capstone Project. The section also includes information on Working Memory (WM) and how it affects second language acquisition. In this case, WM is defined as the way information is activated and manipulated by the brain to complete a task in the short term (Churchill, 1999).

The second section will explore best teacher practices in the immersion setting, including discussion of which teaching strategies are effective, the role of intralanguage (IL) in the language acquisition process, and how to best address the process of error correction. These topics help determine ways to support keeping K-2 students in the TL, which will help them when discussing math concepts and their own reasoning with each other.

The final section will examine best teacher practices in the early elementary math classroom. First, there is a discussion of math anxiety (MA), including how it affects WM and how it can unintentionally be passed on from teacher to student. Methods that can be used to help alleviate MA, including CGI and GM, follow. Lastly, the areas where math and SLA intersect are covered, including teaching strategies that are beneficial in both subjects.

Krashen's Five Main Second Language Acquisition Hypotheses

Stephen D. Krashen's (1987) hypotheses of language acquisition are instrumental in shaping how language educators plan their language lessons to best fit their students. His Acquisition-Learning hypothesis indicates that there are two independent systems in SLA: the acquired system and the learned system. Krashen (1987) suggests the acquired system is subconscious, similar to how babies acquire their native language by focusing on the act of communicating instead of the individual words they say. The second independent system, the learned system, is a more conscious process of learning the "rules" of the language.

Krashen then emphasizes the importance of the role of output in SLA. In my classroom, students have difficulty producing output when beginning to discuss math concepts with each other in the first grade. He indicates that “Output aids learning because it provides a domain for error correction” (p. 61). However, students will not all be able to produce the same output at the same time, even when being taught within the same classroom.

Rather, Krashen’s (1987) Input hypothesis emphasizes the role of providing students with Comprehensible Input (CI) in order for them to acquire, not “learn,” a language. CI is defined as “i (input) + 1,” meeting students at their particular language level and providing scaffolding to make the language comprehensible. In Krashen’s mind teachers must recognize that the students in their classroom are likely not all on the same “i” level, nor at the same developmental stage, and therefore acquire the language at different rates.

Relevant to Krashen's Input hypothesis is Vygotsky's theory of the Zone of Proximal Development (ZPD), defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Interaction with the teacher or with a More Knowledgeable Other (MKO) in learning exercises can help move students through the ZPD by providing them with a place to learn and practice their skills (1978). Scaffolding, defined as a method that "enables a child or novice to solve a task or achieve a goal that would be beyond his unassisted efforts" (Wood et al, 1976, p. 90), is a way to provide students with achievable tasks within their competence level. Effective scaffolding methods involve designing and demonstrating tasks that are simple and engaging to students, controlling student frustration levels when performing the tasks, and emphasizing steps that can help students find the solution (1976). Providing comprehensible input in the language classroom helps move students through their own ZPD, and they eventually are able to perform more demanding tasks.

A process that is more predictable in language learning is seen in Krashen’s (1987) Natural Order hypothesis, which indicates that language students acquire some grammar structures earlier in learning and some in later stages. However, he does not believe that grammar sequencing should be a focus when the goal is language acquisition, placing the emphasis instead on making students “conversationally competent” (p. 77). This means that students can get their point across even when not producing accurate grammar, for example using the wrong tense or verb conjugations. Students must be prepared for the fact that they will not always understand everything said to them or will not always know the right word to use, and Krashen (1987) indicates that conversationally competent students understand how to obtain CI when these situations happen.

Krashen suggests that it is possible to teach students some conversational tools that are easy to learn, either through memorization or as rules. An example of this known to many German learners and teachers is the memorization of dative German prepositions "aus, ausser, bei, mit, nach, seit, von, zu" sung to the tune of Johann Strass II's *Blue Danube* waltz. While students might night be able to correctly apply relevant grammar rules to dative adjective endings, for example, the step of memorizing the dative prepositions brings them closer to being able to monitor their speech and eventually adjust accordingly. This is seen in Krashen's next hypothesis.

Krashen’s (1987) Monitor hypothesis describes how learning a language influences the acquisition of the language. A student’s learning system “monitors” their speech, helping plan, edit, and correct their output. Interestingly, students who are more introverted tend to over-monitor their output, while those who are more extroverted tend to under-monitor (Krashen, 1987). The goal is to find the happy medium between students under- and over-monitoring their language.

Student output is also relevant in Krashen's (1987) Affective Filter hypothesis, his fifth and final SLA hypothesis, which concerns personal variables in language learning. These variables include self-confidence, anxiety, and motivation. Motivated students with high self-confidence and low anxiety tend to have more success in SLA, while students with low self-confidence, high anxiety, and less motivation tend to have a raised "affective filter," which can interfere with their acquisition of a second language.

To Krashen (1987), the acquisition of a language is more important than learning the rules of a language. That is to say that "comprehensible input and the strength of the filter are the true causes of second language acquisition" (p. 33).

Working Memory in Second Language Acquisition

Another important concept in language acquisition for teachers to consider is WM, which plays an important role both in acquiring new vocabulary as well as other larger language constructs (Churchill, 1999). According to Churchill's research, WM is put under more stress when students are trying to produce output in their second language, and that stress can subsequently impact their ability to continue producing in the language. Archibald (2007) supports this, stating that WM is stressed because language tasks ". . . often additionally require motoric responses, problem-solving, active inhibition of competing stimuli, and completion under time constraints" (p. 7).

Additionally, Zalbidea's (2017) work on WM in a second language emphasizes the importance of task-based instruction so that students have the opportunity to communicate their ideas as well as focus on the language itself. Zalbidea indicates that the more complex a task is, the more WM is used by the student, which often leads to a trade-off between the accuracy and complexity of a learner's language output. Understanding how WM can affect students can help language educators better plan their instructional goals, including task design and when as well as how to correct errors.

