BEYOND COMPUTATION: PROJECTS FOR ELL STUDENTS

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Dedication

To those who are small,

The world lies in wait for you,

Grab hold, take flight, soar.

Abstract

English language learners (ELL) often struggle to make real world connections in mathematical contexts. Using an action research model, combined with a project-based learning perspective, this study explores some of the strategies educators can employ to help ELL students understand mathematical concepts. This paper describes how five Grade 1 ELLs explored the concept of patterns in a cross-curricular fashion. The children were encouraged to investigate patterns from a mathematical, scientific, and artistic perspective. Included are digital photographs depicting student process and products. This documentation has made the learning visible to teachers, parents, and the children themselves. In honouring the ways in which children express their learning we value the contributions they make both in and outside of the classroom.

Keywords: English language learners; project-based learning; mathematics; young children; documentation; Reggio Emilia

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First and foremost, I would like to thank my family. They have stood behind me throughout this journey cheering me on, holding my hand, and whispering encouragement when I needed it most. I honour their gifts to me and want to show them the time I have missed has been for good reason. Thank you for helping me turn a dream into reality and for showing me all the places I'll go. I love you like peanut butter.

I need to thank my students for their honesty, candour, and imagination. You have helped me experience the joys found in our classroom each and every day. Being around six year olds does something for the soul. I can never say my day was boring....and I love that!

To the people in my cohort, thank you for the support, the laughs, and the memories. I could not have made it through the program without you. I have learned so much simply by listening to you all. Your passion and commitment are admirable and I count myself lucky to have walked beside you these three years.

For those that understand how much I like having the last word, one more thing....

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Introduction

The face of the public school classroom is changing. The diversity represented, if embraced, can create vibrant and exciting learning environments. My current teaching context is such a place. There are more than 35 languages spoken throughout my school and over 80% of our student population is designated English Language Learner (ELL). As a school, we grapple with ways to help our ELL students make meaningful connections with the curriculum.

Projects are one mode through which we have engaged our student population. By expanding our notion of student expressions of learning we have encouraged students to explore concepts more freely and share that learning in authentic, meaningful ways. This project is going to tie the evidence that I see every day to sound pedagogy and research, showing that projects are an effective way to entice ELL students into learning mathematics beyond computation.

Rationale

It is no longer feasible, or pedagogically sound, for ELL students to receive one-on-one instruction outside the classroom. These students require an environment that supports English language acquisition regardless of the content area being addressed. Authentic vocabulary instruction, multimodal learning activities, and mentorship opportunities can help ELL students understand both the instructions and the task. The focus of this study is on developing ways to incorporate these strategies using a project-oriented perspective in mathematics.

Methodology

There are many examples of ways in which educators can engage in research alongside their students. The model of David Townsend (as cited in Alberta Teachers' Association, 2000, pp. 14-15) outlines 11 key steps for conducting action research and it is within this framework that this project is based.

Key Steps for Conducting Action Research

Step One: Define the Focus or Problem

On any given day, one can hear up to eight languages spoken in my classroom. From Mandarin to Vietnamese, Bengali to Guajarati, my students are a diverse group of learners! As a school, we have experienced a shift in our student population in recent years. The face of the community has changed, as have the needs of our students. We have worked tirelessly to meet these needs in any way we can.

Our school has three designated pathways of learning as outlined in our school development plan: (a) literacy; (b) fine arts; and (c) technology. When I first came to Monterey Park I was nervous about my lack of experience teaching through the fine arts. I felt comfortable teaching ELL students, and knew quite a bit about using technology in meaningful ways, but I was at a loss when it came to the arts. The year that I came there was a change in administration and with that change came my introduction to the Reggio Emilia Approach. There are many key features of this approach, several of which are outlined in the last section of my literature review. For my work, and the ways in which I engage my students, project-based learning is the most vital of these features.

Mathematics is an area of passion for me although I must admit it was not always this way. I struggled with math for most of my life and have never been as relieved as I

was the day I finished my last math class in senior high school. Then I found out I needed "Teacher's Math" to get into my university's teaching certification program. This course helped me understand why I hated math so much. I was never offered the "why" behind the algorithm, I just knew I had to memorize the formula, apply it at the right time, and hope for the best.

In this university class we had the opportunity to make sense of the nature of mathematics, to understand its praxis not just its formulas. Here I came to understand how to be a mathematician, not just a student who needed the credit. It was an invaluable lesson, one that has guided the way I approach the teaching of math ever since.

Some say mathematics is a universal language, I disagree! Different cultures approach the teaching and learning of mathematics in very different ways. There is a divergence surrounding systems of number, the role of computation, and the availability and function of manipulatives across cultures. To help my students make meaningful connections in math, and to help them see how math lives in almost every aspect of their daily life, I needed to help them understand the "why" more than the "how" of mathematics. In struggling with this issue I developed two research questions. First, in what ways, and to what extent, can project-based mathematics strategies help ELL students demonstrate conceptual understanding? Second, in what ways can educators help ELL students understand real world applications in mathematics? I had defined my focus.

My journal entry for July 2, 2009:

Since starting the program at the University of Lethbridge I have been curious about this moment, the moment I begin to really plan how my study is going to

look. I knew a thesis would be an option, but not one I was passionate about pursuing. A project format fits the purpose and scope of my questions so much better. I am full of excitement and trepidation as I look towards the future.

I am fortunate in that much of the work I have done in my graduate courses has focused on my research questions to some degree. Different classes have offered varied perspectives and I have learned a great deal more than curriculum. It is interesting to see how all the ideas and assignments in each course have come together for me in the end. Writing postcard summaries has been hugely helpful as I prepare my lit review. Reflecting about my role as a teacher has helped me define my methodology and affirmed my direction. I know that in my current context there are students slipping through the cracks. This project is going to help me identify these students and improve my teaching to better meet their needs. With any luck, and a bit of confidence, I hope to share what I learn with my team, staff, and community. Knowledge is like cheesecake...better when it's shared!

Step Two (Part One): Collect Information

The first component of this step required a review of current literature. The scope of my project spans several areas of research so for the purpose of this paper I have organized the summary in four sections: (a) English language learners, (b) mathematics, (c) project-based learning, and (d) the Reggio Emilia approach.

English Language Learners

When I began researching English language learners, I was unsure how much current research would be available. I was pleasantly surprised to see that this area of

focus has permeated everything from content areas, such as mathematics and science, to the bigger picture areas like leadership and curriculum design. The *Educational Leadership* journal has become a must-read on my nightstand every month and I was excited to see that ELLs have been given a lot of attention in recent years.

The Sheltered Instruction Observation Protocol (SIOP) Model was developed by Short and Echevarria (2005) to provide effective instructional strategies for teachers of ELL students. This model "offers a framework for organizing instruction, with key features that promote the academic success of ELLs" (p. 10). The strategies range from providing explicit language objectives for all lessons (in conjunction with content objectives), to emphasizing key academic vocabulary, activating and strengthening prior knowledge to promoting academic talk.

These ideas may not be new but they do provide vital opportunities for ELLs to develop and enhance existing understandings of the English language. The SIOP Model affords teachers concrete and reasonable strategies to help their ELL student master both academic content and literacy skills.

Case studies offer teachers tangible examples of issues with which they are concerned. Barwell (2005) attempts to address the need "for a more explicitly reflexive model of the relationship between content, language and learning" (p. 205). After conducting the review of literature for this project I would tend to agree. To negate the connection between content and language is to deny ELL students authentic ways to engage in and apply their learning.

In my own practice I encourage students to work collaboratively. I believe in the social construction of knowledge and I have seen, firsthand, the power in peer teaching.

When this kind of community of learners is developed, ELLs have an environment where they feel safe to take risks. They ask questions more readily of their peers and they receive more opportunities to practice the constructs of language as modeled by people they trust.

Within the content versus language debate, there are those that believe language must come first. In order to adequately express the concept in any content heavy subject area students must first have the language. There are also those that believe content objectives must come first and that the associated language will develop organically as concepts are explored. Barwell's (2005) research argues for a more reflexive way of thinking. In the provided examples of student conversations and researcher observations Barwell identifies a reciprocal relationship between the language and mathematic structures: "Mathematical and linguistic meaning reflexively emerges over the course of the students' interaction. Their linguistic thinking, then, has served, in part, to construct the mathematical meaning of their problem" (p. 216).

In one situation, students debated the use of both vocabulary and verb tenses while solving a math problem. As they reflected on their written work, they argued about which looked right causing a shift from mathematical understanding to a linguistic construct. This kind of reciprocity encourages students to make sense of each concept authentically. The nature of the task helped students switch between language and mathematical learning, offered a meaningful context and an environment in which students felt safe to disagree, and developed a stronger understanding in both realms.

There is a succinct connection between brain-based learning approaches and teaching ELLs. Lombardi (2008) argues that "by creating an anticipatory set for learning

through interactive activities, using graphic organizers, tapping prior knowledge, and encouraging student participation, brain-based approaches can motivate second-language learners" (p. 220). Visual cues and pre-emptory strategies help all students prepare for learning and engage their sense of understanding on many levels. Students are often overwhelmed by information or the speed with which it is delivered. By using advance graphic organizers and mind maps students can organize information in meaningful and effective ways.

Other components of brain-based learning are the inclusion of multi-modal learning tasks and the emphasis on the co-construction of knowledge. In collaborative learning situations ELLs have an opportunity to ask questions in a safe environment. According to Lombardi (2008), they feel less inhibited if the teacher is not waiting for the correct response. Small groups and peer-sharing offer an atmosphere conducive to risk-taking where students feel more socially grounded. This type of teaching and learning is also found in project-based learning environments. Students are given choices about the ways in which they choose to express their learning and are encouraged to work through problems and inquiries with their peers.

As an educational leader, formal or informal, it is important to understand one's student population. Lundquist and Hill (2009) paint a clear picture of the challenges leaders face as they prepare for this population. In the face of high-stakes testing, decreased funding, and the increase of linguistically diverse student populations it is imperative for educators to understand the unique needs of their students, colleagues, and circumstance. Lundquist and Hill juxtapose Bloom's Taxonomy, stages of language acquisition, and effective instructional strategies to illustrate how this kind of matrix can

affect practice and promote academic rigour within schools. By defaulting to the lowest level of the taxonomy we expect the least from our ELLs and take away their ability to enhance their academic communication skills. "Directing and maintaining ELLs' instruction at the lowest level of *thinking* confines them to the lowest level of *learning*" (Lundquist & Hill, p. 39). As educators we need to be more cognizant of these stages so we can help students reach higher levels in both their thinking and learning.

To effectively lead reform in a school, one needs to be masterful with the stages of the change process. Lundquist and Hill (2009) outline four components within this process: (a) create demand, (b) implement, (c) monitor and evaluate, and (d) manage personal transitions. Within each stage there are steps to understanding both the situation and the staff involved. For example, within the initial stage it is important to identify current realities, illustrate why they are ineffective, and develop a vision that offers a brighter future. In the second stage, leaders back their vision with research and begin to implement key practices leading to the desired change.

Within the monitor and evaluate stage, leaders are vigilant about observing the degree to which the changes are being implemented and the effect it is having on those conducting the implementation. This type of data collection informs the leader about the process, allowing adjustments to be made as they become necessary. In the final stage leaders help fellow educators let go of past practices, work through the proposed changes, and celebrate a new beginning.

These four stages directly affect the way I see my own research being shared. In a building with over 80% of our students designated as ELLs modifying my practice is only the beginning. I work very closely with my grade team and have informal mentoring

relationships with many of our new staff. By understanding the stages of language acquisition and how they can be meshed with Bloom's Taxonomy and effective instructional strategies, I have the opportunity to affect change on a grander scale in my building. That will benefit my team, my colleagues, but most importantly my students.

The National Council for Teachers of Mathematics (NCTM) has been a driving force behind effective mathematics reform in the United States. As a collective, they have developed key principles necessary for teaching mathematics in effective ways. The NCTM's Equity Principle (2000) states, "Excellence in mathematics requires equity— high expectations and strong support for all students" (n.d.). To honour this principle, educators need to understand how language and mathematics are inextricably linked. The use of language in math goes far beyond word problems. We use language to explain concepts and show how procedures are carried out. Students are expected to share not only what they know but how they solved a problem. Giving voice to their strategies is empowering for students as it allows for learning to be made visible thus affecting the learning of those around them.

Key vocabulary and language constructs are necessary for all students but in an ELL classroom they need to be even more explicit. Manipulatives and visual cues help students organize their thinking and they can help explain procedures but if students lack the language to effectively communicate what they have done, or where they struggle, teachers may never know how to help. To avoid this situation teachers need to be aware of the academic language required to complete the lesson. Will students need to compare/contrast? Are there expectations to sequence, classify, or categorize? ELL

students may not fully understand what these tasks require, therefore, they may not be able to complete them even if they do have the mathematical skills.

Bresser, Melanese, and Sphar (2009) offer several modifications teachers can make to help ELLs make sense of and complete the task while boosting their academic language proficiency. Although the context in which these strategies are offered is based in mathematics they can be transferred to any content-area subject. The first, and perhaps most important modification, is to determine the language goal within a lesson. What language will students need to show their understanding of the mathematical concept? This includes key vocabulary and process-minded language. If they cannot verbalize what they have done teachers cannot determine gaps or address misconceptions within their process.

Creating opportunities for ELLs to talk among peers is an effective strategy but what happens when they don't know how to frame what they are trying to say? Identifying and explaining key vocabulary is one support and offering sentence frames is another (Bresser et al., 2009). By providing ELL students with the words and grammatical structures they need to share their understanding we enhance both their language proficiency and their ability to co-construct knowledge within their peer groups. By making content, vocabulary, and academic language expectations clear and accessible to all students we honour the equity principle and provide all students with an opportunity to be successful mathematicians.

Anhalt, Farias, Farias, Olivas, and Ulliman (2009) offer a "lesson study" structure as a way to support ELL students in the mathematics classroom. In this format, collaboration and the co-construction of knowledge are key strategies to help ELL

students make sense of the content of the curriculum. Students are given manipulatives and a partner and are asked to work through a given problem together. By stepping away from the front of the classroom the teacher can use the small group time to gauge where students are in their understanding of a concept. Learning through errors is encouraged as students talk, attempt, adjust, and attempt again to find a viable solution. As students work through the problem they become increasingly metacognitive about the process. Students will broaden their understanding of the concept if their initial thinking is challenged.

In this type of environment teachers ask guiding questions, encouraging students to work together and talk about the process throughout. Hands-on discovery is more meaningful for ELL students as they often misunderstand or do not fully understand what teachers are saying when they provide direct instruction orally. The collaborative learning opportunities provided in this model help all students actually do mathematics and, if done successfully, can provide teachers an opportunity to hone their skills in diverse classrooms (Anhalt et al., 2009).

Many people see mathematics as a universal language and that its use of symbols somehow makes it easier for ELLs. This misconception has serious ramifications for both the teaching and learning of mathematics in culturally diverse classrooms. To truly understand mathematics one must understand the praxis and theory behind its application. ELLs are at a distinct disadvantage in this regard as they must work through two separate registers to explain their thinking. The mathematics register, even if the concept is known, carries its own set of vocabulary and syntax. The linguistic register is even more taxing as students work through the explanation in their heritage language then translate

it into English. The key is to provide just the right amount of support while encouraging these students to increase their level of English proficiency.

Garrison and Mora (1999) use Krashen's model of comprehensible input to show how teachers can challenge students learning across the curriculum. The model i+1 is used to illustrate instruction that is one level beyond what students currently understand (p. 35). When planning for instruction, if teachers bear in mind the i+1 construct they can challenge the concept and language proficiencies of ELL students in meaningful ways. The authors outline several key strategies educators can use in their daily classroom interactions.

Using the known to teach the unknown is a key concept for teachers of ELLs. If the concept is unknown (i.e., geometry), use language that is known and understood. If the language is unknown (i.e., content-vocabulary like "polygon"), explore that with known concepts. This is particularly helpful in linguistically difficult subjects like mathematics and science.

Other strategies include teaching vocabulary, using manipulatives, building context, working in groups, developing written responses, and using graphical representations. By developing language and concept related goals for each lesson, teachers open the door for ELLs to make sense of the concepts, develop their language proficiency, and co-construct knowledge with their peers. This, in turn, makes for more authentic learning opportunities and creates a great sense of cohesion between content-specific and linguistic loads (Garrison & Mora, 1999).

Researchers seem to agree, teaching content-based vocabulary in explicit and meaningful ways is a necessary strategy for teachers of ELL students. Unfortunately, the

literature stops short of offering optimal times and ways in which to introduce key

vocabulary. Bay-Williams and Livers (2009) offer authentic anecdotes describing content

and content-associated considerations for teachers grappling with this important issue.

They caution teachers to consider linguistic load when determining content driven

vocabulary. If the word or phrase is not culturally relevant then change the context. ELLs

cannot learn new material, or retain key vocabulary, if content and context are new. The

authors encourage using known situations to developing understandings of new concepts.

Another strategy outlined in the article is the use of realia. The introduction of

authentic materials, or real-world objects, is supported by proponents of constructivism,

brain-based, and project-based learning models. In my experience, fossils, photographs,

books, and collections of artifacts offer students an accessible way into the lesson by

grounding the work in something tangible. Many students, especially ELLs, need more

than mere words to make sense of mathematical constructs (Bay-Williams & Livers,

2009). By using these vocabulary strategies, teachers are able to ensure equitable access

for all students regardless of heritage language, cultural background, or initial conceptual

understanding.