According to Archibald, "familiar lexemes retrieved frequently would place fewer demands on attention during processing" (2017, p. 6). Therefore, providing information to students in smaller chunks and giving them many opportunities to practice would put less stress on WM. Krashen's Monitor hypothesis plays a role here, as breaking down the language and practicing often is help students monitor their language and correct errors that they notice. An example of this from my own first grade German language classroom is when students begin learning the German vowel sounds, as the *A*, *E*, and *I* sounds are very different compared to how they sound in English. These letters, along with others, often have challenging points of articulation in the mouth when compared to English. Students need a lot of practice with them before moving on to building two-letter words and vowel combinations, which many of them struggle with throughout first grade, often hampering them from producing accurate output, especially when reading aloud. Krashen's Affective Filter hypothesis also potentially plays a role here, as students being unsure of letter sounds when learning to read may raise their affective filter, leading them to feel more anxious about reading in the second language.

The Immersion Classroom

Though instruction in the immersion setting occurs mainly in the TL, a student's native language can still play an important role in their acquisition of a second language. In their work on practices in primary-level French second language classrooms, Mady and Thomas (2014) compare becoming bilingual/multilingual to the act of playing a violin. Each string can be played on its own, but teachers can help musicians play more than one string at a time. Mady and Thomas (2014) suggest that ". . .(a) the language learner's multiple languages are always 'resonating' somehow even when only one language is being used; and (b) both monolingual and bi/multilingual language practices play roles in making the 'music' that is communication" (p. 400). Bialystok (2012) points out that, even in situations where fluent bilinguals are only working in one language, both languages are activated and interacting with each other.

While working in the language classroom, teachers often notice students applying unique rules to the TL, especially in spontaneous communication. This process is known as interlanguage (IL), ". . . usefully viewed as a transitional linguistic system (at all levels: phonology, morphology, syntax, semantics, pragmatics) that is different from the TL system and also different from the learner's native language (NL) system" (CARLA, 2017). Throughout my years of teaching in immersion, I have seen many different examples of interlanguage from students. In my first and second grade classrooms, students have overgeneralized (applying conjugation rules for first person singular verbs to second- and third-person verbs), transferred from their native language (pronouncing German words using English letter sounds), and directly translated idiomatic expressions from their native language that do not have the same meaning in German. For example, saying something is a "piece of cake" in English means it is easy, but in German, "ein Stück Kuchen" is simply that: a piece of cake. This concept is essential for language teachers to consider, and should not be seen as a hindrance, but rather as a process that assists students in learning the TL. When correcting errors in the TL, teachers should consider the cognitive development of their students, the feedback needs of individual learners, and which cues to provide for learners to enable them to self-correct (Tedick & de Gotari, 1998).

Comprehensible Input

Before teachers can expect students to produce output in the TL, they need to make sure their TL input is comprehensible. Strategies recommended by the American Council on the Teaching of Foreign Language (ACTFL) to language teachers on comprehensible input are:

- provide comprehensible input that is directed toward communicative goals;
- make meaning clear through body language, gestures, and visual support;
- conduct comprehension checks to ensure understanding;
- negotiate meaning with students and encourage negotiation among students;
- elicit talk that increases in fluency, accuracy, and complexity over time;
- encourage self-expression and spontaneous use of language;
- teach students strategies for requesting clarification and assistance when faced with comprehension difficulties; and
- offer feedback to assist and improve students' ability to interact orally in the TL (2012).

Coyle (2007) agrees, suggesting that the four concepts language teachers find the most effective are gestures/visuals, hands-on materials, multisensory methods, and repetition. Furthermore, students who have the opportunity to negotiate input during interactions with other students, as pointed out by de la Fuente (2002), are able to reach a higher level of comprehension. These methods emphasize much more formative, as opposed to summative, assessment. Other examples of formative assessments from the Center for Applied Research in Language Acquisition (2019) include using thumbs up/down to determine if students understand concepts, using red/yellow/green cards so students can communicate their understanding non-verbally, and providing graphic organizers so students can visually organize their thoughts. At the end of lessons, teachers can provide summary learning checks such as exit tickets (students answer a question on a ticket, which they give to their teacher as they leave), "3-2-1" (students write three things learned, two things that were interesting to them, and one question they have), and Turn-and-talk (students speak with a nearby partner about what they have learned) ("Why Assess?" 2019).

Comprehensible Output

Output produced while negotiating meaning, as reflected in de la Fuente's research (2002), can help learners internalize words and activate them when they are needed again later. When students have the chance to modify output, as seen in Ellis and He's research (1999), they can comprehend a text even if it contains unfamiliar words. Their explanation for this is "producing new words helps learners to process them more deeply, whether for comprehension or for acquisition, than simply hearing them" (297). What students initially produce is often an inaccurate approximation of what is grammatically correct. However, as student language and writing abilities develop, their attention can be drawn more to error correction in writing and they can be given appropriate feedback on how to correct their errors.

It is in the teacher's best interest, as indicated by Izumi, Bigelow, Fujiwara and Fearnow (1999) to not overload students' processing capacity with the activity itself, which can negatively impact their ability to pay attention to grammar. In these beginner language activities, less is more. In a modified output condition in which students are able to negotiate meaning with each other (asking for clarification or circumlocuting if necessary), Ellis and He (1999) believe that learners are exposed to a different kind of discourse than in a more rigid activity where the teacher is the sole person who makes choices or asks for clarification. In this case, circumlocution is defined as using other words to describe a word that the student does not know in the TL. That sort of discourse can help students better acquire and retain vocabulary in the TL.

Keeping Students in the TL

A persistent topic of discussion among immersion teachers is moving students away from IL and toward more proficient, frequent use of the TL, as students in the immersion setting tend to prefer conversing with one another in their native language when they are in the classroom (Tarone & Swain, 1995). Incorporating topics introduced by students and giving them more time to answer, as noted by Garton (2002), can also increase participation and language production. Strategies to keep students in the TL, as provided by the American Council on the Teaching of Foreign Languages, include:

- Plan lessons so as to eliminate idle time, which can lead students to chat in English.
- Change seating often so students have a chance to pair up with different classmates.
- Design info gap activities in a way that students must use the language to obtain the information they're missing. Let students know they could be asked at any moment to report their information to the class.

- Post high-frequency phrases around the classroom so students can refer to them if they get stuck.
- When your students speak to you or ask you something in English, give a quizzical look and say you don't understand.
- Use activities such as inside–outside circles that allow students to practice common expressions and structures in rapid sequence. This also gives the teacher a chance to listen for places where communication is breaking down.
- Try a reward system in which students can earn points for maintaining the TL
- Encourage students to come up with silly stories as part of a survey or TPRS activities (Crouse, 2012, p. 27).