Furner, Yahya, and Duffy (2005) have developed a list of 20 strategies for

reaching all students within a mathematics class. They too paid particular attention to the

principle of equity as defined by the National Council for Teachers of Mathematics. As a

classroom teacher, I found the outlined strategies invaluable and will focus on the

following six strategies throughout my project: (a) the use of realia, (b) relating

vocabulary and prior knowledge to background, (c) offering manipulatives, (d) using

drawings to encourage visualization, (e) making cross-curricular connections, and (f) making expressions of learning multi-modal.

Realia, provocations, and authentic objects all refer to the same thing. They are artifacts, tangible treasures to spark student interest. For example, to initiate the introduction of sorting and classifying with my students I brought in a variety of collections. I placed them on the tables and just asked my students to explore them. You could sense the excitement as they searched through the rusty locks and keys and tried to untangle the costume jewelry. Without prompting they began sorting and organizing the pieces into groups...and so began our exploration of the popular *I Spy* series by Jean Marzollo and Walter Wick. In the weeks that followed, the children brought in their own collections and practised creating illustrations similar to the photographs Wick crafted in these much-loved books. Figure 1 provides an example of this work. The results were amazing! The children were highly engaged, they worked collaboratively, and were able to describe and apply the principles of classification.

Figure 1. An example of an "I Spy" picture.

Relating vocabulary and prior knowledge to background information is essential for ELLs. To broaden the understanding of content-specific concepts it is necessary for

the teacher to help create context for these students. Consider the notion of currency. In Canada, our money looks and feels markedly different than that of even our closest neighbour. When introducing the concept of skip counting one might be tempted to begin with coins. This makes sense with pennies, nickels, and dimes but only if students have used these denominations before. It would be a good idea, and a rewarding one for those students who may be reluctant to take risks, to ask students to bring in coins from home. Ask each student to share information about the coin's value, its aesthetic, and possibly even some history. This provides an opportunity for all students to connect a math concept to a real-world application. It also honours the cultural backgrounds and prior knowledge all students bring to the classroom.

In my classroom, I use manipulatives to introduce, practise, and assess student knowledge of mathematical concepts. These materials range from bread tags to buttons, blocks to felt marker lids. Anything children can hold in their hands, build with, or use to illustrate a point is a manipulative. Mercer and Mercer suggest "best practices in special education call for you to teach concepts with concrete examples, and once the vocabulary and process is understood, then move to more abstract problems (as cited in Furner et al., 2005, p. 17). This idea supports the way our mathematics curriculum is written: start with the concrete, move to the pictorial and them on to the abstract. In grade one, many of the formal mathematics concepts are new so I use concrete materials whenever I can.

Part of teaching through the arts is understanding the power of sketching. Our students are as comfortable with a graphite pencil as they are with a crayon. Sketching and visualization are an important part of helping students express their ideas through the arts. I now use sketching as a vehicle for expression almost every day. In Science, we use

it to depict the results of an experiment; in Drumming we use it to explore West African patterns and the graphic nature of their dance movements. Figure 2 provides an example of how I have used sketching as a way to make sense of a "mystery tool" in math.
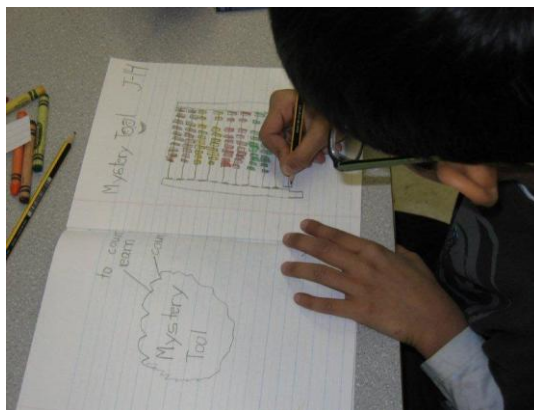
Figure 2. Student sketching a "mystery tool" in math.

This has become a favourite mode of expression for many of my ELL students as supporting text is not always a requirement. They can use what they see and what they wonder about to guide the drawing, not their knowledge of the English language. This would be helpful when we move into addition and subtraction. Making sense of what the questions is actually asking becomes the most difficult part of an equation for ELL students. By drawing the components, and then visualizing how they fit together in the problem, students begin to make sense of the nature of the problem and do not need to get fixated with the lexicon.

Cross-curricular connections are an essential part of the day with young children. They do not draw clear distinctions between Math and Science, Social Studies and Language Arts. To them, school is school! When I plan in ways that incorporate more than one subject the learning opportunities are richer. Students become more invested in the work and they see the bigger picture. Learning becomes a chance to make

connections in many ways, not just to the outcomes outlined in the lesson. Planning in this way has been an ever-evolving process in my own practice. As Wiggins and McTighe (2005) suggest, using enduring understandings and essential questions to inform the planning of learning tasks broadens the scope and effectiveness of cross-curricular projects.

Having three designated pathways of learning within a school was intimidating but it forced me to examine my practice much more closely. If, as a school, we were committed to offering children multiple ways to share their ideas and express their learning then I had better be prepared to make that happen.

The most powerful resource I had in addressing these gaps were my colleagues. When I started at Monterey Park I had never used art materials beyond basic paint and markers. Now I use plasticene, wire, watercolour pencil crayons, and chalk pastels across the subject areas. Many will assume that because my students are young they will not be capable of using such materials in artistic ways. As you can see in Figure 3, they are not only capable, they excel at it!

Figure 3. A self-portrait in ink.

In the wake of major educational reforms in the United States, the Teacher Leadership Quality Program was developed. This ongoing endeavour seeks to improve

student performance by enhancing the quality of instruction available to them. In the initial stages of this article, Joseph and Grennon-Brooks (2008) describe how a group of educators come together to make more effective use of science materials. They began with a very specific area of the curriculum but their work quickly morphed into a broader, more in-depth look at instructional strategies regardless of subject area. Standards-based problems became a way of engaging students in real-world application in science, mathematics, technology, and language arts.

An age-appropriate online simulation program was used to introduce the concept of insulation. Students were asked to manipulate variables and chart results, in effect, conducting an experiment using the scientific method. Teachers found that after using the simulation program students became more purposeful in their work and showed enhanced strategizing within experiments. Within this type of environment teachers may be able to observe gaps in student learning and address these immediately. When student expressions of learning, as opposed to specific curricular outcomes, become the focus it is integrated, multi-disciplinary, authentic, and meaningful (Joseph & Grennon-Brooks, 2008). Students need opportunities to share their learning in ways that are challenging and meaningful to them. Teachers that adhere to strictly to the illustrative examples found within the program of studies miss many of those opportunities. I plan to use strategies similar to those outlined in the article in my classroom by connecting science and mathematics concepts, particularly the use of patterns within nature.

Mathematics

In 2007, Kindergarten, grades 1, 4, and 7 began their year of optional implementation for the new Alberta math curriculum. The front matter developed by the

committee outlines seven mathematical processes: communication, connections, mental mathematics and estimation, problem solving, reasoning, technology, and visualization. Of these, I see two as crucial to my research. The *connections* process describes the notion that mathematical ideas should be linked to other concepts in math, everyday experiences, and other disciplines. The *problem solving* process asks teachers to relate and apply new mathematical knowledge through problem-based tasks. By focusing on these two processes, and mastering associated teaching and learning strategies, I believe I can change how teachers and students view mathematics.

In *Teaching Student-Centered Mathematics,* Van De Walle and Lovin (2006) describe understanding as "a measure of the quality and quantity of connections that an idea has with existing ideas" (p. 2). To help students internalize mathematics, educators need to remember that ideas are only truly understood when they are associated with many other existing ideas in a meaningful network of constructs and concepts. It is not enough to discuss a topic once and assume understanding will occur. Learning is cyclical and for ELL students to retain new ideas they need opportunities to internalize the language, explore the concept in a variety of modes, and practice the application of skills. Van de Walle and Lovin's first chapter is an invaluable resource for explaining the importance of teaching through problem-based tasks. Their outline of reasons for using this approach would be a worthy addition to any parent education evening agenda.

The remainder of the book explains mathematical concepts imperative to developing numeracy proficiency. The big ideas of each concept are outlined in the beginning of each chapter followed by several "Monday morning" strategies teachers can use to tackle them. Literature connections, lesson extensions, and assessment notes are

also offered. In all, this book is a valuable resource for educators. It would make a great start to a conversation for staff or teams regarding the nature and application of mathematical concepts for young children.

Action research is, by nature, collaborative. In this article, Bonner (2006) explores the benefits of this type of research. She uses a modified case study method to explore how two teachers, with a reluctance towards teaching mathematics, transform not only their practice but their attitude towards the subject altogether. Bonner outlines the following six key components that she feels contributed to the transformation of the teachers' attitudes: autonomy, time, a culture of inquiry, collaboration, objectivity, and reflection. The remainder of the article focuses on the action research project itself. It is interesting to note that the teachers initially turned to quantitative data to guide their exploration. By examining the achievement test results, they were able to identify a weakness in students' ability to solve word problems.

Through this initial inquiry of student learning the teachers began to examine their approach to instructional strategies. By establishing a culture of inquiry through frequent collaboration and reflection, the teachers and students started to change they way they approach mathematics. By taking risks and honoring the diversity in student approaches to problem-solving the teachers created a climate of trust within their classrooms. In doing so, both teachers and students felt a greater sense of self-efficacy in their approach to the application of mathematical principles. Action research can be an agent of change if only teachers are brave enough to examine their own attitudes and fears (Bonner, 2006).

Known as the godfather of action research, Lewin (1948) defines action research as "a comparative research on the conditions and effects of various forms of social action, and research leading to social action" (pp. 202-203). Action research requires one to grapple with difficult issues; issues that need in-depth analysis and reflection to be resolved. In *Embarking on Action*, Brighton (2009) outlines how a 6th grade math teacher takes her concerns about student performance and engagement with mathematics and develops a 7-step plan of action. Throughout the process the teacher, Janice, collaborated with colleagues and students to uncover the real reasons for student disengagement.

Janice found that, by re-examining the curricular goals and differentiating student performance tasks, she was able to tap into student interest thus making the mathematical concepts much more accessible to students. This is particularly important when the student population is diverse. ELLs come to mathematics with a variety of backgrounds and experiences. By accessing student interest, and in doing so scaffolding prior knowledge, teachers can gain insight into effective entry points for new material. When students are engaged in the task they are more likely to achieve or surpass expectations (Brighton, 2009).

The article draws on the necessity of outside observers in the action research process. Janice asked colleagues to observe lessons, reflect on her observations, and examine student artifacts. By opening the door to outside eyes she was able to deepen her understanding of what students were actually expressing. This also created a community of learners within her staff and school district who became more committed to addressing the needs of a diverse student population. In all, students were more engaged and felt a stronger connection to "doing" math instead of just studying it, and colleagues became

more passionate about addressing the needs of an often underrepresented student

population. This strongly connects to the use of project-based learning in classrooms with

a high ELL population and offers steps to take when engaging in the action research

process.

Problem-solving is a critical component of the math curriculum across the grades.

However, offering authentic opportunities for solving problems is not as widespread.

Regardless of grade level, teachers search for ways to make math concepts meaningful

for their students. From early numeracy skills to Euclidean geometry teachers spend

hours creating problems that try to contextualize math concepts. What teachers

sometimes fail to consider is not the context of the problem but the context of its solution.

O'Donnell (2009) illustrates three unique, yet effective classroom environments

that foster a sense of authenticity around math concepts and the ways the underlying

principles can be applied. In Carol's inquiry-based classroom, the author finds a primary

classroom rich with opportunities in the exploration of number. By examining the day's

date students begin to see relationships between odd and even, prime and composite, and

they are encouraged to share their insights with partners after individual reflection time.

What I found particularly valid in this example was Carol's own advice about the

efficacy of her students: "Not all students may be ready to understand the math concept

we are learning today, but they are building experiences so they can understand

tomorrow" (p. 119). As a teacher of young children I often worry about their ability to

grasp new concepts. I forget, that as a learner, it often takes me several experiences and

many attempts to understand complex material. Carol's words ring true in more than one

way. I need to be able to offer repeated experiences to my students but I also need to be

okay with the fact that many will not achieve understanding and mastery under my guidance.

O' Donnell (2009) outlines four teaching strategies that help this inquiry-based classroom function. First, the teacher must hold high expectations. In order to empower students one must be willing to allow students to explore a concept freely even if it appears to be beyond their scope of understanding. They do not follow a set algorithm in learning new concepts; they construct meaning out of how new ideas fit with what they already understand. Algorithms can describe steps to a solution but they will not depict how a student comes to construct knowledge.

"Think time" and "wait time" are popular phrases used to describe the opportunity teachers give students to process and make sense of new information. I have been guilty, too often, of not allowing my students enough time to think through a question. O'Donnell outlines ways to share in small groups as a way of honouring both the individual and group's opportunity to think about a concept or problem. Many ELLs are reluctant to share their thoughts in the large group. With strategies that focus on peer sharing students have an opportunity to make sense of the material, verbalize their thoughts and build key vocabulary as they discuss these with a classmate. Scaffolding of prior knowledge and a safe environment for risk-taking are key components for success in formalized settings. This goes hand-in-hand with the third strategy: give students responsibility. The author urges teachers to expect students to share their learning and prove their answers to their peers. This helps students become accountable for their learning and compels them to become an active participant in the learning environment.

The fourth, and perhaps most poignant strategy, is to accept that some students will not get the answer. Students need to struggle with problems that counter their frame of thinking. If the answer is provided too prematurely then the student may not understand why his or her reasoning is flawed. This is crucial to problem solving. We require students to find patterns, apply algorithms, and find counterexamples as they come to understand mathematical principles in a meaningful way. If we do not allow them an opportunity to grapple with flawed reasoning we take away their ability to create generalizations and truly understand the nature of mathematics (O'Donnell, 2009).

Borasi (1994) champions the notion of using errors as springboards for inquiry. She offers a case study illustrating how two high school students worked through misconceptions, flawed design, and limiting theorems to increase their confidence and appreciation of mathematics. In using this kind of the inquiry approach, students are encouraged to see errors as an integral part of learning. Missteps and conflicting solutions often lead to enhanced understanding of mathematical concepts as students are required to persevere until a viable solution can be ascertained.

In her quest to determine how students can use errors to further their learning, Borasi (1994) developed a nine part taxonomy articulating the strategies and pedagogical implications for such work. For the sake of brevity I will outline the following three components of this framework as they relate to my own teaching context: (a) experience constructive doubt and conflict regarding mathematical issues, (b) experience initiative and ownership in their learning of mathematics, and (c) verbalize mathematical ideas and communicate them.

Constructivist thinking is a key component within my teaching philosophy. I would much rather have my students work through a task, asking questions and scratching their heads than be the one at the front of the class instructing how to solve a problem. In the study, the two secondary students found that particular errors created a kind of dissonance, something that caused them to question their methods or perspective (Borasi, 1994). This unsettled feeling caused the students to examine their approach and question the validity of their chosen formula.

In Grade 1, our focus is not on the application of a formula but on understanding the nature and processes within mathematics; yet this cognitive dissonance can still be valuable. When a student understands that math is not static but is a dynamic and exciting field of study they may be more inclined to question particular applications. Instead of asking why, students may begin to ask why not.

Ownership in learning is something I encourage at every level of education. With young children I help them understand that learning can be frustrating but on the other side of this frustration comes new learning. My enthusiasm over student frustration has now become somewhat of a standing joke in my classroom. My students know that when they are struggling I will stand beside them and help them through, but they also know that they will be the one leading the charge. "Aubrey, I'm really stuck!" is often followed by my "YES! Awesome!" a collective eye roll, and a fit of giggling. My students know that understanding often comes through struggle and they know that our classroom is a safe place to take that risk and struggle aloud.

In Alberta, our curriculum has a focus on verbalizing learning, helping our students become more metacognitive. In almost every subject there is an expectation that

students will be able to explain their thinking or share their thought process aloud. ELLs have a hard time with this kind of verbalization even after years and years of reading and writing in English. In the early years, ELLs need repeated opportunities to hear and experiment with academic language.

In my opinion, young students find more success communicating through art or movement and then, retrospectively, they are able to reflect on this process verbally. With this project I plan to offer materials and kinaesthetic experiences as initial provocations. I will then introduce the spoken and written components once students have an experience from which to draw their explanation. It relates back to Krashen's model (as cited in Garrison & Mora, 2008) of comprehensible input (i + 1), teach one level above the current understanding of your students (p. 35).

This model helps students reach for new understanding while exploring within at least one known point of reference. Expecting students to explain tasks with which they are intimately familiar can promote self-reflection and augment their ability to articulate the learning. They have a personal investment in the explanation and are better able to communicate the process when it comes from an experiential perspective.

Although Borasi's (1994) study focuses on the journey of two high school students there are implications for my classroom context. The problems presented to the students, and the ways in which they were expected to find solutions, achieved more than a better understanding of the underlying concepts in math. This work also "fostered the development of attitudes and behaviours more conducive to success in school mathematics – such as increased critical stance, independence, and self-esteem as mathematics students" (p. 199). The ideas presented are aligned with good pedagogy in

mathematics, English language acquisition, and education as a whole. Using errors as springboards for inquiry promotes deep understanding about the nature and value of mathematics. In allowing students to appreciate and reflect about the significance of their errors we illustrate a healthy respect for the dynamic nature of learning.

In his classic article, Cuevas (1984) makes salient points about teaching mathematics to ELLs. He explains that in content-area subjects, such as mathematics, teachers need to be cognizant of the process involved with second language acquisition. To meet the needs of these students, teachers need to understand the complexities and functions of the mathematics register. This is defined as "the meanings belonging to the natural language used in mathematics" (p. 136). This register is more precise than a language register as mathematical vocabulary is much more unambiguous and is much narrower in scope. Just think of the many synonyms and homonyms we use in everyday English.

Many mathematical terms are used differently in everyday communications. Think of the term "take away." In math, it is often used to describe the process of subtraction but one can go to a restaurant and get "take away" for dinner. It can be very confusing for ELLs and as educators we need to differentiate those terms. By contextualizing terms we are offering students, regardless of their heritage language, an opportunity to make sense of the word in specific contexts. By building from concrete to the abstract we can help students retain vocabulary in meaningful ways. Cuevas (1984) summarizes this notion succinctly "the mathematics teacher becomes not necessarily an English-as-a-second-language (ESL) teacher, but rather a teacher of the language needed to learn mathematical concepts and skills" (p. 140).

An atmosphere of risk-taking is crucial when educators aim to help students understand the nature, as opposed to simply the algorithms, of mathematics. Whitin and Whitin (2003) examine how educators can create an atmosphere conducive to deep and meaningful exploration of mathematics. The authors outline three main goals of the project: (a) to dispel the myth that mathematics should be quick and that mathematical tasks can be worthy and engaging challenges; (b) to encourage students to construct theories about what and how mathematical principles apply in a specific puzzle; and (c) to seek a diverse set of responses from students.

The classroom teacher and researcher decided to entice students into problem-based mathematics by introducing the "Magic Triangle" puzzle to a group of Grade 4 students. They intentionally did not provide the desired sum or a list of possible solutions, hoping the students would seek multiple solutions instead. In doing so, they began creating a climate of risk-taking and honoured student voice by encouraging diverse solution-seeking strategies. After having the students work through the puzzle for a short time they were asked to convene as a whole class. It was here students were asked to share their answers and frustrations.

Students began sharing their strategies and as some talked many adjusted their own thinking. Feelings of frustration began to show and so the teacher and researcher asked the students to discuss these as well, explaining that it is a natural part of coming to new understanding. Students began to see how mathematicians work through complex problems. They understood that mathematics was not simply a matter of finding the right answer but, more often than not, it involved asking the right questions. By encouraging students to seek multiple paths to a solution, and by honouring their choice of strategy,

teachers are able to build a community of mathematicians, scientists, poets, and inventors (Whitin & Whitin, 2003).

Any teacher that has walked into a classroom absolutely sure their students will love their painstakingly planned lesson, only to find out they were sadly mistaken, understands the role motivation plays in risk-taking! Meyer, Turner, and Spencer (1997) conducted a study to determine the effect of motivation and challenge seeking/avoiding strategies within a project-based learning environment. The study was heavily influenced by the following five areas of research: academic risk-taking, achievement goals, self-efficacy, volition, and affect. The authors draw a strong correlation between project-based learning and challenge-based learning activities. Both offer students multiple pathways for problem-solving, encourage diversity in strategy application, and can help students gain a greater sense of competence. The authors do caution that although these things can take place, these types of problems may frustrate students if intentional safeguards are not in place.

A kite project illustrated concrete ways that project-based learning was taking place in a mathematics setting. By combining geometry, measurement, and air/aerodynamics the project reached across the boundaries of curricular subjects and provided a platform for students to showcase their challenge seeking and challenge avoidance strategies. In the end Meyer et al. (1997) encourage teachers to "ask hard questions…and to support learners who might have insufficient or unsuccessful experiences with challenging learning activities" (p. 518).

This article outlines a project that was developed in response to what Kleiman (1991) refers to as the dehumanized view of mathematics. This perspective sees

mathematics as a kind of secret garden, only accessible to a select few and, with the exception of computation, disconnected from the human experience. When educators view mathematics, and its relevance, in this way we often teach what Kleiman refers to as "impoverished mathematics, one that focuses on detailed facts and procedures while neglecting the fundamental nature and value of the field" (p. 48).

The project was developed with a sensibility around multi-modal learning and it sought to make connections between the ways in which we engage students in the writing process and the way we teach mathematics. In writing, we encourage students to make personal connections with the material. We ask them to write about experiences because this prior knowledge serves to engage the memory and it becomes a function of the writing. In math we should also be drawing on the experiences of the students (Kleiman, 1991).

Collaboration, shared experiences, and mutual respect for individual approaches to expressions of learning can be honoured in both language arts and mathematics classrooms. A sense of ownership is a vital component to success in both realms. By developing a shared language of math concepts such as analyzing, comparing, and identifying patterns, teachers can help students communicate across the curriculum and into the lives they lead outside the classroom. Kleiman (1991) reflects, "it's a language children can bring into the worlds they create" (p. 51).

When considering the nature of algebra, one's thoughts usually turn to the common refrain: "solve for *x*." Schifter, Russell, and Bastable (2009) explain that in the early grades, algebraic reasoning requires students to state generalizations, creating both examples and counterexamples. In thinking about the nature of problem-solving in this

way students begin to develop a sense of the principles that underlie the mathematics they are performing. This, in turn, leads to a deeper understanding of how the principles can be applied in a variety of contexts. In looking at the diverse student population within my classroom I question how I can help each student develop this sense of reasoning.

Schifter et al. (2009) offer two classroom vignettes depicting how this algebraic reasoning looks in an elementary school setting. Each illustrates how the co-construction of knowledge among a diverse range of learners benefits all members of the class. "The social context for learning with her classmates, all of whom have varying abilities in mathematics, is strengthening (her) understanding of mathematical ideas and expanding her perspective on what mathematics can be" (p. 234). This notion of the social construction of knowledge fits well with the rationale research provides for using project-based learning. Students bring their own perceptions, misconceptions, and ideas about how and why mathematics is used in particular contexts. Algebra is the study of the rules surrounding operations and relations within our number system. In developing algebraic reasoning, teachers offer their students a way of proving their thinking while providing a common language for their budding community of mathematicians.

The use of manipulatives is a well documented strategy in mathematics. This is particularly important with young students, especially those that may not have the language capability to express content-based learning adequately. I have a variety of cultures represented in my classroom. Many students are Canadian born and speak a language other than English at home. In trying to develop a unified understanding about numeracy I feel as though I have missed an obvious realization. With so many heritage

languages, and so many cultural entry points into numeracy I cannot assume they would understand how patterns are at the very core of our number system.

Some cultures see mathematics as strictly computation. Others value advanced algorithms and their application over expressing understanding in a variety of ways. If I want to develop numeracy in a way that makes sense to all my students then I need to begin with something they can all get excited about. I need to make patterns accessible and meaningful for all my students. The best way for me to ensure authenticity and emotional investment is by asking what they already know, what they are curious about, and what excites them about patterns.

Naylor and Naylor (2001) encouraged students to create an abacus and invent their own methods for using one. In doing so, students developed a greater sense of understanding when they tested and proved, or disproved, their own theories. By using concrete manipulatives teachers provide an excellent catalyst for more complex learning.

Project-Based Learning

The work of Dr. Sylvia Chard has changed the face of early childhood education. She has worked tirelessly to promote the implementation of project-based learning with our youngest students. Chard's (1994) *The Project Approach: Making Curriculum Come Alive* offers guidelines to implementing project-based learning (PBL) in meaningful ways, all while honouring the voices of children.

Chard's (1994) three-phase model of research encompasses two salient features: the acquisition of skills and the application of these skills through authentic project work. One might question the reasoning and effectiveness of project-based learning. Chard offers several reasons for this educational paradigm. First and foremost, it bridges the

kind of learning children engage in at home to the kind of learning they are doing at school. Children learn through their senses, through a natural curiosity that compels them to figure out life's mysteries. Inquiry is a way of life outside the classroom, why not make it part of life within its walls?

Projects encourage collaboration and are inherently differentiating. When offered choices, children will often select a task that is challenging. Most children naturally work alongside their peers, asking questions and sharing their findings. Environments like these become communities of learning, places for everyone to contribute and feel like their work is valued. Children will explore a variety of media when they feel safe to do so. In an effective project-based environment their voice is honoured regardless of the final product. Once students understand this premise then a whole new world opens up and they can venture into it with eyes open, hands ready.

There is a fine balance that educators must strike between the acquisition of skills and their application. Chard (1994) outlines important considerations when trying to get the most out of project work with young children. Classroom climate is crucial for success. If students are offered choices they are less likely to compete with their peers. Encouraging self-evaluation and reflection helps students focus on the process. This engages their sense of ownership and requires them to be accountable for their learning. Project-based learning is not about showcasing an impressive final product; it is about encouraging the representation of different modes of learning.

Another consideration that must be addressed is the role of teachers. In a project-based classroom teachers are part instructors, part facilitators. They reserve more traditional direct teaching methods to help students ascertain the skills they will need

further along in the project. During the investigation and debriefing phases, teachers become more like a supportive resource. Students and teachers stay in constant communication throughout the process but teachers take a step back once students have developed the skills they need to work independently. Teachers help students understand how things work and how they are made, while students figure out why they are important.

Project-based learning requires teachers to have faith in their students. A deficit model of learning and a focus on student achievement will simply not work in this atmosphere. Teachers must understand that each student brings with him/her a unique sensibility about their environment and a natural curiosity to make sense of that. It is our job as educators to help them find ways in which to answer those curiosities. In this sense, planning is organic in a project-based learning community.

Chard's (1994) model of research has three distinct phases: starting, investigation and representing, and concluding. Figure 4 offers a graphic representation of this model.
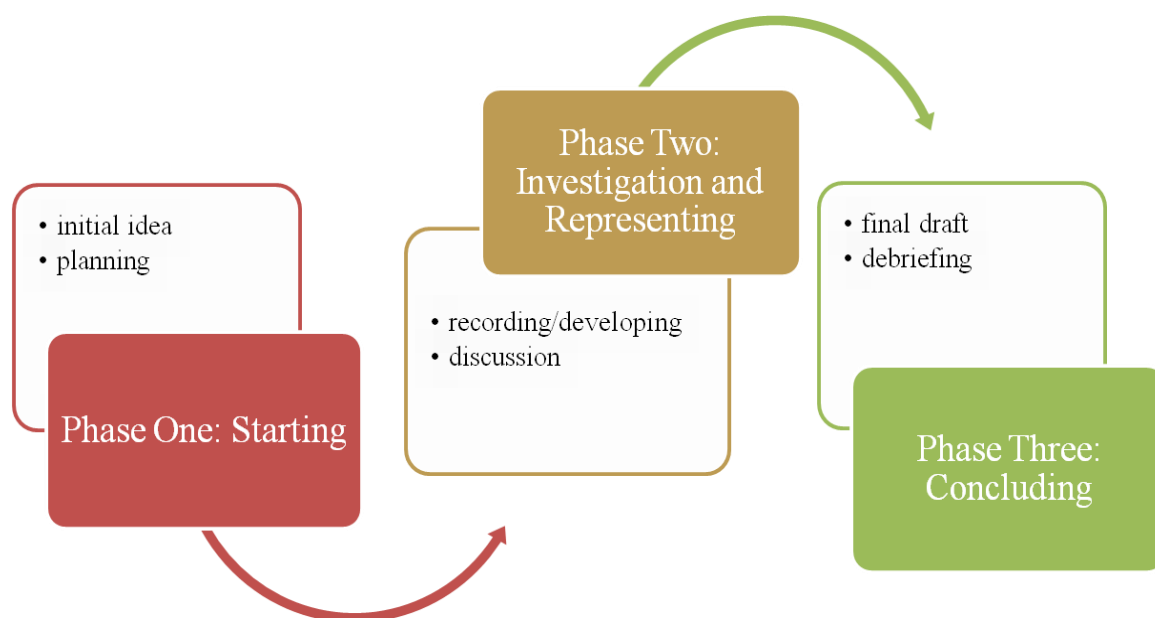

Figure 4. Chard's research model, the Project Approach.

For the first phase, Chard outlines the planning process by offering steps and templates useful during initial implementation. Topic webs and the listing of student questions guides the work of all parties by keeping students focused and helping teachers determine what complementary resources will be necessary. Within the planning process, teachers must be mindful of what final products might result and ensure there are ample opportunities for students to share their work.

In the investigation and representation phase, field work becomes the focus. Field visits, special guests, and recording of data take centre stage. Children begin to see how research can be enacted outside of school, drawing a strong connection between learning at home and at school. Within this phase students begin to differentiate between primary and secondary sources. They come to understand that it is often the person, place or object that tells a more conclusive story. Using artifacts and experts allows children to gain firsthand insight into the answers they seek. Texts, the internet, and museums are all engaging secondary sources and, with adult help, students can begin to validate the information these sources offer.

The third phase, concluding the project, asks students to debrief with the group and personalize new knowledge. The children are asked to select the most poignant aspect of their research to share and the process of summative evaluation can begin. The re-creation of data for a specific audience causes students to reflect on their process more deeply. This is an important part of the model, one that empowers children to internalize their learning. In honouring the voices of students, and providing an atmosphere of inquiry, teachers are able to help children make sense of their world by showing them how to answer their own questions about it.

It is no secret that education has great swings in pedagogy and practice. Teachers have become exhausted from the constant shift in expectations and the inevitable overuse of the latest and greatest buzz words. Many have disengaged from research and choose to step away from the tough conversations regarding student learning. In my building I often hear the refrain "Yes, but how will it work with our ELL students?" This is frustrating to me on many levels. Children are children. Their heritage language and cultural background should most definitely be considered when planning for instruction but the ELL label should not act as a barrier for trying new ways of presenting learning opportunities. We have an obligation to help all students succeed and in knowing that we should be compelled to conduct our own research, to ask the important questions, and to be vulnerable enough to reach out to others when our own practice is not effective.

Beneke and Ostrosky (2009) use the case study method to examine how seven teachers felt about implementing the project approach within their ethnically diverse preschool classrooms. The state of Illinois was the first to legislate free preschool for all 3- and 4-year old children, ensuring guaranteed access to preschool education for many children who might otherwise not be able to attend. This access created more diverse and culturally rich classrooms and left early childhood education teachers seeking out methods that will help them provide optimal learning experiences for all children.

In this article, interview data were used to analyze teacher thoughts on the efficacy of a project-based approach. From this data four major findings emerged: (a) the impact of PBL on diverse learners; (b) child outcomes and motivation; (c) the provision of real objects and materials; and (d) planning with children (Beneke & Ostrosky, 2009).

Project-based learning environments helped the teachers include diverse learners. Children have their own questions and naturally come to tasks from different perspectives. By using student voice to guide projects, and the tasks within them, teachers were better able to adapt activities to ensure the success of every child. Along with this engagement came an increased sense of intrinsic motivation. Students are more likely to stay focused and try something new when they are excited about the topic. This kind of risk taking affects the group dynamic as students begin to co-construct knowledge and ask each other questions.

Using real-world objects, authentic materials, or provocations was an exciting way to engage children in the learning process. These treasures became a springboard for student conversation and helped bridge the distance between classroom activities and the outside world. Children will often use authentic materials to guide their questions and refine their understanding so in providing them to our youngest learners we are in fact asking them to be self-reflective and metacognitive beings (Beneke & Ostrosky, 2009).

Learning to plan *with* children can be terrifying. Curriculum objectives and the expectations of outside sources often weight heavy on the minds of educators. It is nerve racking to ask students "what is it that you really want to know?" The idea of starting 25 separate and distinctly different projects is overwhelming for the most experienced teachers! Classrooms that follow a project-based learning perspective do not let students run amuck or choose every aspect of their day without guidance. In fact, there are parts of a PBL class that are quite structured. The key is to listen to the students. In asking more open-ended questions, and observing more than directing, teachers are able to draw groups of children to each other based on needs, skills, and expertise. This heightens the

sense of ownership students have regarding their exploration and levels the playing field for ELL and special needs students.

Guided by their own questions, ELL students understand that they are valued. They feel as though their voice is honoured and their curiosities are worthy. In group situations these children can hear how others communicate and they can offer wisdom and suggestions in a variety of ways. PBL environments are inherently reflective. Children ponder aloud, ask advice, and seek out assistance from peers and teachers. This self-reflection positively impacts both the language proficiency and social skills development of all students.

A key point Beneke and Ostrosky (2009) offer is the pivotal role professional development plays in implementing the project approach. In PBL teachers become mentors and facilitators of learning. This shift in roles may be difficult for some teachers to make and they will require formal and informal support to feel successful. It is simply not enough to extol the virtues of PBL. One must understand, from the inside out, why it is an effective choice for children, and how it can be done well. The early childhood centers of Reggio Emilia illustrate PBL at its best. Teachers in these schools work tirelessly to offer authentic learning experiences. Their notion of collaboration is so woven into their practice that it is simply not an option to teach in isolation. Expert teachers, "pedagogistas," meet regularly with teachers to reflect and enhance their professional development. This type of mentorship ensures a committed and collaborative team of teachers working towards a common goal: to honour the voice of children.

In the 21st century, teacher education programs strive to provide a well-rounded experience for their students. Part of that experience is the content knowledge base built from various course offerings and practicum opportunties. Another part of that journey is developing attributes and abilities that foster an understanding of how children learn. If done well, project-based learning has the ability to engage both teachers and their students in the process of this rigourous and rewarding work.

Teacher preparation programs are the perfect place for prospective educators to explore different learning environments and develop their own teaching philosophy (DeJong, 1999). When working with adult learners it can be easier to step out of the role of teacher/lecturer and into a mentoring/facilitating role. Project-based learning must be lived to be understood. If adult students develop an understanding of PBL from the inside they will have a better sense of how it may be used effectively with young children.