Math Anxiety

A struggle I have noticed some students having in my classroom that is reflected in this literature review is the concept of math anxiety (MA), defined as "a negative mindset towards solving mathematical problems" (Das & Das, 2013, p. 1), which can have a significant impact on student learning and performance. Results from the 2012 Programme for International Student Assessment (PISA) indicate that an average of one in three students feel some sort of MA, and note that countries that had students with higher MA tended to perform lower on the mathematics portion of the assessment (OECD, 2015). Many teachers assume that MA only occurs in students with less advanced mathematical skills, but an emerging area of research suggests that MA can also occur in students who are in typical or high-achieving math ranges as well (Sorvo, R., 2019; see also Ramirez, Chang, Maloney, Levine, Beilock, 2016).

Students who are math-anxious "may show deficits in mathematical processing that lead them to have poor math performance, which in turn engenders mathematics anxiety" (Herts & Beilock, 2017, p. 720). According to Carey, Hill, Devine and Szücs (2016), it is possible that poor math performance in childhood could be a cause of MA, given evidence found that students with math-related learning disabilities tend to have higher MA than other students. They suggest that "poor performance can trigger MA in some individuals and MA can further reduce performance, in a vicious cycle" (p. 5).

In the review of the research for this capstone, three major negative impacts of MA were identified: 1. Causing students to revert to problem-solving methods that are less efficient (Herts & Beilock, 2017; Ramirez et al., 2016; Ramirez, Hooper, Kersting, Ferguson, and Yeager, 2018); 2. Leading to an increased load on WM, causing a decrease in performance (Ashcraft & Moore, 2009; Herts & Beilock, 2017; Foley et al., 2017; Ramirez et al., 2016); 3. Negatively affecting children's ability to learn mathematical concepts (Herts & Beilock, 2017; Ramirez et al., 2016). Herts and Beilock (2017) indicate that further research is needed in the area on how MA in the classroom affects student learning outcomes so that teachers can be more adequately prepared to work with and/or prevent MA in their students.

The Impact of Math Anxiety on Working Memory

An important concept to consider in the discussion of MA is how the working memory (WM) of students with MA is affected while they are performing math tasks. MA is one of the types of anxiety, as Herts and Beilock (2017) point out, that has "been shown to tax the working memory system, leading to decreased performance on tasks that demand heavily on it" (p. 721). This concern is also reflected in the work of Foley et al. (2017), who find that "[I]f math-anxious students must juggle math-related worries when their working memory is taxed (e.g., when a letter task is added to the mix, or when problems are difficult), their performance suffers" (p. 54).

WM is being addressed because it came up throughout the literature review with regards to both language learning and math anxiety, and therefore is very relevant to teaching math in the immersion classroom. While research on the subject was not found, I see the potential for students whose WM is taxed due to MA to have difficulty speaking in the TL, given the demand placed on WM in both SLA and during mathematics tasks. The opposite could also be true: students with difficulty speaking and comprehending the TL could potentially have problems during math tasks due to their WM being overloaded.

The Role of the Teacher in Math Anxiety

A teacher's personal feelings about math can have a large impact on student math learning even if they do not communicate them directly, according to Ramirez et al. (2018). Furner and Duffy (2002) agree, suggesting some teachers might be unknowingly transmitting their own MA to their students. Even if teachers do not outwardly display their own MA, Ramirez et al. (2018) indicate that those teachers "may be less likely to employ process-oriented teaching practices that send a message that all students are capable of being good at math," (p.8) which students are able to perceive. The perception of that belief "partially explains the relationship between teacher math anxiety and student math achievement" (p. 8).

The importance of the educator's role in paying attention to the potential for MA in students in early elementary (K-2) grades is emphasized by Harris et al. (2019), who stress the importance of math instruction that focuses on both feelings about mathematics and math skill development, especially among those students who struggle in math. This sentiment is echoed by Ramirez et al. (2016), who indicate that in order for students to use more successful math strategies, they must be taught math content as well as ways to mitigate MA they might be feeling.

Teaching Methods in the Math Classroom

Mathematical proficiency, as defined by the National Research Council (2001), has five strands that are interdependent and "provide a framework for discussing the knowledge, skills, abilities, and beliefs that constitute mathematical proficiency"(p.116). Those five strands are:

1. conceptual understanding - comprehension of mathematical concepts, operations, and relations;
2. procedural fluency - skill in carrying out procedures flexibly, accurately, efficiently, and appropriately;
3. strategic competence - ability to formulate, represent, and solve mathematical problems;
4. adaptive reasoning - capacity for logical thought, reflection, explanation, and justification;
5. productive disposition - habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy (p. 116).

Students with MA might have difficulty with one or more of these strands, so part of this literature review focuses on two math teaching methods I have explored in professional development sessions at my school to better help students develop these strands and reduce MA: Cognitively Guided Instruction (CGI) and Growth Mindset (GM).

Cognitively Guided Instruction

Cognitively Guided Instruction (CGI) is defined as “a principled approach to teaching mathematics which recognises mathematics learning as a sensemaking activity,” but not as "a prescriptive pedagogy or an acquirable teaching technique" (Moscardini, 2014, p. 71). CGI does not assume that students come to math class as blank slates, but instead that students come with informal mathematical knowledge that can be developed into more formal knowledge (2014). The CGI process involves an emphasis on students working with word problems and the need for teachers to focus on what their students understand, which then helps teachers design further work that builds upon student understanding (2014).

In their CGI teacher development program, Fennema et al. (1996) noted common themes in the CGI teacher learning process:

(a) Children can learn important mathematical ideas when they have opportunities to engage in solving a variety of problems;

(b) individuals and groups of children will solve problems in a variety of ways;

(c) children should have many opportunities to talk or write about how they solve problems;

(d) teachers should elicit children's thinking; and

(e) teachers should consider what children know and understand when they make decisions about mathematics instruction. (p. 407)

Richardson (2012) confirms these themes, reasoning that "[I]f we look only at the ability to get right answers, we miss the information to determine what children know and still need to learn" (p. xii). Instead of just asking for an answer, teachers should ask students to demonstrate how they arrived at their answer, whether correct or incorrect. Classroom interactions during the

CGI process provide teachers with a way to learn about their students' conceptual understanding, allowing teachers to better respond to student needs (Moscardini, 2014).