Recent research has discovered there is a strong correlation between brain-based learning and project-based learning environments. Caine and Caine (as quoted in DeJong, 1999) have developed a theory based on the neurosciences and cognitive psychology that sees the role of the learner transformed from "an absorber of information to one who interacts dynamically with it" (p. 328). This fits seamlessly with the project-based learning model. DeJong outlines five key similarities between the two. Both look to open-ended, multi-modal expressions of learning. They rely on the social interactions within student groupings, encourage students to identify and construct patterns, and require students to step back and see the whole picture. These learning environments are dynamic and multi-faceted and require students to be reflective about their process and progress.

In terms of developing student abilities and attributes the fieldwork component within a project-based learning environment offers a unique opportunity for students to look beyond their current context. By looking to outside sources, these prospective teachers gain firsthand insight into available resources, community offerings, and expert contacts (DeJong, 1999). By engaging in projects, students practice self-management skills. Adjustment and redirection are part of the reflective nature of PBL. Students are also required to hone their observation, questioning, and interview skills. These skills are invaluable and easily transfer to the assessment of project work.

If students are responsible for developing and answering their own questions the commitment to their work is undeniable. Accountability becomes less of an issue as students are actively involved in finding answers to their own queries. The context of the learning is inherently meaningful, students created it themselves.

DeJong (1999) encourages teacher preparation programs using PBL to spend time exploring the role of teacher as mentor/facilitator. As with any shift in paradigm, it will take time for students to fully understand the reason for the change. In a mentor role teachers are able to guide without directing, question without evaluating, and become part of an investigation rather than be the reason for one. In this instance the work of the students, rather than curriculum objectives or administrative expectations, become the focus of the work. With clear goals and expectations and immediate, constructive feedback, students can successfully make the shift from student to researcher and from teacher to facilitator.

Who hasn't taught a unit on pumpkins in the primary grades? It comes right after apples and before snowflakes, right? I cringe when I think about the apple stamps,

pumpkin seeds, and paper snowflakes I thought were so engaging for my students! I don't live near an orchard, my local economy does not focus on agriculture and to be honest I don't even like paper snowflakes! The power in project work is its ability to respond to a child's natural curiosity of the world around him. The work is engaging and generative and, if done well, helps students develop higher-level thinking skills.

When students are involved in work of their own design, their abilities to analyze, predict, hypothesize, and solve problems, are honed. There is no one moment when the teacher says "okay boys and girls, time to learn about making a hypothesis" because this skill develops out of the natural exploration of their curiosity. Concept-related vocabulary also occurs organically. When students are engaged and motivated by a project they begin to cultivate expertise. In doing so, they enhance their language proficiency and sense of self-efficacy (Harris, 2004).

Harris (2004) refers to Chard and Katz's (2000) model of the Project Approach as a way of involving students in their own inquiries. By focusing on processes that inspire thinking, rich topics, and meaningful products, teachers are able to help students extract meaning from a variety of sources and share their learning in a variety of ways. Documenting this journey is a way to make the learning visible for students, colleagues, and the community. Documentation panels, digital displays, and interactive exhibits allow the children to showcase their work and have enlightened conversations with peers and those not directly involved in the learning process. These examples of student work inform the teaching process and help to monitor student growth.

By tapping into student interests, teachers are able to establish an atmosphere of inquiry that encourages risk-taking and the meaningful exploration of text. Students begin

to see the connection between the printed word and their quest for knowledge. They learn strategies for extrapolating data from text and are excited by their growing language proficiency. The emotional investment students make cannot be underestimated. As Harris (2004) notes, "children often surprise us with the depth of their learning when we follow their interests" (p. 61).

Wiggins and McTighe's (2005) Understanding by Design model has radically changed the face of planning and assessment across both curriculum and grade levels. Within the model there are three succinct stages: identifying desired results, determining assessment evidence, and developing the learning plan. By starting with the end in mind teachers will gain a deeper understanding of how students will engage in the learning process and how they can showcase their learning, as opposed to how they will test for understanding once the unit is complete.

This has forever altered the ways teachers and students approach learning. When targets are clear and student voice is valued in this way, assessment becomes a natural part of the instruction. Unit tests and report cards are no longer the focus as students explore a topic in more authentic and meaningful ways. Teachers become co-constructors of knowledge as they align desired results and methods for collecting evidence of learning to best determine what a student has learned. This method has broken through many assessment and evaluation stereotypes as it places the value on students, not on their ability to answer test questions. This model meshes the best of pedagogy and practice to honour the work of students. For my own teaching context, Understanding by Design (UbD), has helped me include student voice within the PBL environment particularly in terms of assessment.

In *Put Understanding First,* Wiggins and McTighe (2008) describe how all teachers, regardless of context, can change their practice to ensure that deep understanding is the primary focus. The authors offer various vignettes, albeit from a strictly high school perspective, that exemplify a shocking disconnect between the ultimate goal of a high school education, to make meaning of content, and the ways in which major decisions are made ranging from instruction and assessment to curriculum design.

In order for students to learn for understanding "instruction and curriculum must address three different but interrelated goals: helping students (a) acquire important information and skills; (b) make meaning of that content; and (c) effectively transfer their learning to new situations" (Wiggins & McTighe, 2008, p. 37). The authors point out design flaws within the current secondary curriculum being implemented in the United States. Learning in contrived contexts and relying on a climb-the-ladder model of cognition focuses solely on the acquisition of knowledge. If, as Wiggins and McTighe suggest, the goal of a high school education is to become thoughtful about, and productive with, content then students need opportunities to puzzle over genuine problems.

The 11-step instructional sequence outlined in the remaining pages of the article will forever change my practice. For the sake of brevity I will not reiterate each step but, I will say, the sequence and strategies provided can be applied within a Physics 30 class as easily as a second grade exploration of boats and buoyancy. This model has the potential to take inquiry-based learning to a whole new level.

The pedagogical pendulum swings are legendary in our field. Teachers have become wary, even fearful of change. This kind of instructional paradigm is massive in its scope and effect, requiring time, money, and human resources to create the impact for which many Wiggins and McTighe supporters are hoping. I feel the argument for this type of planning and implementation would have been stronger if the authors had varied their contexts and applied the strategies to situations beyond the realm of high school mathematics and science. The fact that the article was not published in a peer-reviewed journal, and that very little research was cited, will affect its credibility.

I strive to make understanding the basis for all my instruction but I know there are times when deep and meaningful understanding does not take place. This article has shown me ways I can increase the authenticity in my teaching. I believe using a hook problem and a final performance task will capture the imagination of my students. Connecting the learning within the classroom to the world outside its walls makes the content interactive and highly engaging. Real-world applications provide students and their families with rich opportunities to extend learning and become involved in the curriculum in an organic sense. This kind of teaching will heighten levels of student engagement and offer more diverse opportunities to express learning. Who could argue with that?

As much as we would like to deny it, the corporate world has a direct influence on schools and the development of curriculum. Educators are expected to help students gain the requisite skills students need to be successful in the world of business. Trilling (as cited in Moylan, 2008) identifies seven skills necessary for effective learning in the 21st century: (a) critical thinking and problem-solving; (b) creativity and innovation; (c)

collaboration, teamwork and leadership; (d) cross-cultural understanding; (e) communications and information fluency; (f) computational, information, and communication technology fluency; and (g) career and learning self-reliance (p. 287). Moylan investigates these skills and seeks to draw a correlation between their application and project-based learning environments.

Projects help students make real-world connections between what they are learning in class and what happens outside school time. Learning environments that establish these connections are constructivist by nature. Students ask questions, seek out answers, and ask more questions in order to satisfy their queries. In doing so, students build on their existing knowledge base, and become engaged researchers rather than recipients of information.

Moylan examines the role of the teacher in project-based learning environments. His notion of the teacher as "guide on the side" is consistent with the existing body of knowledge on this subject. Teachers are more facilitators of learning, offering ways for students to utilize technology, experts, and each other to further their explorations. This intentional stepping back from the front of the class enables students to become more self-directed and self-reliant learners.

The collaborative nature of projects affords students the opportunity to work within many group dynamics. It develops a sense of responsibility around clear communication and teamwork. Collaborative group projects mirror expectations set out in the corporate sector. By practising the rules of engagement before entering the workforce, students gain valuable insight about how this can be done effectively (Moylan, 2008).

Projects that focus on issues of social justice cause students to look beyond their own situation. With the advent of the internet, and the ease with which information can be accessed, global awareness and international cooperation have become standard expectations. Students of the digital age are able to reach across geographic and cultural boundaries on their quest for answers. Teachers must adequately prepare them for this by explaining cultural norms and establishing a protocol for requesting information. This cultural sensitivity will be very beneficial as they enter the workplace.

The seven skills outlined by Trilling, and further examined by Moylan, exemplify attributes and behaviours the leaders of business require of future employees. Project-based learning environments not only address these skills, they enhance the global nature of the quest for information. Students in PBL classrooms benefit as learners, workers, and citizens.

Part of the work I do in my school involves the documentation of learning. The goal behind such a practice is to make learning visible to students, colleagues, parents, and the outlying community. When I made the initial steps on this journey I struggled with the ways in which I could effectively document the learning process without disrupting it altogether. After some professional development, and many, many conversations with colleagues, I came to understand how I could achieve this lofty goal. The digital camera became my new best friend.

Using digital images in a classroom full of young children can be rewarding and exhausting. Many of my students, upon first glance of my camera, stopped what they were doing, put on their best smile and all but screeched "Cheez!" at my lens. It took some time, and a few class meetings, to explain the purpose behind the pictures. I agreed

that they were indeed all cute children but the photographs were to help me understand how they were learning. I must admit I was relieved to be using digital technology because I would have spent a fortune on film otherwise!

Land, Smith, Beabout, Park, and Kim (2007) document their investigation of the effectiveness of digital images with a nutrition project with nine first-grade students. By using an everyday topic like nutrition, the authors hoped to make the learning accessible for each student. This tangibility, or real-world application, is a hallmark of project-based learning and one of the reasons its use is so attractive to educators.

Through daily photographic logs the children began to document and classify their daily food choices. Their guiding question "How healthy is the food I eat?" became an exciting investigation of fundamental health and nutrition concepts. Engagement was very high as student artifacts began to take shape. When the children shared their digital logs they immediately began to reflect on both their food choices and their process. They analyzed data, classified food choices, and started to draw conclusions about the healthfulness of their selections. This is an exciting step for six and seven year olds! By making the learning visible, the researchers were able to help the children answer their initial question regarding the healthiness of their food choices and the ensuing conversations led to the deeper understanding of how food affects different aspects of their life (Land et al., 2007).

I plan to offer the same opportunity to my own students. I will be taking photographs and audio/video clips and using the data I collect to inform my practice. That will, in turn, make the learning visible for students, colleagues, and parents.

As Yuen (2009) illustrates, project ideas can come from the simplest of conversations. In an effort to shift from a theme-based to a PBL environment, teachers in a Hong Kong kindergarten began listening to their students more than the designated curriculum. Following a unit on "The Body" the children expressed an interest in their feet. They were curious about measuring and comparing feet and started to explore the types of shoes people wear. Teachers and children began bringing in ice skates, high heels, and sneakers so they could examine and compare their infrastructure. Parents were informed of the interests of the class and began collecting materials for the new "shoe designers."

The children naturally separated into groups based on their curiosities. One group wanted to investigate the concept of waterproofing and began conducting various watery experiments. Another group decided that Lego would be an effective way to represent the anatomy of a shoe and started designing their versions together. Throughout the process the children were using the topic of shoes to develop and enhance the social construction of knowledge. Ideas were shared, experiments conducted, and in the end the children felt as though they positively contributed to a class understanding of shoes.

To honour the work of the children the teachers documented the process through photographs, recorded conversations, and anecdotal observations. As a collective, the children decided to host an exhibition so they could share their learning with their parents. They showed a keen understanding of the designing and manufacturing process and began using associated skills and vocabulary independently. Parents were in awe of the experience and felt more connected to their child's learning process. A community of

learners had formed and parents were excited to be part of something that so obviously benefitted their child.

As with any paradigm shift the teachers did struggle with parts of the process. Time becomes an issue when planning comes from the children. One cannot sit at a table on Sunday night and plan out the week's lessons in a PBL environment. The needs of the children become apparent in the moment and teachers must be quick on their feet and willing to change plans or alter an activity to accommodate these needs (Yuen, 2009).

Fairness was another issue expressed by the teachers. As in any group dynamic, there are those that work very hard and those who do not. In a PBL classroom the children are responsible for their own learning. This may be difficult for some children initially but with guidance and encouragement all children can actively engage in the work.

Two of the six teachers expressed a loss of control in this type of atmosphere. They struggled with letting the children work independently and found it difficult to let go of the teacher-centred style of instruction. Traditional styles of teaching can be tough to change as many teachers experienced this type of teaching as a student. PBL requires teachers to be collaborative and in many cases vulnerable. It is an act of courage to loosen one's grip on the reigns and really listen to students, but it is a worthy and admirable endeavour.

The Reggio Emilia Approach

Many educators flock to the small Italian town of Reggio Emilia to observe the ways in which teachers engage their young students. Since WWII, the people in this community have committed to providing the most invigorating and innovative

environments for children. Abramson, Robinson, and Ankenman (1995) outline the eight

key features of the Reggio Emilia Approach: community commitment, supportive

relationships, unique philosophy, preparation of the environment, atelier, project-based

curriculum, collaboration, and multiple languages.

Community commitment and supportive relationships go hand in hand. Schools

look to the community for materials, time, and expertise while the community sends

almost 50% of its preschool population to the infant/toddler and preschool centers. Much

like our North American context, each school has a parent advisory council. This council

works to facilitate an effective home-school network furthering the partnerships many

families have with these centers.

Built on constructivist theories of child development, the Reggio Emilia

Approach sees children as competent and capable learners. The phrase "image of the

child" illustrates the belief that each child has rights and is full of potential, regardless of

their circumstance (Abramson et al., 1995). This image influences many major decisions

within the Reggio Emilia experience, from the accessibility of art materials to the ways

educators encourage expression of learning.

In Reggio schools the environment is considered the third teacher. Teachers are

constantly striving for ways to stretch a child's aesthetic and social opportunities. The co-

construction of knowledge is a goal that can be felt from the children to the adults in the

building. The environment is set up in such a way as to engage the senses and ignite the

curiosities of all members of the Reggio community.

The word "atelier" is roughly translated as studio or resource room. Each center

has an atelier and an atelierista, or artist in residence. These artists work with students,

teachers, and parents in preparing and documenting the projects in which the children are engaged.

Project-based curriculum guides the learning experiences for the children in Reggio centers. Teachers listen intently to the children and create learning opportunities from student interests. These projects evolve as the children's understanding grows allowing for a repetition of activities and experiences with multiple media. These undertakings often involve small groups of students with the teacher as facilitator and partner rather than guide or information giver. A key step in project work is the process of documentation. This component involves the teacher capturing the learning process as students travel through it. Photographs, audio/video recordings, and documentation panels all represent the path the group has taken. These panels communicate to all members of the school community making learning visible for all parties. The focus of this work is not just to illustrate what has taken place but to honour the journey of the children and extend an invitation into the worlds they explore (Abramson et al., 1995).

Collaboration is an expectation in Reggio inspired work. For students, small groups foster interactions that help children develop linguistic and social competence. For educators it offers multiple perspectives about the work and the ways that media can be offered to children. Loris Malaguzzi, considered the founding father of the Reggio Emilia Approach, was a champion for multiple expressions of learning. His poem, *No Way. The Hundred is There,* honours the child's process, the way he or she comes to understand (see Appendix A). These multiple languages encourage children to build, sing, create, and share how they discover the answers to their curiosities. The visual arts, along with

the atelier, are "inseparable from the whole cognitive-symbolic expression of the child" (Gandini & Edwards, as quoted in Abramson et al., 1995, p. 198).

As with any educational philosophy, context is crucial for understanding and implementing its salient features. Many teachers come back from visiting the Reggio centers, inspired yet full of trepidation. Many wonder how collaboration and the multiple languages will work within their school contexts. Art materials are not typically available in well-stocked studios and one does not usually have teams of artists and master teachers with whom they can talk, plan, and co-document. In my school setting, the most prevalent question I hear regarding the Reggio philosophy is "how does it work with such a diverse group of students?" Initially I was unsure. I was cautious about project-based learning because I wanted to be sure I could support my ELL students with their linguistic and content-area proficiencies. The more research I read, the more I am convinced that the image of children, the co-construction of knowledge, and the multiple languages serve my students more effectively than traditional methods of teaching.

Meaningful connections and authentic experiences are what really drive the understanding for ELLs. They must make sense of why a task is offered before they can make sense of what it is all about. Projects are a perfect way to engage students in meaningful learning opportunities. When students express curiosity they have an emotional investment in searching for answers. One way that Reggio inspired teachers draw students in to the journey is by offering authentic materials.

"Provocations" are a way of stimulating the imagination of students. They entice students to ask questions, feel, and identify with the object often causing quite a stir! A good provocation begins a conversation. It gives the community of learners a chance to

be active participants in the co-construction of knowledge and often encourages deeper exploration. By honouring visual expressions of learning, through provocations and project work, teachers give diverse learners an opportunity to express themselves without the burden of a language that may be new or unfamiliar. Students are able represent their learning anyway they choose. In this way, heritage language and cultural background do not affect a student's ability to learn, or teach those around them.