In her work, Richardson (2012) highlights the importance of students having a solid foundation in a mathematical concept before they are to build upon it. CGI can help students better understand mathematical concepts, for example by encouraging students to verbalize what they understand about a math problem and creating a visual representation of how they solved the problem (Pfannenstiel, Bryant, Bryant, & Porterfield, 2015). Richardson (2012) agrees, indicating that numbers alone are too abstract for young learners, and that students need more meaning in order to make numbers less abstract. She shares an example of students coming up with their own word problems in order to better understand addition:

> STUDENT 1: When you say 5 yellow and 3 green, we know what that is, and we know it is 8. But when you say numbers, we just see numbers and we don't know what that is.
>
> RICHARDSON: [. . .] This time I will say numbers, but you think of what the numbers
>
> mean. 3 + 4. [. . .] What did you think about?
>
> STUDENT 1: I knew 3 toothpicks and 4 more toothpicks make 7 toothpicks.
>
> STUDENT 2: I knew that if I had 3 cookies and my mom gave me 4 more, I would have 7. (p. 70)

From this interaction, Richardson goes on to share that she "realized that for young children, numbers are adjectives, not nouns. They need to know what the numbers are describing so they won't just picture an equation" (2012, p. 70). The goal of the lessons should not be focusing solely on the correct answer, but on understanding the process that a student went through to arrive at that answer.

Word problems are useful and important for students in developing their mathematical understanding, but those problems are more than just words and numbers. Students must understand the language itself, the structure of the math problem given, and come up with a strategy to arrive at an answer (Pfannenstiel et al., 2015). Ultimately, the goal of CGI is not for teachers to model step-by-step ways to solve problems for students, but instead "to teach students a strategy to help them become more independent learners" (Pfannenstiel et al., 2015, p. 292). When students have developed these strategies, they develop a better understanding of what is happening in a math problem and are able to build upon that understanding (Richardson, 2012).

Classroom interactions, as seen in the Richardson example above, are of the utmost importance in developing students' mathematical understanding. These interactions should not only take place between teacher and student, but amongst students themselves. Fennema et al. (1996) noted several factors in their longitudinal CGI study that seemed to have had a positive effect on mathematical achievement:

(a) Teachers provided more opportunity for students to grapple with concepts and engage in problem solving;

(b) children were provided opportunity to share their thinking and their thinking was valued; and

(c) the teachers whose instruction was categorized at the higher levels increasingly adapted instruction to the problem-solving abilities of their students. (p. 430)

In classrooms where mathematics talk is encouraged, students are able to share their ideas with teachers and each other, co-constructing knowledge and allowing teachers to know how students think (Brodie, 2011). Fennema and Romberg (1999) assert that a teacher's role in a CGI classroom is sometimes active and other times passive. The active part involves the teacher establishing an environment where all students can learn math with understanding, while the passive aspect involves providing space for students to struggle, either alone or with each other, while solving math problems. This concept is reflected in Furner and Berman's (2003) research, which states the importance of focusing more on the process of solving a problem and less on a particular method to do so. They affirm that:

> Teachers need to emphasize more communication in the classroom through discussion, problem solving, discourse, and writing. Teachers benefit children most when they encourage them to share their thinking process and justify their answers out loud or in writing as they perform math operations. [. . .] With less of an emphasis on right or wrong and more of an emphasis on process, teachers can help alleviate students' anxiety about math. (p. 172)

Growth Mindset

A growth mindset (GM), defined as the concept that mistakes are a natural part of learning and that one can learn from those mistakes (Boaler, 2015), is one that is beneficial to students in the math classroom. The opposite of this is a fixed mindset, defined as the idea that one's intelligence and/or ability is something that cannot be changed (Ramirez et al., 2018). According to Boaler (2015), there has been an increase over the last decade of students with fixed mindsets. These students believe that those who perform well on math tests are the ones who get it and since they struggle on those same tests, they must just not be math people.

Alleviating Math Anxiety

Both CGI and GM teaching strategies encourage students to be more flexible in their mathematical thinking. This flexibility does not require students rely on a mathematical algorithm, but instead promotes problem solving and critical thinking. Methods used in both CGI and GM have been recommended by the National Council of Teachers of Mathematics to help alleviate MA in students. These include group discussion of problems, questioning and predicting, justification of answers, integration of content, and modeling problem-solving techniques (NCTM, 1995). The recommended methods are heavily language-based, meaning that students in the K-3 immersion setting might have more difficulty understanding and participating in the methods, given their relatively little exposure to the TL.

Another potential way to alleviate MA does not involve the students directly, but instead their teachers. A study by Beilock et al (2009) measured MA throughout the school year in first and second grade classrooms. At the beginning of the school year, there was not a substantial difference between the four groups of students studied (girl and boy students whose teachers had MA and girl and boy students whose teachers did not have MA). However, by the end of the year, girl students of teachers who had MA achieved significantly less than the other three groups. Beilock et al posit that this could be due to those female teachers with MA conforming to the idea that boys are better in math, pointing out that girls who believed boys are better in math and that girls are better in reading had lower math achievement in the study.

The key to overcoming MA is to address how math is taught in the classroom, especially in early elementary grades. The NCTM emphasizes the importance of teachers considering both mathematical dispositions and work habits in their math teaching practice. Teachers should keep in mind how students view themselves as math learners, how they persevere when faced with mathematical challenges, and how they can communicate their ideas (Lappan, 1999). Additionally, teachers must help students develop their mathematical work habits, such as how they organize their work, how they make connections between known and new concepts, how they use mathematical language, and how they work independently (Lappan, 1999).

Where Math and Second Language Intersect

To effectively teach mathematics in the immersion setting, teachers need both a strong pedagogical background and native or near-native language skills in the TL. In their longitudinal study, Fleckenstein, Gebauer, and Möller (2019) report that the quality of math instruction seemed higher in the TL than in students' native language, which they posit might be due to the "generally higher teaching motivation of teachers working in immersion programs compared to teachers in conventional classes" (p. 229). Additionally, Ramírez, López, and Ferron (2019) found that characteristics (including training, years of experience, and cultural beliefs and practices) of teachers working in the language classroom had a positive impact not only on math, but also on their students' literacy and language skills. Eight cultural forces in classrooms, as defined by Ron Ritchhart (2002) and identified as integral to helping students become powerful mathematical thinkers by the NCTM (Clark, 2017), are equally important in the language learning classroom. They include communicating expectations, focusing on specific language, providing enough time, modeling appropriately, giving students opportunities, managing classroom routines, promoting positive interactions, and providing an environment that is responsive to student needs (2017).

While there has not been much research done in the area where math and second language intersect, there is potential that research in the topic will increase, given the increase of immersion education in the U.S. and Content and Language Integrated Learning (CLIL) in Europe. CLIL is defined as an educational method where " subjects are taught through a foreign language with dual-focused aims, namely the learning of content, and the simultaneous learning of a foreign language" (Darn, 2006). This method, which was first implemented in Europe in the mid-90s, is designed to support the European Commission's goal of having students proficient in three European Community languages (Darn, 2006). Similar to immersion education in the U.S., use of CLIL has expanded, but research on its methods has lagged behind (Pérez-Cañado, 2011).

Chapter Two Summary

This chapter began with a discussion of SLA, specifically Krashen's five hypotheses and the relationship between WM and SLA. It continued with teaching strategies used in the immersion setting, including CI and CO, as well as methods used to keep students talking in the TL. Lastly, math topics were covered. Information on MA of both students and teachers was presented, followed by methods that can be used to alleviate MA (CGI and GM). Finally, there was a brief look into an emerging area of research in where math and language intersect, which leads to my capstone project.

Chapter Three Preview

Chapter Three is the backbone of my project. The school setting and target audience will be discussed, followed by a description of the project. Information on how adults learn, as well as best practices in professional development in general and professional development in math in particular, comes next. Lastly, the learner outcomes for the five sessions are explained in detail.

CHAPTER THREE: PROJECT DESCRIPTION

Overview of the Project

Chapter Two was a review of concepts relevant to my capstone project, based on the research question *What are effective input and output strategies for teaching mathematics in the K-2 immersion classroom?* Target Language (TL), Working Memory (WM), and Math Anxiety (MA) were defined. I also highlighted Stephen Krashen's five theories of language acquisition with a focus on input and output and reviewed strengths and challenges in immersion education. Lastly, I shared two particular math teaching strategies [Cognitively Guided Instruction (CGI) and Growth Mindset (GM)] that are used in my classroom as well as how WM is affected during both SLA and math instruction.

The goal of this capstone is to create a series of professional development (PD) presentations for immersion teachers to implement CGI and GM strategies in their math lessons, as well as build strong input and output strategies so students can have conversations about math in the TL. In the PD sessions, teachers will:

1. reflect on how they were taught math as students as well as how they teach math as teachers,
2. learn about the foundations of CGI and GM,
3. consider which input/output strategies will work best for their students, and
4. determine how to implement these strategies in their classrooms.

School Setting

The PD series will take place in a German-language public charter school in the Upper Midwest. The school will be in its 15th year, serving around 600 students in grades K-8 with an average class size of 24 students. The staff will comprise 40 teachers, 9 educational assistants, and 15 native-German speaking interns. 81% of the staff are fluent in the TL of German. Ethnicity of the student body is Asian/Pacific Islander 2.1%, American Indian/Alaskan Native 0%, Black/African-American 2.2%, Hispanic 1.4%, White 86.7%, Two or more races 7.7%, with an assumption that demographic settings will not radically change. Results of the Minnesota Comprehensive Assessment (MCA) for students meeting state math standards during the academic year 2017-2018 were 75.6%, a decrease of 1.8% from the previous year.

Project Audience

The American, German, Austrian, and Swiss colleagues who will participate in the PD series have a broad range of experience levels, leading to unique perspectives. Some of them are teaching their respective grades for the first time, while others have five years or more of experience teaching in elementary classrooms. While the majority of the non-American teachers have several years of experience teaching in elementary classrooms, this is the first foray into teaching in an American school for many of them.

The majority of the K-4 teachers have a Master's Degree in Education/Teaching or an equivalent from their home country. No matter their experience level or country of origin, all of the teachers participating in the PD series at the school level provide math instruction daily. These teachers adhere to state standards, often adapting German curriculum to do so. They differentiate for students, providing extra support when needed. In this setting, the school day is longer than a standard elementary school day in Germany/Austria/Switzerland (almost 8 hours in the state in the Upper Midwest, compared to an average of 5 hours in the countries mentioned), which can be an adjustment for teachers who are not accustomed to the longer hours.

Project Description

This project is designed for immersion teachers in grades K-3 who teach mathematics, but anyone in higher grades who are interested in participating, as well as educational assistants, will also be welcome to attend. The project will be presented in a series of five PD days, one hour per day, throughout the 2019-2020 school year. There is potential to adjust the presentation length to one hour and reach a wider audience through presentations at smaller language teacher conferences within the Midwest as well as larger conferences throughout the United States.

PowerPoint and PearDeck software will be used to present the PD series. PearDeck is interactive educational software that can be included in PowerPoint presentations that allows participants to give feedback and collaborate via their own devices. Participants will share their opinions and ideas during whole group discussions throughout the sessions. Each participant will also receive a folder with relevant handouts for each session as well as sheets for notetaking and data collection. Homework will be assigned at the end of each session with the expectation that teachers use what they have learned in sessions, collect data and student observations, and bring them to the next session in order to further develop their practice through reflection and collaboration with colleagues.

As anyone who has had to present to a group of teachers knows, they can be a tough crowd! PD often occurs after a long day of teaching, and said PD is often presented to teachers in a top-down method where everything is handed to them, which can lead to their disinterest or disengagement. The PD sessions that have been the most effective to me have required me to participate, engage with others in the room, and provide examples from my own teaching experience. With this in mind, I have researched effective methods of PD presentations and applied them to the project.