In *Working in the Reggio Way*, Wurm (2005) explains how the guiding principles of the Reggio Emilia Approach can be applied in a North American context. It is a common misconception that this approach to working with young learners can be transplanted into any environment. In fact, this is not only dishonouring of the work that takes place, it is disrespectful to the learners one is trying to engage. In the Reggio approach the environment becomes the third teacher. It would not be authentic to re-create the Italian village feel within the walls of an urban Canadian classroom. To work in the Reggio way, one must be thoughtful and intentional when developing a learning environment. It must take into account the children living there and consider the ways they want to express their learning.

According to Malaguzzi (as cited in Wurm, 2005), a teacher's goal is not to facilitate learning thus making it easier but rather to stimulate it by making problems more complex, engaging, and difficult. Projects are an excellent way of providing this type of stimulation. When working with ELL students, it is important to ensure they understand both how and why a project is being offered. To encourage language acquisition one might consider mixed ability groupings. Within these groups each member could have a well-defined role with the responsibility of reporting progress to

the teacher. Discreet opportunities for asking questions are built in and the social aspect of learning is at the forefront. Project work is inherently differentiating. It honours a student's chosen method of expression and encourages multimodal learning experiences.

How we see children affects how we plan for their education. Tarr (2003) challenges the notion of children as cute, miniature adults. If society sees children as cute and helpless, the learning experiences we offer them have no value and do not further their understanding of the world. Curriculum becomes a checklist sandwiched between cartoon posters and colourful, mass produced scalloped borders. In Reggio Emilia, children are seen as much more than that. Carla Rinaldi, a pedagogista or pedagogical consultant in Reggio Emilia, explains "the image of the child is above all a cultural convention that makes it possible to recognize certain qualities and potential in children" (as quoted in Tarr, 2003, p. 8). This vision of children helps educators see past typical developmental stages. North America we judge a children's abilities to handle materials by their biological age. We would never think to give small children wire and small beads but in Reggio this is very commonplace. Teachers work alongside students to ensure safety but the children are encouraged to explore a variety of media when they are representing ideas.

Another way schools often depict their image of children is through the physical set up of the space. Are the chairs adult-sized? Is the art hung at a height for those over five feet tall? Can you feel the presence of children even when they are not in the building? Through careful deliberation and intentional documentation the schools in Reggio honour the voices of their students. Panels depicting various projects and student work are part of the fabric that weaves the story of that particular center. The learning

process is made visible for everyone both in and outside the building. Parents can see how their child's day unfolds and they understand the type of work with which their children are engaged. This kind of overt reflection encourages meaningful communication between students, teachers, and parents. In making the learning visible the educators create what Tarr (2003) refers to as a pedagogy of listening.

By asking educators to step back from their traditional role in front of children Reggio schools offer these teachers an opportunity to construct knowledge alongside their students. In offering a variety of materials, and encouraging the use of the many languages of expression, educators help children seek and explain their learning in authentic ways. "Experiences in visual expression are not add-ons or isolated activities but are a form of inquiry or way to investigate a theory, idea, or problem, a way of clarifying understanding, the communication of an idea" (Tarr, 2003, p. 11).

Gone are the Friday afternoon art lessons where every student creates a version of the desired result. Children are artists in their own right and deserve a chance to express themselves without the limiting expectation of a prototype. If we step back from these cookie-cutter lessons, and open our eyes and ears to the voices of our students, we will find they are engaged with the world around them. The choice is ours: follow the steps or create your own.

Children learn through their senses, just ask anyone who has ever watched a baby spit out the cereal to chew the spoon. They make sense of their environment through their mouths, ears, and eyes. Their inability to use words or full sentences does not impede their learning. As observers, we learn to read how very young children communicate with us. Body language, tone, and facial expressions tell the parts of story we need to truly

understand. Young children enter school knowing there are many ways to share their needs and ideas. Wright (1997) argues that the arts provide a way for children to externalize their feelings and share their thoughts in a way that evokes an emotional response from an audience. The arts are an authentic way for young children to communicate with the world.

In North America we have become text-centric. Malaguzzi (as quoted in Wright, 1997) reflects, "Today spoken language is increasingly imposed on children through imitative mechanisms which are poor in, or devoid of, interchange, rather than through strong imaginative process linked to experience and to the problems of experience" (p. 362). Our schools have placed value in reading and writing to the detriment of our arts. When a budget crisis is on the horizon, arts programs feel the cut the deepest. Music, drama, and visual arts have become offerings to the most fortunate of students. Even in the early grades, students do not often experience these areas under the guidance of an expert. This denies children the opportunity to learn through the arts in an organic way. Instead, art has become a Friday afternoon filler. The nonverbal languages, through which children naturally communicate, are devalued and children are forced to express themselves in contrived and oft times uninteresting ways.

Movement and drama allow children to explore their feelings and questions through a kinaesthetic mode. From the time they are babies, children observe, re-create, and imitate through movement. Yet when we take away the language of movement we are, in fact, removing the most natural way for children to express themselves.

To have a true understanding of the power in the arts one must not see music, drama, and the visual arts in isolation. In Reggio Emilia, these languages are integrated

into the daily life of students through project work and the posing of real-world problems.

Upon reflection of their work, if children feel their initial representation does not match

their current understanding, they are encouraged to rework it. Revisiting ideas and media

opens the door for students to construct knowledge in a multitude of ways. They are not

bound by one expression of learning but are, instead, encouraged to build upon it, make

adjustments, and enhance their representational skills. Wright (1997) aptly summarizes,

"By making the arts the core of the curriculum, societies can begin to reaffirm their

cultural role of giving our lives a sense of identity, belonging and purpose – both socially

and spiritually" (p. 365).

According to Kroeger and Cardy (2006), documenting students' work is a way of

getting closer to their thinking. It is not merely a collection of portfolios or artifacts; it is

the intentional observation of the learning process to improve the quality of interaction

between student and teacher. In this way, documentation makes learning visible and

reciprocal.

Reflection comes through observation. Whether that observation is overt or

subconscious it causes learners to think about what they are seeing, hearing, or doing.

Documentation is a way of helping students revisit their work. If they are encouraged to

re-examine previous learning experiences then they can modify past understandings to fit

what they know now. This opportunity helps students see the value in taking risks and

build on what they already understand. Effective documentation comes out of judgement-

free, focused listening. It requires the documenter to put aside pre-conceived notions of

what might take place and focus solely on what is presented. As Kroeger and Cardy

(2006) explain, "Listening does not produce answers but instead helps to formulate questions" (p. 392).

The North American context focuses on standards-based assessment and the ability to aggregate results in quantitative ways. Most curriculum is developed with a standard in mind, often neglecting what is locally relevant. In turning away from a child's interest we are decreasing their ability to engage with the material yet teachers are bound to skill-based measurements and superficial exploration of somewhat meaningless topics. It can be hard to make the switch to a qualitative practice, such as documentation, in these circumstances. The work is worthy but the shift can be overwhelming.

Documentation can look many different ways. In my school the range is tremendous. Some teachers have just started using digital photography as the first step in documenting student learning. Others create more traditional panels displayed for students, colleagues, and families. Still others use technology in creative ways to engage the students in the process of co-documentation, asking them to share and celebrate the work of their peers. Regardless of the entry point, educators at my school are using documentation as part of the reporting process. They value student work, listen throughout the learning process, ask questions to further the understanding, and help students take charge of their own learning. Documentation may be a hard to reach place but the reward is immense once you get there.

Step Two (Part Two): Reflection

Reflection is a key component in Dr. Townsend's action research model. Each step requires one to think about what is pertinent, what is relevant, and what is required

for success. In honouring this process of reflection I began keeping a field journal and I will use my entries as a way of illustrating my thought process throughout the study.

My journal entry for July 16, 2009:

Well here I am, 30 hours after my last official grad class has ended, and I am beginning to focus on my culminating project. I am excited to take the next step but scared at the same time! This summer has held some pivotal moments for me. I have spent the past three years with the most amazing, articulate educators...they have taught me so much. I was given the opportunity, the humbling opportunity, to edit some of the work of a few close cohort members. Reading the passion in their work and seeing the level of discourse was invigorating, it has given me a greater sense of reverence for the work going on around me. Until that point I had been too focused on my own work to be a fellow researcher, instead I had remained a member of their class.

If I am going to effectively conduct research within my own classroom I need perspective. To gain this, and hopefully reduce my teacher bias, I will need to call upon colleagues. I will need to be courageous and vulnerable, honest and open-minded. I owe it to my students to overcome any sense of unease and ask the tough questions.

Step Three: Make Sense of the Information

It is overwhelming at times to look at the quality and quantity of research that has been done in education. It leaves me wondering how I have made any progress with students, how I have taught anyone anything! The saving grace for my sense of self-efficacy is that I know my students well. I spend a great deal of time watching, listening,

and talking with my students. To that end, our classroom becomes an environment of trust, a safe place to ask questions and make mistakes. The kind of research I am planning to conduct will help me become a more effective teacher. It will help me identify and implement effective strategies for all students regardless of their cultural background and heritage language. Honouring student voice is very important to me and, even if my teaching practice could stand some improvement, I know my students feel the commitment I have to this conviction.

The areas of research in all four components of my literature review complement one another well but I feel it would be constructive to outline the key features of each.

Pedagogical considerations for supporting English language learners:

- consider linguistic load - be cognizant of both language registers and content-specific registers

- context and prior knowledge are key – use known language or concepts to teach the unknown

- set both language and content area goals for each lesson – especially vocabulary

- offer authentic tasks, experiences, and artifacts to ground concepts in real-world application

- offer hands-on experiences where possible – manipulatives, realia

- allow many opportunities for the co-construction of knowledge – peer sharing, collaboration

Pedagogical considerations for teaching mathematics:

- consider the nature of mathematics – do not focus solely on the teaching of algorithms

- provide authentic tasks for discovery and encourage risk-taking – use errors as a way to enter into inquiry; ask students to provide justification and counter examples

- disequilibrium can be important for growth – do not shy away from problems that appear to be beyond the reach of students

- use visual representations and manipulatives whenever possible – graphic organizers, key word banks, charts, arrays

- provide lots of think/wait time – leave some problems unanswered, it piques interest

- teach content-specific vocabulary explicitly – i.e., use "addition" instead of "plussing," illustrate and define these concepts as concretely as possible

- present opportunities to express learning in a variety of ways – multi-modal, cross-curricular

- collaboration is critical in developing a community of learners – students need to hear each others' ideas, strategies, and curiosities

- make cultural connections where possible – i.e., Chinese suan pan (abacus)

Pedagogical considerations for project-based learning environments:

- role of teacher is facilitator/coach/mentor

- ensure student voice guides the exploration –student interest is key

- students are co-planners and actively involved in determining the focus, direction, and product

- give clear guidelines/expectations – give students opportunities to draft and revisit

- provide scaffolding for students – multiple entry points depending on their prior knowledge and experience

- use real-world context to support the investigation – it bridges the work between home and school

- field study and experts are invaluable

- offer provocations/authentic materials to engage students in the initial exploration

- encourage multiple expressions of learning – art/drama/music/writing

Pedagogical considerations in understanding the Reggio Emilia Approach:

- image of the child – students are capable, confident, and autonomous learners

- environment as third teacher – teachers are always searching for ways to increase educational and social experiences

- community connection – strong relationships with local community, business owners, artists

- expert teachers (pedagogistas) and artists (atelieristas) work with students and other teachers

- develop a pedagogy of listening (Tarr, 2003) – involving students in the process and using this data to guide projects, further exploration, and assessment

- project work is the key component guiding student learning experiences – these ideas come from the children

- learning experiences promote the social construction of knowledge – collaboration is essential for students and teachers

- honouring the multiple languages of children – multi-modal opportunities ("The Hundred Languages") paying particular attention to the non-verbal languages

- documentation of student work is essential for making the learning visible – use images, student work and audio/video of student process and display for children, staff, parents, and community -- this can look a variety of ways: artifacts, photos, video, panels

My journal entry for November 2, 2009:

There is something therapeutic about putting thoughts on paper! My project has just received approval from the Calgary Board of Education so I am officially ready to start. I wish I had tightened up my literature review before now. Am I really ready to begin?

I sat down with each of the five ELL participants today, conducted a pre-study student questionnaire (see Appendix B), and was surprised by their answers. Not one said math was about numbers! Two said addition and subtraction were a part of math...but no numbers? I need to find some common ground, an entry point that will engage and excite all my students. Where to begin?

Much has been written about the best pedagogy for teaching ELL students, and in particular in a math-specific contexts, but there are gaps in the current research in terms of my particular interest. I am searching for ways that teachers can use project-work and documentation to help ELLs contextualize, and

therefore enhance, their learning. I think seeing the process in action speaks far louder than a mark on an exam or a parent-teacher interview. I have had parents come in to my classroom during their designated 15-minute time slot smile, nod politely, and simply ask "What can we do to help our child?" They do not understand what it means for a 6-year old to represent scientific concepts using charts, graphs, and diagrams. They want to know if their child is kind to other students and how they can help support what is happening at school. When I thought about how frustrating it must be for these parents to look at a 4 page jargon-laden document I vowed to do something to help the situation. My introduction to digital literacy would change my practice and the way I report to parents forever.

My journal entry for November 9, 2009:

Working in a Reggio inspired school, and having access to a variety of artists in residence, I have come to know the power in technology. In my second and third years at Monterey Park the staff was fortunate to have an opportunity to work with a videographer. I will be the first to admit that the experience was not exactly what I expected, but I did learn a lot about using film with young children. From script writing and rehearsals, to costume design and editing the footage, students learned the power in storytelling both in front of and behind the lens. Our final production "Whatever Floats your Boat," was a huge success in the eyes of both students and parents. The students were so excited to take home their very own DVD and parents saw a tangible example of their parent council dollars at work.

Being surrounded by my colleagues and the very best equipment is inspiring! When I first came to my school I did not know how to plug in a SMART Board! When I saw the level of student engagement, and observed firsthand how technology levelled the playing field for my ELL students, I knew I had to hone my skills and become technologically savvy.

One of the goals in my Teacher Professional Growth Plan (TPGP) in 2008-2009 was to enhance my repertoire of strategies for incorporating technology in all areas of the curriculum (see Appendix C). I vowed to find ways to help both my students and their families understand the nature of the work in which we were engaged at school so I began taking pictures, lots and lots of pictures.

Digital photography has been the most powerful advance in my practice to date. Over the years, my photography skills have improved slightly but the biggest change has been in the ways I engage my parent population. As part of that TPGP goal I committed to producing a film documenting each term. Consisting mostly of photographs and a few slides of supporting text these films actually show parents what it is like to be a learner in our classroom. These CDs are added to the report card package each term along with a list of student-derived questions.

The children in my class have become photographers, cinematographers, editors, and critics throughout this process. They have developed a sensibility around sharing their learning in visible ways and of course they love giving their parents homework! The beauty of the film is that students are able to sit with their

parents and explain each section using the language in which they feel most comfortable conversing. The small amount of supporting text within the film simply introduces a new section or special experience so, in essence, the photographs and the children do all the talking.

My journal entry for November 16, 2009:

What is doable? What can I do within the scope of my classroom that supports the students and advances the learning that is taking place? What can I take from the research and apply in my context? How can I make this come together? This is such an important and daunting step. I know what works for my students this year. They are a high energy group who need visual supports and lots of hands-on experiences. They need opportunities to work together and time to reflect on their own about new concepts. They need time to digest, practice, and then express their learning. They are typical 6-year olds.

I know that for this project I would like to explore the underlying concepts of place value. I would like to examine international systems of counting and use student prior knowledge about tools and manipulatives (like the abacus) as a provocation. I would like to dig deep into the early numeracy concepts and find ways to make our number system and methods of counting, building, and representing numbers meaningful for students. I also know that to be successful, and to really enhance my understanding of how project-based mathematics works in a classroom with a high ELL population, I need to listen to my students.

Looking through the initial student surveys I see all five participants feel good when they are doing math. They show a keen interest in building

mathematical concepts. One student even said she needed to build when she was frustrated with a concept. This kinaesthetic sense guides their learning, and thus, should guide my teaching.

Another interesting note from the surveys is that all five children saw me as the sole teacher. Now I know that sounds ridiculous, of course I am the teacher, but I work very hard to build a community of learners within my classroom. For me, this means setting aside the notion that I am the only teacher in the room and helping students see the power in learning from each other. Moylan (2008), DeJong (1999), and Katz and Chard (2000) all stress the important role that collaboration and the co-construction of knowledge play for ELL students in project-based learning environments. If I expect my students to learn from one another I need to help them see themselves as valued educators first. That is not only doable, it is necessary.

My journal entry for November 25, 2009:

Using an outline always helps me stay on task and on target. Here is the plan:

1. through class conversations determine what concept/mathematical construct the students are interested in studying further

2. consult the curriculum and research to develop a plan of action for the investigation of this topic

3. speak to colleagues about the exploration – what advice can they offer?

4. begin preparing supplies

5. document, document, DOCUMENT!!!

6. secure photographs and audio/video clips on personal laptop in well marked and password protected folders

Step Four: Share the Information

To ask questions about one's practice is to teach in the spirit of inquiry. According to Danielson (2006), professional inquiry is essential for initiating change and defying complacency. Schools can remain vibrant and innovative places if they embrace an openness to change and a thirst for continuous improvement. Critical examination of school practices is a necessary and often humbling experience, but when a strong commitment to improving student learning guides the conversation it can also be liberating.