Adult Learning Methods

Adults learn differently than children do. Malcolm Knowles (1984) suggested that as pedagogy is the way of teaching children, andragogy is the way of teaching adults. He developed a list of five assumptions of adult learners:

1. They are self-directed;
2. Experience gained through their lives becomes a resource for new learning;
3. Their readiness to learn becomes more connected to their role;
4. They move from subject-centered to problem-centered learning;
5. Their motivation to learn is more internalized.

With this in mind, some effective professional development methods are defined below and are followed with information on how the methods are used in the project.

Darling-Hammer, Hyler, and Gardner (2017) define effective professional development as "structured professional learning that results in changes in teacher practices and improvements in student learning outcomes." They found that the most effective PD methods include a focus on content, active learning, collaboration among colleagues, models of effective practice, coaching/support, time for feedback/reflection, and an adequate amount of time to do these things so that the positive effects can be sustained.

Focusing specifically on math, the National Council of Teachers of Mathematics (NCTM) indicate that PD in mathematics is effective when it builds on teachers'

1. mathematical knowledge and their capacity to use it in practice,
2. capacity to notice, analyze, and respond to student thinking,
3. productive habits of mind, and
4. builds collegial relationships and structures that support continued learning (2010). Additionally, the NCTM suggests that systemic support, active learning, and time all help support the aforementioned effective PD strategies (2010).

Choice of Method

The school where the project will initially be presented is moving toward a PD model where experienced teachers provide some of the PD sessions during in-service days. Given the wide range of experience and teacher interests, as well as the lack of teachers well-versed in both content and language teaching methods, the hope is to provide a variety of professional development opportunities for teachers so that they may self-select according to ability level, interest, and experience.

I have chosen to use PowerPoint as a presentation method, with PearDeck slides included for teacher reflection and whole group discussion. Teachers who choose to attend this series will have reflected Knowles' (1984) assumption that adult learning is self-directed. Before the session begins, the teachers will be asked what they hope to gain through their participation. To keep participants interested, the PD sessions will involve activities that focus on content (math), encourage discussions as well as collaboration amongst colleagues both horizontally and vertically, and provide time for teachers to reflect on the methods they have implemented.

Learner Outcomes

PD session one, in September, will begin with background information about the project and an introduction to using PearDeck software so that participants can be comfortable with using it throughout the series. A discussion of our experiences with math in primary and secondary education and with how we view math as adults follows. This will continue with a video from Jo Boaler's "Week of Inspirational Math" series introducing Growth Mindset, which will be followed with discussion of personal experiences teaching in the classroom. Boaler's Mathematical Mindset Practice 1: Growth Mindset Culture will be shared with teachers, who will identify where they are currently in their teaching practice (Beginning, Developing, or Expanding) within the domains of Mindset Messages, Praising the Learning Process, and Students' Mindsets. Then, video examples of the Expanding level in each of the three domains will be viewed. Afterward, teachers will discuss what they notice and reflect on what it could look like in their immersion classroom. Homework for the next session is for teachers to choose one of the three GM domains discussed and implement it in their classroom, to share with colleagues in the following session. Participants will receive a GM rubric to best gauge which mindsets their students have.

PD session two, in October, will begin with a review of GM and a discussion of how teachers implemented the ideas from PD session one in their classrooms. Afterward, Boaler's Mathematical Mindset Practice 2: Nature of Mathematics will be shared with teachers, who will identify whether they are Beginning, Developing, or Expanding in the domain of Open Tasks. Video examples of the Expanding level in this domain will be viewed, with a discussion following about the types of problems teachers provide for their students. Participants will then move to examples of closed and open tasks hung around the room, read them, and sort them into the correct categories. Then, they will discuss what differences they notice between the two task types and why open tasks could be beneficial in the classroom. Information about WM and the role it plays in both SLA and MA is next, followed by CI and a discussion of how participants make input comprehensible for their students. Tips for providing CI are given, and participants then work in grade-level teams to create an open task and how to provide CI for that task. This task is part of their homework: they will use open tasks in their classroom and collect observations of how their students interact with them, which they will share at the next session.

This will lead to the introduction of CGI, including how children's methods of problem-solving develop, beginning with Direct Modeling. Teachers will view videos of students solving CGI problems in kindergarten through third grade, then discuss the types of problems used and how the students solved them. This session closes with a discussion of advantages and disadvantages of using GM and CGI in the immersion setting. Teachers will develop one CGI-style math question appropriate for their grade level. Homework for the next session is to ask each student this question and determine which problem-solving strategy each student uses, as well as where students are with regards to GM.

PD session three, in November, begins with a discussion of successes and challenges seen by teachers during open math tasks as well as which forms of CI were helpful for their students. CGI is then introduced, including student problem-solving methods, and participants discuss which types of strategies they see students using in their classrooms. Participants then learn more about different types of CGI problems, gauging the difficulty levels and discussing them with each other. Videos of children's methods of problem-solving in Kindergarten, First, Second, and Third Grades are viewed and while viewing, teachers have the opportunity to share what they notice about the teachers' and students' language via PearDeck and discuss afterward. After discussing potential challenges in the immersion setting and reviewing CI strategies, participants will work together in grade-level teams to create a CGI problem and CI methods to be used to teach it. Problems will be shared and documented for the group. Homework for the next session is to use CGI problems in their classrooms and to document the problems, as well as input was kept comprehensible.

PD session four, in December, begins with a discussion of the problems and CI methods participants created in the previous PD session, and whether students succeeded or struggled with math concepts, with the language, or with both. Comprehensible sentence prompts probing for student understanding are shared via a PearDeck slide so that participants can include other examples of similar sentence prompts they use in their classrooms. Afterward, the concept of CO is defined, followed by examples of how to scaffold for students to produce CO in the TL. Another PearDeck slide with examples of CO sentence frames provides an opportunity for participants to share ways they scaffold CO with their students. Participants then share key math vocabulary their students need to describe their mathematical reasoning, with their ideas captured and shared with the group. Then, they will then work in grade-level teams to create three CGI-style problems, as well as their CI and CO methods. Problems will be shared and documented for the group, followed by a discussion of commonalities and differences of language and problem-solving methods across grade levels. Homework for the final session is to continue using CGI problems with CI and CO, documenting how students use CI and CO to explain their mathematical reasoning, as well as to document GM of their students. To document

GM of their students, participants will keep in mind how their students approach challenges, if they learn from mistakes, how they react to feedback, how they incorporate previously used strategies, if they persevere in difficult situations, and what sorts of questions they ask. Lastly, participants will select a subject in which they would like to create cross-curricular CGI problems.