The action research framework fits seamlessly with this notion of inquiry. It is not simply a willingness to dispel ineffective practice that elevates a school; when inquiry becomes a part of the culture, the very lifeblood within the building, amelioration occurs. The ATA's (2000) *Action Research Guide* states, "action research is a strategy teachers can use to investigate a problem or area of interest specific to their professional context. It provides the structure to engage in a planned, systematic and documented process of professional growth" (p. 2). This is an essential understanding when one ventures down the path as a teacher-researcher. It is not enough to ask the questions and read supporting literature. To really understand the nature of the issue one must be prepared to plan, act, observe, and reflect about it. Townsend's model (as cited in ATA, 2000) provides teachers with a succinct and efficient framework to implement successful action research. In terms of professional inquiry, Danielson (2006) asserts, "it is the other aspects of culture, including an environment of respect, a vision of learning, and a culture of hard

work and opportunity, that help the projects undertaken by teacher leaders to actually improve that program" (p. 57). For this project, I am very grateful for where I teach.

The composition of my grade team is unusual. Within it, there are five Grade 1 teachers in four classrooms and a learning leader. Having the fifth teacher has provided us with an opportunity for team and co-teaching as well as a chance to work with smaller groups of children. It has not always been easy but we have worked very hard at becoming a cohesive group, one that plans and implements innovative practice together. We have established a strong commitment to collaboration and it has benefitted both our pedagogy and our practice.

Our weekly team meeting is a time for conversation, questions, and concerns from both a teaching and learning perspective. Three out of six of our team members are currently immersed in a Masters program so our exposure to current research and recent technology is very high. The articles and resources we share often act as a catalyst for discussions regarding pedagogy, assessment, and our student population. As a teacher on this team, I have been blessed with colleagues that share a common passion and level of commitment. I am able to share questions and concerns about my own teaching without fear of judgement or rebuke. We help each other through difficult situations and offer suggestions and support when they are needed.

When I started planning the initial steps for this study I found myself struggling with how to begin. If I was going to promote the use of project-based learning I needed a provocation that was worthy of sharing with others. I got so wound up in trying to make my ideas fit into the project that I forgot to listen to my students. Luckily, one of my

partners reminded of this, and set me back on the right path. I put aside what I thought we should study and asked my students what they thought. More on that in a bit...

One of the ways I prepared myself for this journey was by rewriting the mathematics curriculum into kid-friendly language. I wish I could say this was an original idea, one that came to me in a flash of brilliance during a late-night planning session but, alas, it was not. I have the honour of working with some amazing colleagues, both in and outside of my grade team. Two of my closest co-workers have done some remarkable work with project-based math in grades five and six. When I knew I was going to be looking at a similar framework I began picking their brains. Being the wonderfully generous women they are, they sat down with me and shared all the resources, lesson ideas, and planning tools they had used to implement the most effective math program I have ever seen. Of all the ideas they shared, the notion of rewriting the curriculum strongly resonated with me.

Once I sat down to rewrite the learning outcomes I was excited and frustrated at the same time. It was liberating to change the somewhat stilted language of the Program of Studies into something my young students could understand. The frustrating part was realizing I should have done it years ago! (see Appendix D). By mapping out each of the four strands (Patterns and Relations, Shape and Space, Number, and Statistics and Probability) I found myself more engaged with the curriculum. Project ideas came to me more readily and I began to see how my students could make sense of a document I had always reserved for teachers.

When I shared this document with my students, and subsequently with my colleagues, I explained that it would be used to track how we learned about each strand.

As our project-based investigations were completed, we would colour the box beside every objective we examined as a result. Needless to say, everyone was very excited! The *I Spy* project we started at the beginning of the year had drawn to a close so we marked off the outcomes in the Number and Patterns and Relations strands that applied. Graphic organizers such as this support ELL students with spatial arrangement thus making concepts more tangible (Lombardi, 2008). The students immediately felt a sense of accomplishment and were excited to see where we were going next.

In my view, patterns are the cornerstone of mathematics. Without them our number system could not function. Patterns help students make sense of mathematical constructs, and when they begin to make generalizations about what they see, learning becomes more accessible. Schifter et al. (2009) state, "when the generalizations are made explicit – through language and through spatial representations used to justify them – they become available to more students and can be the foundation for greater computational fluency" (p. 236). Making mathematics accessible is one of my main goals in my teaching. To help my students understand how math works I needed to focus on patterns. To understand how math works for my students I had to go to the source.

My journal entry for December 1, 2009:

When we started the year, my students were fascinated by some photos I took on the first day of school. There was the shot from behind the bench showing rows upon rows of circles (see Figure 5), and the grate covering a vent at the side of the building.
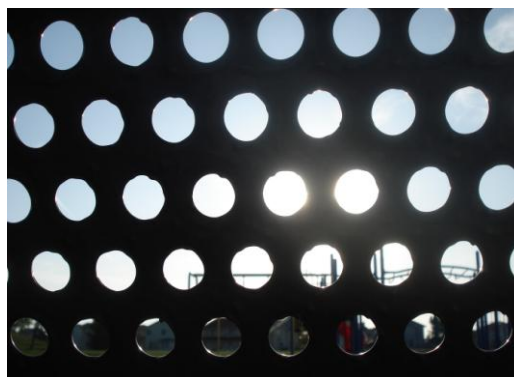
Figure 5. A photo from behind the playground bench.

They began to debate about perspective and camera angle, "I wonder where she took that one?" "That's the bench!! You know, the one by the playground" "No it's not!!" "I think it IS! Look at how the light comes through the circles!" It was the start of our investigation of patterns in our world.

Step Five: Plan Action

To me, patterns are the most important and most exciting strand within the mathematics curriculum. After the pre-study survey I knew patterns would be the cornerstone of this project, I just was not sure how. As I said, initially I was thinking along the lines of patterns within the number system or the patterns found between international systems of counting. I was hoping to engage my ELLs in the nature of mathematics by providing cultural connections across key concepts. I wanted to illustrate how mathematical applications reached across cultural boundaries thus offering multiple entry points into the investigation. My students, however, had other ideas.

I had no idea how integral those first day pictures would be to this project. I created a "What do YOU see?" board as a provocation. I used the photographs to captivate the minds of students and colleagues. It seemed no one could pass by the board without stopping to figure out what they were looking at.

Lombardi (2008) and Furner et al. (2005) suggest that graphic organizers are inherently motivating for ELLs. If students know what they are going to be learning then they feel more at ease and are better prepared for the day's lessons. Knowing this, I began planning to support this need and determined mind mapping would be the best place to start. Using *Inspiration* software, we outlined what we already knew about patterns (see Appendix E). With the kid-friendly curriculum in hand, I summarized the specific curricular outcomes for my students and they actually laughed! "We already know all that stuff!" "We can make patterns, and continue patterns." "We can show them with blocks, and with our bodies...." So I had to ask "If you guys know all that stuff then what do you want to know about patterns?" That is when things started to get interesting.

As the conversation continued, talk turned to animals. "Why do tigers have stripes?" "Why do jaguars have spots?" "Why are pandas black and white?" "Do chameleons have patterns?" These are all very important questions to 6-year olds. It was exciting to watch them become enthralled with the natural world and as we mapped these ideas (see Appendix F). I knew it would be the perfect segue into our primary exploration.

Wiggins and McTighe's (2005) UbD model has guided much of my planning this year. Whenever I sit down to plan a new unit with my teaching partner we start by determining the enduring understandings. What is it that we want the children to walk away with at the end of the unit and how are they going to show us what they know? After our class brainstorming session, I compared the math/science curriculum to our mind maps. There was an obvious connection between graphic patterns in animals and the function of mimicry and camouflage in nature. The tricky part was going to be

engaging my students, particularly my ELLs, in a way that would enable them to share their learning without a lot of writing.

The math curriculum states that students in Grade 1 need to use patterns to describe the world and to solve problems. They need to reproduce, extend, and create patterns using a variety of materials. Looking a little more deeply at the outcomes, and aligning them with those in science, I found a connection between translating patterns and identifying animal adaptations. A tiger has stripes for the same reason a zebra does, to blend in with the tall grass on the savannah. A tiger uses its stripes for camouflage during the hunt, whereas, a zebra uses its stripes to hide from the hunter. Hunter versus prey is an important concept when learning about the needs of plants and animals. If we could enter into that conversation by determining how patterns help animals adapt and survive then we could begin a cross-curricular investigation of how patterns are an integral part of the natural world. This kind of multi-faceted exploration would help my ELLs make connections on several levels. They could enhance their proficiency in science, math, art, non-fiction writing...the possibilities are endless. Narrowing down the topic was easy, now I needed to determine how we were going to begin!

In using UbD, I have come to understand the importance of starting with the end in mind (Wiggins & McTighe, 2005). From Kindergarten, the children in my school are encouraged to use the fine arts as a way of expressing learning in all areas of the curriculum. They are as comfortable with clay and a paintbrush as they are with a pencil and crayon. I, on the other hand, am not. When I saw how intrigued my students were about the graphic nature of patterns I knew we would have to use art as a vehicle for its exploration. Wright (1997) suggests that by focusing on non-verbal languages, ELLs can

develop understanding in a way that fits with their current level of language proficiency. In asking students to reflect on final products after the fact we provide meaningful context through which they can verbalize their thought process.

As I planned, I kept thinking of the initial and final tasks. Written labs would be a great way to build skills and teach concept-specific knowledge, but they would not be visual enough for these students. I needed to start with a provocation rich enough to capture their imagination and to end with something that truly celebrated the journey. As I searched through the images I had detailing animal patterns, an idea came to me. I could use an image depicting magnified animal skin and ask the students to extend it. Even better, I could crop the photo in such a way that the students could only see a portion of the animal and then they would have to complete the drawing. I had my provocation!

Pencil and paper tasks are limiting and, at this age, are not effective ways to assess student understanding. Performance tasks provide students with an opportunity to express their learning in a variety of ways. From weaving to sculpture, comic books to oral presentations, performance-based tasks can honour the voices of children by providing an avenue for their expression of knowledge. When students choose the mode or medium through which they share their knowledge teachers get a more authentic view of their understanding. "When understanding is the focus our evidence must be grounded in authentic performance tasks that involve real problems, not mere exercises" (Wiggins & McTighe, 2005, p. 169).

Plasticene is a material the students in our building use very well. From self-portraits and cross-sections of volcanoes, to van Gogh inspired sunflowers and sculptures, it has inspired many works of art. As a medium, plasticene is very tactile and

forgiving. Students are attracted to these properties and their artistic efforts often yield

incredible results. When I saw how fascinated my students were with the graphic nature

of patterns plasticene became an obvious vehicle for their culminating project.

Having established the initial provocation and final performance task, I began

creating the skill-building science labs. Each would explore a different aspect of animal

patterns and introduce a new scientific tool to support the collection of evidence. As I

worked through this component, I turned to two of my partners for advice. Were my

students ready for a written lab? Could they be independent enough to complete two of

the three labs with limited teacher guidance? What was the most effective way for them

to show what they had learned? After two or three conversations, a few hours scouring

for the perfect images, and many drafts of the lab templates, it was time to dive in.

My journal entry for December 28, 2009:

I cannot believe it is time to really get started! Sitting down with my team really

helped me solidify my plans. It feels good to say them aloud; there is no turning

back now! When we get back from winter break we will be in the eye of the

storm. I will continue to read and summarize, journal and reflect, but I will need

to concentrate on taking it all in, on being present with my students. I hope my

documentation skills are adequate enough to capture the action! My camera is

ready to go, a fresh folder is labelled for the project and sitting on my desktop,

and my batteries are all charged up. I can use my laptop to record video if I think

I'm not getting enough with my anecdotal notes and photographs. I have also

talked with my one partner to see if she can provide me with some release time so

that I can sit down with my students after the majority of the tasks are completed.

I will need some uninterrupted one-on-one time with the five participants if I am

going to collect useable data in the form of an interview...It's very exciting!

Step Six: Take Action

Albert Einstein (as quoted in Calaprice, 2005) stated, "It is the supreme art of the

teacher to awaken joy in creative expression and knowledge" (p. 70). Provocations have

become an integral part of my practice. Instead of worrying about how I will engage my

students in the next topic, I let the artifact do the talking. After our mind mapping

sessions my students were seeing patterns everywhere! They would come in from the

playground and discuss patterns they had discovered. We went on a pattern hunt with the

digital camera and took more photographs of patterns in nature. They were ready to take

the next step and I was ready for them!

When we came back from our nature walk I split the students into four small

groups. Each group received a large piece of paper with a small black and white

photograph glued in the center. They were asked to look at the photo and decide, as a

group, what animal was depicted. Then they were to complete the drawing paying close

attention to the size and proportion of the pattern represented. You could have heard a pin

drop for the first few seconds...and then the room erupted in conversation! Heads

hunched over the paper and pencils came out....

As the groups set about the task I watched very carefully. Two groups started

right away, unanimously convinced they knew their animal's identity. They went about

extending and then adding details specific to that animal's appearance (see Figure 6).

Figure 6. One group begins to extend their animal pattern.

Both of these groups completed the task in relative silence, sure about their path and the role each member had to play to achieve the end result. Another group was unsure about the pattern and debated the details of the photograph. In the end, that group remained divided about the animal's identity but united in how the pattern extended. After considerable debate, they were able to create a picture representing the pattern but lacking in animal-specific details.

The fourth group's issues were unrelated to the academic outcomes of the lesson, this group experienced difficulties with the collaboration. One group member was unconvinced that her animal was a lizard—she thought it might have been a crocodile. When the group asked her why, she explained that both the crocodile and the lizard had similar circular patterns. I suggested she check out the "What do YOU see?" board to locate something that might help her decide one way or the other. One group member accompanied her and pointed to the lizard skin. "See, this one has circles that are all the same size. That one (pointing to the crocodile skin) has small ones inside big circles." She turned to me and simply said, "Yup, it's a lizard!" and with that the group came together to finish their sketch (see Figure 7).

Figure 7. The "lizard" group set to work.

In the end, each group had the opportunity to share what they had drawn and offer justification for their selection. Three of the four groups included facial features and distinct body parts while the last group, the one that remained divided on the animal's identity, focused on the mechanics of the pattern. To their credit, the shark skin was the most difficult to recognize (see Figure 8).

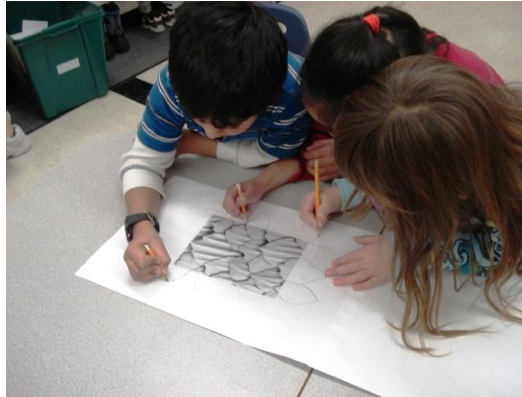*Figure 8*. The "shark" group extend their pattern.

After the sharing session I revealed large colour pictures of each animal on our SMART Board; there was a lizard, a crocodile, a tortoise, and a shark. The students delighted in seeing how close their renditions came to the real thing. Even the shark group was excited. The one group member who was convinced it was a shark even received a round of applause!

The collaborative nature of the activity and the focus on non-verbal languages benefitted all of my students but I saw the greatest impact with my ELLs. These students felt safe to contribute to their group's drawing, they were able to ask and answer questions among their peers and they made cross-curricular connections in meaningful ways. The learning environment was non-threatening and invited students to take risks. Content vocabulary was modeled by peers and they were able to engage their hands in the creation of new knowledge. The lessons were well aligned with brain-based learning models (Lombardi, 2008) and met the needs of my diverse group of students. It was a fantastic start to our project on animal patterns.

The skill-building lab experiments were next. Set up as three simultaneous centers, these labs required a different kind of collaboration. Students did not work together to produce a group representation, but they did need to rely on one another for direction and help with the multi-step labs. The *Pattern Match* lab asked the children to examine a small black and white photo showing a magnified animal pattern and match it to a larger colour photo depicting the whole animal as shown in Figure 9.
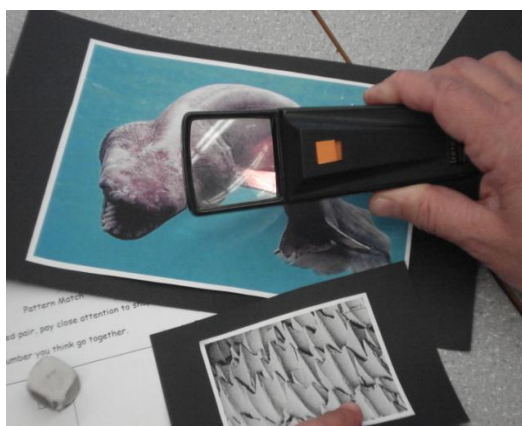

Figure 9. A student attempts to match photo samples.

Then, using the lab template (see Appendix G) and large magnifying glasses, they matched its source, re-created the pattern, and justified their hypothesis (see Appendix H). Sketching with supporting text, as opposed to just writing observations, lessened the anxiety for my ELLs and encouraged the use of different modes of expression. As Tarr (2003) advocates, "Experiences in visual expression are not add-ons or isolated activities but are a form of inquiry or way to investigate a theory, idea, or problem, a way of clarifying understanding, the communication of an idea" (p. 11). This was certainly the case in this lab.