PD session five, in January, begins with a review of the 4 previous PD sessions. Teachers will re-examine the three GM practices that were discussed and rate themselves and their students in their chosen domain (Beginning, Developing, or Expanding in Open Tasks and their choice from Session One), sharing their own successes and struggles since beginning the PD in August. Afterward, teachers will examine their curriculum and create cross-curricular CGI problems, also identifying the vocabulary and CI/CO methods prompts necessary to foster discussion in the TL among students. To close the session, each grade-level group will share at least three CGI problems they have integrated into their curriculum. These will all be saved via Google Drive, to be shared with the teaching staff. At the close of this session, teachers will provide feedback and determine whether there is the desire to continue developing CGI-style questions and working on GM activities throughout the rest of the school year.

While working on this project, I have considered challenges that could arise. A potential challenge is participants consistently preparing for the sessions. While the time between sessions allows participants to work with the concepts, it is possible that some might neglect to continuously use the concepts or collect the data until the next session nears. With this in mind, I will send out bi-weekly emails to participants. These emails will serve as a way to check in with participants to see if they have questions as well as a reminder that the work they do outside of the sessions make the subsequent sessions more valuable to them. It is my hope that teachers who choose to participate in this PD series will develop their own GM, both in math and in general. I also hope they use the CGI problems in the TL to help their students discuss their mathematical ideas and better develop mathematical understanding. While work on both GM and CGI is never done, I hope these sessions provide teachers with a good start that they can build on and share throughout their career.

Summary of Chapter Three

Teachers will benefit from a better understanding of how students problem-solve, as well as from having multiple opportunities to collaborate with their colleagues. Students will feel better-equipped to discuss their mathematical ideas with each other in the TL, will be able to identify that mistakes help their brain grow, and will understand that everyone is capable of "doing" math. The effectiveness of this PD series will be determined by discussions during the sessions themselves, observations teachers share from their classrooms, and feedback delivered to the facilitator at the end of the series.

Chapter Four Preview

As mentioned in Chapter One, my goal is for my students to have a better math experience in school than I did. As a teacher, I seek out as many opportunities as possible to support the idea of GM and to use CGI-style math problems to help students connect math to the "real world." In this chapter, I have highlighted effective PD practices as well as PD practices specifically related to math, and used these concepts to develop the PD series and learner outcomes. Chapter Four will summarize the outcome of this project.

CHAPTER FOUR: REFLECTION

Throughout the course of my time teaching in the elementary immersion setting, I have had multiple opportunities to share both my love for my second language and my love for learning with many students. The beginning of my career was a sink-or-swim experience in figuring out how to translate my language level to that of first graders, as well as figuring out how to deliver content in a way that students could understand, as I was not yet finished with my full teaching license. My own teacher learning took place not only in university classes and in my classroom, but in professional development sessions with colleagues. When I decided the time was right for me to work more on my teacher practice in math instruction, the concept of Growth Mindset (GM) opened my eyes to the way my own feelings about math were being passed on to my students, no matter what the language of instruction. Years of developing my own GM led to me being well-known for my enthusiasm toward teaching both math and language, and ultimately influenced my capstone project question *What are effective comprehensible input and output strategies for teaching mathematics in the immersion classroom?*

The purpose of this capstone project was to develop a series of professional development sessions for immersion teachers in the lower elementary setting. In these sessions, participants would first engage with the math teaching strategies of GM and Cognitively Guided Instruction (CGI), developing ways to use those strategies in their classrooms with their team members and other elementary teaching colleagues. They would build on the language concepts afterward, specifically with the strategies of Comprehensible Input (CI) and Comprehensible Output (CO). By working on these concepts, teachers would provide students with more ways to understand math concepts, as well as ways to explain their mathematical reasoning in the target language.

This chapter will revisit topics covered in my literature review, including second language acquisition, teaching in the immersion setting, math teaching methods, and math anxiety. I will share the parts of the review that were most helpful to me, as well as what I have learned through the research process itself. Then, I will discuss the limitations and implications of the project, including any future research that could be performed. Lastly, I will cover how the results of my research will be best communicated, including how they could be beneficial to the profession.

Revisiting the Literature Review

Second Language Acquisition

In the process of working at an immersion school for multiple years, teachers participate in professional development with each other, as well as reading and learning about subjects on their own. Being a second language speaker myself and having attended conferences and professional development sessions concerning language, I knew bits and pieces about SLA. However, this capstone process has helped deepen my understanding of many concepts in this area. I chose to focus on Stephen Krashen's (1987) hypotheses of language acquisition because he was the person whose literature I had read the most. His influence on other researchers, who both agree and disagree with him on many topics, provided an excellent array of topics that were often difficult to narrow down.

While reading these hypotheses, I reflected on ways to improve my language teaching practice. Specifically, according to Krashen's Input hypothesis, I wanted to revisit ways I could make input comprehensible for my students. In the spring of my first thesis semester, in the midst of learning more about CI, I found a CI conference where Krashen was the keynote speaker. I was fortunate enough to attend and the conference was very valuable, both to my teaching practice and the capstone process, as I learned many strategies to keep input comprehensible and deliver better content instruction to students.

The concept of CI is part of my research question, with the other part being comprehensible output. Merrill Swain (1985) disagreed with Krashen, arguing that CI alone was not enough for students to acquire a language, but that they also need ways to produce CO in the target language. This concept holds true with concepts I learned at the conference mentioned above, specifically with targeting ways to keep students processing in the target language. By doing so, students are able to negotiate meaning with teachers and each other. Swain points out that students communicating in the target language can become aware of gaps in their knowledge of the language and modify their output to cover the gap, or ask for clarification. In doing this, the students are also substantiating Krashen's (1987) Monitor Hypothesis theory in that they are planning, editing, and correcting their output.