The *Hunter or Prey* lab was the most teacher-directed experiment. Here, students were asked to determine whether an animal used its pattern for the purpose of hunting or hiding. The children had to examine several animal photographs and, by looking closely at the kind of pattern that was present, determine whether that animal was most typically a hunter or prey (see Appendix I for examples). This was a challenging lab, hence its teacher-directed nature, but it led to very intense conversations about the nature of the animal patterns! Many of the children used prior knowledge of the animal to make their decision, while others asked questions about environment, size, and eating habits. For some of my ELL students these animals were completely foreign. In this case we began looking at the photographs in search of context cues. In some photos the animal's habitat was well depicted and helpful. In other examples these students relied on their peers to help fill in the gaps. It was exciting to watch my ELLs use many strategies to try to decipher these photographs.

This small group dynamic was very interesting to watch. Students that are typically reluctant to share their ideas in the large group found their voice here. Furner et al. (2005) reason:

> Not only does cooperative learning restore a sense of comfort in a school setting where there are students with differing needs, it also offers students collective psychological support as they learn new content. ELL students gain models for language development. (p. 19)

Every student had an opportunity to ask and answer questions based on their background knowledge and natural curiosity. After each animal's role was debated, the students had to match its letter (photos were labelled A - L) to either HUNTER or PREY based on the group's conversation (see Appendix J for lab template).

Offering various technologies can help develop digital literacy but it is not enough to simply present the tools. McKenzie (1999) articulates "impressive student outcomes might result from an investment in networked information and communications, but only if the elders do their part" (p. 16). The third experiment, *Who Am I*, illustrated the way I believe technology can be used as a provocation. In this scenario, students needed to observe a partially obscured photograph on the SMART Board (see Appendix K for examples). Using the "shade" and "magic pen" functions within SMART Notebook software, students were required to view one of the partially covered images and highlight the exact spot that helped them identify what animal was being portrayed. Then they were asked to sketch the entire animal (without moving the shade) paying particular attention to the animal's natural habitat (see Appendix L for template and a student

sample). Did the animal fly? Was it a swimmer? A walker? Did it have two legs, four legs, hundreds of legs?

These three labs were multi-disciplinary. Within each, there were elements of science, math, art, literacy, technology, social skills development, group work, and assessment. Each one required students to observe, sketch, and reflect about their hypotheses. Various tools were introduced to further the learning opportunities and promote kinaesthetic investigation. Word banks, photographs, the SMART Board, and magnifying glasses were used to stimulate the imagination and hands of the students and help them pinpoint supporting evidence for their claims. These tools not only extended the curricular learning, they encouraged high-level thinking and offered the ELLs a way to explore a new concept in an engaging way.

Collaboration and the co-construction of knowledge were essential as these labs ran simultaneously in the classroom. Students turned to each other when they had questions about the task or the pattern they were viewing. They were excited by the topic, the tools, and their discoveries...their curiosities had been honoured.

When a teacher brings out a stack of empty CD cases, students at my school know the plasticene is coming out next! After completing the three skill-building labs the children were ready to show me what they had learned. I explained that their final "test" would be a plasticene rendering of any animal pattern they chose. Like any good architect or sculptor, they were required to develop both a blueprint and a list of materials required for their creation.

My students set to work, preparing for their final exam although there would be no late night cramming or reviewing of notes. Instead we put on some jazz music and

grabbed our sketch books happily re-creating our favourite pattern in big, bold colours. The atmosphere in the classroom was light and relaxed, something right out of *Hooray for Diffendoofer Day* (Prelutsky & Smith 1998). As the children started sketching I walked around taking pictures. My students were at ease with the thought of creating, extending, and then translating patterns (see Figure 10).

Figure 10. The work of translating patterns begins.

I had worried about the depth of their understanding but they were showing me I had nothing to fear. They had learned far more than I had taught them directly, they had learned from each other.

As the final products began to take shape (see Figure 11), I took more and more photographs, stopping to ask the students why they had chosen their pattern.

Figure 11. A plasticene rendering of lizard skin.

Some liked the idea that tigers were hunters and so they wanted to show how those stripes helped them blend in. Others were drawn to the photographs on our "What do YOU see?" board and re-created the textures found there. Regardless of the inspiration, these depictions were works of art (see Appendix M for more examples).

My journal entry for January 26, 2010:

I must admit that being a math-phobe has tempered the way I look at many approaches to the teaching of mathematical concepts. I never understood how math worked, beyond arbitrary algorithms, until I had to teach it. I am the kind of learner that has to make sense of a concept from many angles, often from the inside out. It was fascinating to see how much research has been done in this field as of late. Recent reform movements in the US have changed the face of education and, in doing so, have left an indelible mark on students. High-stakes testing has so adversely affected the teaching and learning that takes place within classrooms, it is shocking. I feel fortunate to teach within a system that values teachers, listens to students, and encourages the variety of ways students come to learning.

The resounding message I received from my literature review in this area was student engagement is key. Many students are fearful in their math classes, parents feel helpless as they watch their children struggle, and teachers lack confidence in their own mathematical competence. I found myself nodding along echoing concerns around the authenticity of mathematical tasks. If we are to help students, regardless of their heritage language, we need to understand what they already know. If we access students' prior knowledge, especially with our ELL

population, we will have a much better sense of where gaps exist. We can then make informed decisions about how to bridge the distance between existing knowledge and new material.

Having curricular outcomes and both content and language goals visible for students helps them attain the objectives. "Students can reach any target they know about and that holds still for them" (Stiggins, as quoted in Davies, 2000, p. 19). If we do not identify what it is we are looking for, we have no hope of helping students find it. I have found that rewriting the curriculum in kid-friendly language has helped tremendously. I have also rewritten the science curriculum in this way and have shared both documents with the members of my grade team. Although I do not set out language goals for my students for each lesson I do plan to make my expectations around mathematical language much more transparent. My students need to know how we use mathematical vocabulary. They need to hear how mathematicians speak and if they are to become successful mathematicians themselves.

Student engagement is a topic that appears again and again in the math-related literature I researched. When asked about their first memories involving math, many of my colleagues recounted horrifying moments of being ranked by test scores and yelled at for not following a static algorithm. They have a very clear and vivid set of memories...and this guides they ways in which they engage in mathematics as adults.

Entire libraries could be written on the effects of teacher efficacy and student engagement, particularly in math, but for the purpose of my project I want

to address the ways I tackle engagement with my group of very diverse six year olds. They are not simply blank slates that progress through predictable stages to become mini-adults. Children are the creators of culture, they are competent in living and learning (Tarr, 2003).

Looking back on how my students have engaged with our exploration I am very proud. Project-based learning is an exciting approach for ELLs in mathematics. When done well, it engages students, provides authentic learning opportunities, and makes the learning visible for all involved. My students have shown me the value in letting ideas develop through conversation and hands-on experiences. Artifacts, tools, performance tasks, and clear expectations invite students to take part, to be present in the learning. By providing intentional tasks that speak to the queries of my students I have uncovered what may be a universal language: engagement.

Step Seven: Collect Information

When I think about collecting information I think about documentation. In a traditional sense this may refer to the writing down of important details, the accounting portion of time well spent. In my school it looks markedly different. We use documentation to bring the thoughts and ideas of our students to light. It informs our practice and captures the nature of an investigation, providing an insider's view of the learning taking place within. "Documentation embodies the essence of getting closer to children's thinking; it helps teachers understand and support their learning processes as well as their attainment of knowledge" (Turner & Krechevsky, as quoted in Kroeger &

Cardy, 2006, p. 391). Documentation is not easy. In fact, it is something with which I continue to struggle but the results are so powerful that I continue to forge ahead.

I have some conventions that make the process of documentation easier for me to implement. First and foremost, I begin each year with an open and honest conversation with my students. I explain that I know they are all very cute children but when I bring out my camera I do not want photographs full of "CHEEZ!" Pictures are tools for learning and they will be a big part of how we share what we know both with each other and our parents. When I bring my camera out now my students do not even turn. They make sure I can see what they are doing, but they know not to change their focus.

Along with my camera I often have a clipboard. This board is equipped with labels, denoting each student's name, the date, and the primary focus of my notes. This system was taking directly out of Boyd-Batstone's (2004) article "Focused Anecdotal Records Assessment: A Tool for Standards-based, Authentic Assessment." This article provides a structure for the collection of anecdotal evidence and has enhanced my assessment practices tremendously. By selecting a focus *before* sitting down to observe, one narrows the scope of the assessment. Too often I have sat down only to take copious amount of notes that, in retrospect, told me very little about the actual learning that took place. In using these focused anecdotal records assessments I have found an efficient way to sharpen my focus and attend to the learning needs and discoveries of my students.

As mentioned previously, I have had the opportunity to work with a videographer and have learned the power in film firsthand. I have used film and video documentation to make learning visible for my students, colleagues, and parent population. If the process of documentation is successful, it brings educators closer to the minds of their students.

By using digital technology I have bridged the gap that often exists between home and school. Linguistic and cultural barriers exist, regardless of our best intentions. The honouring of student work in such a graphic way embodies a spirit of collaboration and mutual respect. That is a positive thing in any language.

Early on in my documentation journey I found myself torn between living in the moment and stopping to document it. I had yet to develop a workable system and missed many teachable moments. In the case of an unexpected discovery, or an unpredictable reaction to an activity, I found myself woefully unprepared to document. Then a wise colleague explained the fine art of re-creation to me. If students capture the essence of something so exciting, so undeniable, I am not above asking them to re-create it once I have my camera in hand. If the purpose of documentation is to make learning visible then snapping the picture on the second attempt still does the trick!

For the purpose of this project I had my camera at the ready every moment of the day. In fact, I now leave it sitting on the edge of my teaching table and if my educational assistant, a guest, or a student notices something they want to preserve they grab the camera. Being prepared in this way has helped me understand my students more deeply. An ELL may not contribute to a group discussion or be able to clearly articulate their learning verbally but there is no denying a photograph that captures them using scientific reasoning, sharing a unique solution in math, or expressing a new concept through the arts. Documentation provides students with an opportunity to revisit and reflect on their work and it shows that their ideas and efforts are valued.

I have used photographs and appendices throughout this paper to provide a tangible example of documentation at work. As an educator I want to exemplify the

changes I wish to see in the field, therefore I must be willing to share how it can be done. Writing this paper has helped me make my own learning visible. As I sift through my extensive collection of classroom photographs I find myself drawn to certain images. Some provide a clear example of the concept we were exploring and others depict a moment that changed the course of our path. Yet, there are a few photographs that have had a profound impact on me. To an outsider, they may not tell the story but, to me, they are the story. It is these images I will hold dear as they whisper quietly...telling me I am on the right path.

The traditional documentation panels seen in many Reggio-inspired settings seem somewhat pretentious to me. They serve a purpose to be sure, but in my school context they do not communicate effectively with parents. After I had my system for the collection of evidence under control I knew it was time to tackle the way I represented information.

As I began collecting raw data I continued to share my thoughts with my partners. We looked at the collaborative drawings and discussed how the children had gone beyond my expectations. We were all amazed at how much detail the groups had offered! My one partner thought she could use a similar provocation with her class' exploration of patterns in mosaic tile. She made note of the group work expectations I had outlined and started planning her next performance task. One of my other colleagues saw what we were doing as a springboard for the work she would be doing in my classroom in the coming weeks. She would be joining our class after Spring Break and was excited at the groundwork we had laid.

When we started to conduct the lab experiments these two partners were diligent in asking how things were going. It was a relief to have people with whom I could share some of the details of our work. After the first day of the labs I was not entirely happy with the level of independence my students had shown, especially considering the technology issues we had experienced. Hearing that, our learning leader offered to stop by during our next session just to help out. It turned out to be a life-saving offer! The SMART Board tools were acting unpredictably and she was able to stay and work with that group for the entire block.

After we finished each lab I collected student notebooks to analyze their write-ups. I found that many of my budding scientists had gone beyond my expectations. Some had paid such attention to detail in their sketches that there was no question they knew not only what animal they had seen but where it lived and how its pattern manifested. I found that many of the children had not completed the written component. I knew some students ran out of time but others were reluctant to share their ideas through the written word. To ease the stress surrounding the writing expectations I began subsequent lab session with a key word brainstorm.

I asked the children what words they thought they might need and drafted a list on the whiteboard. Throughout the lab students would ask for words to be added to the list. This was an easy accommodation to make as most students were so much more at ease having the writing support in place that taking two seconds away from my group did not cause issues at all. Word banks became a lifeline for many of my reluctant writers (Furner et al., 2005). In fact, they were so successful students began asking for them in all subjects! This project was starting to affect much more than my math lessons.

My journal entry for February 5, 2010:

I have always been a big believer in cross-curricular teaching. As an elementary generalist I am unsure how one can teach every outcome in every subject without doing this! The interesting thing about what is happening in my classroom right now is the students are seeing these connections without guidance or prompting. I knew multi-disciplinary teaching was good practice but my students are showing me it is how they prefer to learn.

Word banks are simply the start of what many people in our building call "cross-pollination." This blending of ideas and sharing of expertise has changed the way I plan with students. Initially I had wanted to explore international systems of number. When I was struggling with the development of authentic learning opportunities I was frustrated. Why could I not get my head around this? I started to stress, my whole project was riding on this work. That was when I realized that the idea did not align with the needs of my students. They weren't interested in counting and representing numbers just yet, it was too abstract for them this early in the year. I needed something more concrete, something they could get a handle on before introducing the symbolic. In my rational mind this makes perfect sense. I know that developmentally speaking the best teaching begins concretely, progresses through the pictorial and then on to abstraction.

What seemed like my students' disengagement was not actually a reflection of their disinterest in the topic, they were showing me they weren't quite ready. Thank goodness one of my partners pointed that out before I went too far down a path that would be wrought with missteps and anguish.

Step Eight: Analyze

To be completely honest, it was daunting to prepare for this section. I had a recurring fear that during the analysis stage I would find out that my students had not learned a thing! What if, after all this work and preparation, my students walked away with a vague concept of pattern coupled with a lacklustre sense of the power of mathematics? What if I had not collected enough evidence? What if what I did collect ran contrary to what I was trying to prove? I decided to start at the beginning and examine the interview data I gathered before the actual study commenced.

Interviews can be an effective way to glean information from students but they are very time-consuming. To streamline this process I develop the questions, rubric, or checklist *with* my students. This has helped prepare the children for our conversation and it helps us stay on track. It is similar to the pedagogy behind focused anecdotal records. Having a focus before sitting down helps narrow the scope of the discussion, keeping you to topics or queries that directly reflect what you are trying to uncover. In this way, interviews provide students with an opportunity to share and reflect on their learning. This, in turn, guides my teaching and informs my practice.

For this project I developed a simple pre-study questionnaire (see Appendix B). Initially, I wanted to determine how my students saw themselves as learners and how they felt about studying mathematics. After sitting with each of my five participants I was unsure if my questions uncovered anything of value. When I looked a little more closely I realized some of the information I wanted could be found not in the words the children offered but in their absence. For example when I asked "What is math?" only one student

said numbers! The other participants saw math as drawing, addition, subtraction, and building...but not as numbers.

All five students explained they were excited while doing math and one shared that even if a concept was difficult it made her happy because she was learning something new. This was valuable because it spoke to the nature of my students, they were not afraid to take risks.

When we discussed learning style preferences four of the five students would choose to build a new concept while the fifth child found it easier to hear about a new idea first. This was congruent with what I knew about teaching ELLs and teaching young children, the majority need to make sense of a new concept kinaesthetically first.

For me, making curriculum accessible means showing its relevance through real-world application. When I asked the students where we use math, each cheerfully answered "at school!" After a little bit of prompting two of the children thought they probably used math at home and one child explained that he used it when he was counting minutes with his parents. This part of our interview was particularly inspiring. My commitment to showing how math can be used in a variety of contexts for a variety of reasons was not unfounded. These students did not see the connection between many of their daily interactions and the math behind them...at least not yet.

In the end, my survey uncovered more about student self-efficacy and learning styles than the level of mathematics knowledge my students had but in a way I was grateful for that. New concepts, regardless of curricular area, need to be experienced through the senses when you are six. If students come to school with the knowledge that their classroom is a place where they can experience concepts firsthand and safely take

risks among their peers then they will come ready to try anything. This is particularly important for ELL students. I knew my students were ready for the work that lay ahead when I asked them the final question, "Are you a mathematician?" and, with a twinkle in their eye and a big smile, each answered with a resounding "YES!"

After our collaborative pattern extension sketches I asked the students to share their work with the whole class. They came together and explained who their animal was and what had helped them identify it. I was surprised at how thoroughly each group discussed their drawing. They had paid close attention to details such as shape and size but they had also started to question the function of the pattern. For example, the shark skin group debated and debated about the purpose for the diamond shape scales. Some thought the reasoning was strictly aesthetic, reasoning, "Well, it looks nice that way." In the end, the one student who was convinced it was a shark explained that the pattern had everything to do with the animal's habitat. He verbalized a connection between the way the scales overlapped and the way it moved about in the water. To him the pattern had a function and looking pretty was not it.

During the group sharing exercise many of my ELLs were quiet. A few shared a detail or two but many sat back to watch and listen to their peers. A year or so ago I would have encouraged these students to be more actively involved but preparing the literature review for this project has opened my eyes to the value in letting ELLs absorb information from their peers. I have been careful not to mistake passive listening with disengagement. ELL students need time and exposure to concepts such as verbalizing learning before they are able to do it independently. It is liberating to watch these

students observe their classmates knowing they are gleaning more from the conversation than relief from not being in the hot seat.