Immersion Education

SLA leads into the topic of immersion education. When researching teaching practices in immersion education, I often came across topics that had already been mentioned in my research on SLA, so I used the opportunity to turn the SLA section into a review of theory and the immersion section into a more practical one, with strategies that can be used to keep students in the target language. Many of the suggestions that came up are things that many immersion teachers do automatically, including providing CI, scaffolding CO, and having reward systems in place for students who remain in the Target Language (TL). I had to remind myself that, while teaching all day in an immersion setting and employing all of these suggestions can be exhausting, we in the immersion setting have the luxury of the language the entire day. Comparatively, my colleagues who teach in non-immersion settings tend to have at most an hour, and at the least 24 minutes (sometimes on a rotating schedule instead of daily, as I discovered at the CI conference) to teach their students.

Given that immersion education, specifically immersion-only education, has existed in the U.S. for a relatively short period of time, I expected to not find as many resources for this section as for my others. I was right, but was also heartened throughout the process as I found that more colleges and universities are offering classes, if not degree programs, in immersion education. Thanks to accessing the international research field, where many more research materials are available, I was able to learn more about Content and Language Integrated Learning (CLIL), another type of language education inspired by the Canadian immersion method mentioned in Chapter One (Wielander, 2013). CLIL has been used across Europe to accommodate diverse learners, provide students with more exposure to the TL, improve students' linguistic and communicative competencies, and increase learner motivation by providing students with more authentic language interaction (2013). I focused my CLIL research on mathematics strategies.

Mathematics

An area where I found an overwhelming amount of information was in math instruction. Given my experience with GM and CGI, I knew where to start with research in those topics. What was unexpected was the topic of Math Anxiety (MA) and how teachers can unknowingly pass it on to their students. Through my research, I found that both GM and CGI are methods that can be used to help alleviate MA. Students with GM have a positive attitude toward math, which is a good base. By learning problem-solving methods and sharing their thinking with their peers through CGI, students are even better prepared to overcome any MA they might have.

Another thing that surprised me was the toll MA takes on Working Memory (WM). WM is needed to retain and manipulate information in math problems, and if a student experiences MA, their performance in math can suffer. In addition to being important in math, WM also plays a large role in the processing, comprehension, and production of a second language. While little research was found on the connection between MA and SLA, I wonder about whether the subject could be an emerging field for future research. Is it possible that students who are confident in math, but not in the second language, have difficulty with their WM in math because of the second language? I also wonder if the opposite is true, that is if math-anxious students confident in their second language have difficulty retaining more in their second language due to how their MA affects their WM.

Major Learnings

To say that the capstone writing and project process felt like a rollercoaster is an understatement. When I was in the process of completing my first Master's degree nine years ago, I was faced with a decision: go into academia or become a K-12 teacher. I chose the latter, and during parts of this process, it was abundantly clear that that was the correct decision for me. Working full time as a teacher and continuing with researching and writing in the evening was arduous. However, throughout the literature review process, I was surprised at how often I thought, "Oh, that topic would be interesting to research further!" There were multiple times that I came across topics I wish I could have researched myself, as well as topics that would be fascinating to research in my own school. While I insist that this is the last degree I will complete, something tells me that academic research of some sort is in my future. Given the rise in interest in CLIL, I suspect that there will be areas for more research into content-based language instruction, in math as well as in other topics.

What I have valued most about this process is the new methods I have found and been able to implement in my own classroom. Reading research of what has and has not worked in classrooms has helped me to re-examine my own teaching practice and made me stronger. For example, Krashen's (1987) Natural Order hypothesis has helped me relax as far as error correction goes, since students acquire some grammar structures earlier and some later in the target language. Hence, when students have difficulty with a grammar construct that does not exist in their first language, I know over-correcting it will not help, because according to another one of Krashen's (1987) hypotheses, that issue will likely correct itself when students are better able to monitor their output. This happens later in the language acquisition process.

Limitations

The most pressing limitation, as in so many other places, was time. I removed part of the project I had originally planned on because there were only so many professional development hours available on our school schedule. Ideally, the series would take place all school year, or possibly in a Professional Learning Community more than once a month. Reflecting with colleagues on the topics covered is important, but with a month between sessions, it is possible that some may not complete their tasks or may complete them soon after the session, but not incorporate them into their math practice as a whole. Another limitation is the lower-elementary grade levels. While limiting the grade levels is necessary for both research and instructional purposes, so many other colleagues could benefit from this work.

Benefit to the Profession

Given that both MA and immersion education are on the rise, I believe that my project is beneficial to the immersion teaching profession and could potentially be beneficial for teachers of English Language Learners in non-immersion schools as well. The horizontal and vertical alignment opportunities in the series give teachers a chance to collaborate with colleagues they might not be able to work with during the school day due to schedule limitations. The homework assignments give participants something to use in their classroom right away, as well as ways to reflect and build upon their teaching practice. My hope is that at least some of the participants will want to extend their learning beyond the sessions, which could be done via book club meetings, PLC work, or even just lesson planning together during prep time. By extending their learning, those colleagues would not only strengthen their own teaching practice, but also their students and the school as a whole.

Sharing Results

As mentioned above, I chose to go into teaching instead of academia. In my role as a teacher and as a school coordinator, I have had the opportunity to attend several local and national professional conferences. I always leave those conferences full of ideas and enthusiasm, as well as missing the research and presentation aspect of academia. Sharing the results of this research at conferences and connecting with colleagues beyond my school who are also interested seems like a good compromise. I plan on presenting a version of this conference at a local immersion school conference at the fall, and possibly later at regional or national conferences. Additionally, I believe communicating the results of the professional development series with our school board is also very important. Doing so will emphasize how critical it is that teachers have time (e.g. on scheduled professional development days) beyond their normal school day to develop their practice by collaborating with each other within and across grade levels.

Summary

This chapter has been a reflection on the capstone project answering the question *What are effective comprehensible input and output strategies for teaching mathematics in the immersion classroom?* Throughout the chapter, I reflected on my background and what led me to my research question. My major learnings from the literature review were covered, as well as other learnings from the process of researching and writing. Limitations of the research were addressed, along with benefits to the profession. Finally, the chapter concluded with a discussion of my future plans to share the project at the local, and possibly the regional and national level, in the future.

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