Analyzing student work can be difficult, especially if clear expectations have not been laid out beforehand. When I looked at the completed labs after the initial round I knew I had to scaffold the written component with key word banks. This assessment is formative; it can be used to guide practice and instructional strategies rather than focus on a student's ability to achieve outcomes. Coupled with observations of the process and conversations with students, product-based formative assessment provides a more complete picture of student learning (Davies, 2000).

In analyzing the labs of my five ELL students I made some interesting discoveries. First I was amazed at the level of detail in their *Pattern Match* sketches. Each student spent a great deal of time carefully observing and depicting the pattern's shape, size, and proportion. Their illustrations showed careful consideration of the animal's identity, habitat, and physical appearance. Both sketches, the magnified and the life-size, show a certain level of fascination for the animal. The students approached this lab excited by the possibility of using new tools (magnifying glasses) and ready for the challenge of matching the samples. As I watched from my own group of scientists I could feel their sense of wonder as they poured over the photographs, comparing and sharing their ideas with one another. To an outside observer it may have seemed like a typical science lab but to me it showcased the collaborative and respectful nature of my students.

The written component of the *Hunter vs. Prey* lab offered little information, but as the lead scientist at the table I learned a great deal about the levels of prior knowledge my students had. Upon viewing the photograph of the hyena (see Figure 12), many of my

students were unsure about what they were seeing. Some thought it was a kind of wolf, others were certain it was a dog, but they were all equally perplexed by its stripes. They knew that tigers and zebras had stripes to blend in with the tall grasses, but why would a dog have to blend into the grass? Was it a hunter or was it prey?

Figure 12. Striped hyena -- hunter or prey?

Each photograph brought debate, not so much about who we were seeing but about the role it played. Surely the octopus (see Figure 13) was prey, wasn't it?

Figure 13. Indonesian mimic octopus -- hunter or prey?

My students are used to me referring to them as my teachers. They understand that I am as much a learner as they are and that, regardless of formal designation, we are all teachers in our classroom. During this lab I found myself questioning my

preparedness. I had planned to help my students understand that an animal's pattern can help determine its role in nature. I had been very intentional about the photographs I had chosen but once my students started questioning and challenging each other my level of confidence in achieving the goal of the lab waned. How could I not have seen the dichotomy? Every animal is a hunter and, to some extent, the animals I had chosen were also prey. I was fixated on the obvious choice rather than look at the pictures with fresh eyes. If I knew nothing of these animals would I really be able to tell if it was better known as a hunter or prey simply by looking at it? The answer is an unfaltering no.

Who Am I was my favourite lab to develop. Utilizing the SMART Board is always exciting but it brings with it the challenges inherent in using technology. When everything works it is vivid and engaging but when things do not it can be difficult to solve the issues and get things back underway without losing the attention of your audience! Technical issues aside, this lab brought about a new challenge, determining how an animal moves within its habitat (see Figure 14). I wanted the children to make connections between pattern and environment. Are patterns only a function of camouflage and mimicry or can they be aesthetic too?

Figure 14. Who Am I on the SMART Board.

This lab was designed to challenge the idea that one can determine an animal's habitat by the patterns on its skin. Stripes on a tiger and spots on a jaguar make sense, the patterns cast by grass and trees help to camouflage these great hunters but what are the squares on a seahorse for? What about the stripes and spots on a cuttlefish? The cuttlefish was a conundrum for many of my students. As soon as they saw the bold black and white stripes they were convinced it was a zebra, until one student whispered "yes, but a zebra doesn't have spots...." There was a moment of absolute silence as my scientists pondered this dilemma. It was true that a zebra did not have spots but if this animal was not a zebra then what was it? To be honest it was a delicious moment!

The labs were multi-faceted and, in being so, offered diverse perspectives on the learning that took place. In terms of the written component I gleaned the most information from the *Pattern Match* lab. The graphic nature of the students' sketches and the ways they represented associated habitat were very clear expressed. In the *Hunter vs. Prey* activity it was listening to my students question and challenge one another that provided the most succinct examples of learning. For *Who Am I?* I learned the most by watching my students interact with the technology. They were very intentional when they used the Magic Pen function to highlight certain aspects of the photograph. After the first few seconds of novelty in using the new tools they settled down to the task at hand: determining what animal was hiding beneath that partially obscured pattern. The focus of these labs was to build skills in sketching and observation. However, I learned a lot about how my students approach new concepts, how they request scaffolding, and how they best represent new knowledge. Student sketching and observation did improve but so did my ability to analyze the specific learning needs of my ELL students.

Assessing art, and sculpture in particular, is a difficult task for me. As an elementary generalist responsible for teaching all academic areas of the curriculum I have developed tools for assessment. Portfolios, rubrics, and interviews seem too impersonal when I am looking at a piece of student artwork. I struggle with assessing a person's ability to share their view or tell their story through painting, dance, and sculpture. When I first came to my current school I knew assessing the fine arts would be a long journey for me!

What has helped me refine my assessment practices in the arts is the notion of criterion-based referencing. Students need to be involved in developing the criteria for their artistic expression. Gregory, Cameron, and Davies (1997) establish a succinct and ready-to-use sequence for developing criteria with students. Within its pages there are many examples of how one can introduce and organize criteria and subsequently link it to effective assessment practices. For this project our setting of criteria was much more informal. As a class, we discussed the parameters of an effective plasticene depiction and students went to work. In retrospect, I would make this a more formal process, posting the criteria and offering student examples as supporting evidence. My ELL students would have benefitted greatly from this additional step. It would have provided them with examples of excellence, subsequently enhancing their understanding of the expectations.

Reflecting back on the plasticene patterns I can offer some general observations for the purpose of analysis. In terms of process, my students were well planned. Before they could begin using the plasticene they had to sketch out their ideas and share them with me first. The reason for this is two-fold. I wanted the children to be able to verbalize not only who they were representing but also what the pattern was. Many times the

artistic rendition is not always obvious to the audience; I wanted to be sure that in their own minds these children could articulate the intention behind their work.

As the children re-created their patterns I walked around the room taking pictures, asking questions, and offering suggestions. I noticed how content my students were. Using their hands provided a sense of calm for them. They needed to work through their steps physically before they would be ready to talk about what lay on the paper. This is directly in line with effective teaching practices aimed at ELLs (see DeJong, 1999; Furner et al., 2005; O'Donnell, 2009). Yet, in this moment it resonated very deeply with me. "Build first, ask for descriptions and clarification second" may be my new mantra. I stepped back and just watched this group of engaged, intentional artists. It was here I gave myself permission to put down my camera and enjoy the moment. My initial goal of making patterns accessible had been realized. What I did not expect was the ability for my students to take that concept and go far beyond the expectations set out for grade one students. They understood not only how patterns were created but also the roles they often played outside the walls of our classroom.

The last component I would like to analyze is the debrief assessment I conducted with my five ELLs (see Appendix N). This was done after the final performance task and was much more focused on patterns than my pre-study survey was. In this interview I asked my ELL students to verbalize their understanding of some of the concepts we had been exploring.

For the first question "What is a pattern?" I have a range of responses. Two students offered colour patterns (i.e., orange-brown-orange-brown). Another child used actions to show her understanding of patterns (i.e., pat-clap-snap-pat-clap-snap). This

affirmed the importance of offering students choice for me. Some of my ELLs were making sense of patterns at the concrete level using actions to show understanding. Others were stepping into the pictorial representations by sharing colour patterns. The visual nature of these patterns related directly to our work with the plasticene, offering the children a graphic memory of patterns.

The second question was very telling. "Where can you find patterns?" was an attempt at assessing the student's ability to see patterns beyond the basic understanding outlined in the Program of Studies. One student shared that she found patterns in many places in the classroom (i.e., math tubs, cards, felt pens). It is interesting to note that in this case she referred to many of the manipulatives we had used to create patterns in the very beginning of the year. She saw patterns as things yet to be built, defined by material choices, rather than something that already existed in the world. Two other students excitedly answered "In animals!" as they smiled and pointed to either their plasticene or our "What do YOU see?" board.

A fourth student found patterns on the playground, recalling the colour of some of the equipment. This was an exciting revelation because on his pre-study survey this student saw math at home and school but not outside. He had started to see math taking place in the other parts of his world! At first, the fifth student just smiled when I asked her this question. She almost rolled her eyes as she giggled "Patterns are EVERYWHERE!! They are in people, outside on the playground, in animals like a giraffe." Patterns were definitely accessible to her!

I asked each of the give students to draw a pattern using any shapes or objects they wanted. Looking at their responses, I'm not sure I could have asked for a more

varied sampling! Two students drew a variation of animal spots. One drew a full leopard complete with spotted tail and the other focused on the concentric rings of the blue-ringed octopus. Another student sketched concentric boxes. It is important to note that this particular student was fascinated by the spiral pattern within a nautilus shell. He saw patterns in a non-linear way, something that did in fact repeat but not necessarily in a straight line.

Another student shared 1-2-1-2-1-2 as her pattern of choice. She knew patterns repeated and stayed very linear and concrete with her representation. The last student represented an ABC pattern using three shapes (circle-triangle-square). She is the only child whose pattern had three attributes and she was the only one who could translate the shapes into letter names as recommended by the curriculum. Her understanding of patterns has gone beyond the concrete and well in to the pictorial. She was comfortable creating, extending, and translating patterns without support.

As a group, these children have shown growth in terms of their understanding of patterns and their application. Although the levels of progress and understanding differ, as they do with all students in all subjects, all of these children improved their ability to verbalize their learning. ELL students need opportunities to practice concepts kinaesthetically, discuss their process with peers and then verbalize their learning in a more formal way (Anhalt et al., 2009). By offering a provocation to pique student interest, planning skill-building tasks that promote collaboration and conversation, and using art as a vehicle for the final performance task, these students were able to develop a deep understanding of pattern. Graphic organizers, key word banks, and sketching enhanced the process and helped these ELL students connect to the material on more than

one level. Introducing new technology and tools throughout the study was exciting for both students and teacher! If I am asking students to trust me enough to struggle through challenging concepts I need to take risks in my approach and application of pedagogy.

My journal entry for February 18, 2010:

After all the research and writing, planning and preparing, I learned the most from simply watching my students. In analyzing the process and products detailed in this study I have learned to trust my gut and provide experiences over activities and offer my students as much choice as possible. If given the opportunity, and the right tools, students will show you not only what they know but why that is important in their life. By stepping back and becoming more of a facilitator in learning I am not disengaging, I am asking my students to step forward and become the primary focus in their own learning journey. Curricular outcomes, standardized testing, and learning task expectations will shift and change but they will seem less daunting when the commitment to honouring the voices of students remains at the forefront of all teachers do.

Step Nine: Assess Achievements

Thorough analysis of this project has provided me with perspective and reduced my anxiety around the depth and breadth of the learning that took place. Although my fear has waned my need to look ahead, to be proactive has not. Researching best practice and sitting with colleagues to discuss my questions and curiosities has been therapeutic. It has shown me that by asking others for their input, and in turn being vulnerable to the critical eye, I have become a more effective teacher. I am no longer reluctant to think aloud about my students and my current partners are a big reason for this. They have

shown me the courage in asking for help and in working through the planning, assessment, and celebration process with others.

My students have certainly learned throughout this process but they have taught me more than I have offered them to be sure. They exemplify strength and resiliency each day they come to school. These children have seen much of what humanity has to offer, well beyond the headlines on the local news, and they come to school each day with a smile and a sense of gratitude worthy of admiration. They are naturally curious and unafraid to try something new. They see challenge through the eyes of an adventurer.

In terms of evidence-based practice, I see growth in all areas. My team has opened itself up to conversations about good pedagogy for our ELL population and we have started to examine the ways we can incorporate project-based learning into our mathematics programs. We have fused what we know about planning for inquiry with the hallmarks of effective documentation and the Understanding by Design model (Wiggins & McTighe, 2005). We are a cohesive group that is committed to helping our students and each other experience learning at its most prolific.

In my students I have seen an enhanced sense of community. Opportunities for collaboration are endless in my classroom but there are times when some students, particularly my ELLs, need that collaboration to be product-driven and modeled in a way that clearly illustrates the expectations. When students focus on a common goal they speak the same language. Bengali, Punjabi, and Spanish are no longer a consideration when the task requires one to communicate through sketching or sculpture.

In encouraging the use of non-verbal languages I have directly influenced my students' abilities to express their learning verbally. Working through tasks physically

first provides students with experiences on which to build understanding. Initially they may not be able to put words to the process of classification, but ask them to sort out a basket of buttons and understanding will be proven.

Tarr (2003) warns teachers about the limitations imposed by overly rigid thinking in regards to developmental appropriateness. It is true that one must pay attention to the readiness of one's students but it is restricting to think solely in terms of developmental stages when planning for project-based learning. Often students will ask questions and make discoveries far beyond the expectations outlined in the task. As O'Donnell (2009) suggests, showing high expectations and a willingness to empower students beyond the scope of their understanding will improve learning and encourage deeper exploration of concepts, even if they appear to be beyond the scope of current understanding.

By opening my mind to the interests of my students I was able to engage their hands, minds, and imaginations. Their levels of understanding are varied but every student experienced pattern from the concrete to the abstract. They have made connections beyond what I could have predicted and have extended their understanding beyond both the designated curriculum and the scope of our classroom. My ELL students were offered many opportunities to collaborate with peers and they heard effective communication modeled on many levels. Language and content-specific goals were achieved and exceeded. Students were able to express their learning through a variety of modes and, once completed, were able to share their thought process with the class.

As a teacher-researcher I have learned so much from this process. First and foremost many components of my teaching philosophy were affirmed. I knew that manipulatives were an excellent entry point for new mathematical concepts but now I can

give voice to why that is (see Borasi, 1994; Garrison & Mora, 1999; Van De Walle & Lovin, 2006). I have always respected, even craved, collaboration with colleagues and now I understand why that is so important to the profession. Being an island is lonely! Working in isolation is not in the best interest of students, teachers, or administrators. It is an act of courage to open oneself up to the critical eyes of colleagues but if student learning is at the center of the inquiry the leap is less intimidating.

I have always known that ELLs need support to build their capacity in English but I was never quite sure of how to do that without obvious differentiation. I work very hard at creating community in my classroom and labelling or pigeonholing students works in stark contrast to this aim. The strategies outlined in this project are beneficial for every student regardless of their level of language proficiency.

I have learned to be more intentional about my planning process, asking myself if the voices of my students are clearly represented within the tasks. Each time I set about planning for a concept I will use a provocation to capture the attention of my students, ensuring emotional investment in the investigation right from the start. I will introduce new tools in the skill-building phase and offer multiple opportunities for students to investigate their queries as the process unfolds. Final performance tasks will guide the preparation for the initial two components. Outlining enduring understandings and essential questions prior to an exploration helps me focus on what is really important for students. Assessment will be ongoing and authentic, involving students wherever possible. Celebration and the honouring of student work will remain important elements throughout the journey. Students and their efforts will be valued from start to finish.

An area of focus for my teaching will be on making assessment expectations even more transparent. When assessing the labs and the plasticene patterns I felt ill-equipped. Tools and strategies I had used in the past did not seem to fit in with these expressions of learning. Interviews are helpful and very informative but not always possible under time constraints. I need to develop a greater repertoire of assessment strategies with my students to ensure the target remains still for them. Alignment of curricular outcomes, assessment, and products is essential for a well-rounded perspective of student achievement. I will work on improving my ability to develop well-aligned and thorough explorations.

My journal entry for March 2, 2010:

This project has opened my eyes to the power of learning alongside my students. It is a relief not to be the sage on the stage. I would rather facilitate learning through the eyes and minds of my students. One measure of success is my ability to take risks in my teaching and offer my students a varied and exciting experience in school. Curriculum outcomes are always a consideration, but to promote lifelong learning and a passion for challenge I need to exemplify that firsthand. I recall once reading Gandhi's words of wisdom about being the change you wish to see in the world if I wish to make a lasting difference.

Step Ten: Publish

In the process of gaining informed consent for my five participants I outlined possible future applications of this work. I plan to bring my analysis and conclusion to my team in hopes that they can share their thoughts and feedback with me about the process. This may act as a springboard for future conversations and it may provide a basis

for professional development in the coming months. In sharing this work with my colleagues I hope to affirm the quality of the work in which we have been engaged as a team. Teaching philosophy is so personal and working within a cohesive team can cause one to question their path at times. This project has provided me with the perspective I needed to understand my own work. I can offer research to undergird my suppositions, I can share the insight I have gained from analyzing student work and I can provide a critical, non-judgemental eye for those working through their own inquiries. In a sense, this project will help build the capacity for action research within my team. Illustrating its benefits firsthand is the best way to encourage similar behaviour. I have talked the talk...now I can show I have walked the walk.

One of the ways that this research has indirectly affected my team is in our application for the *Open Minds* school program this fall. This program offers grant funding and off-campus locations as a way to encourage intense field-study with students. Our administration approached the team about putting together a proposal for this cutting edge program. We were excited about the prospect but found it challenging to present our ideas in a way that reflected the depth of thought and innovation we were experiencing. Having conducted so much research and written about the effects of hands-on learning, for ELL students in particular, I was able to help frame our proposal in a way that showcased our dedication to effective teaching practices. We have applied to exemplify a new way of thinking and preparing for field study. Using a Reggio inspired planning template and a strong commitment to kinaesthetic, scaffolded learning experiences our team has pioneered a new way to approach off-campus activities. I would not have had the ability to articulate our team's vision had I not experienced the process

of action research firsthand. Being reflective is only a part of the journey, being committed to change and future innovation is quite another.

It is imperative that teacher's have a strong voice guiding the direction of their professional development. It is my opinion that in the absence of this voice, professional learning becomes misguided and disconnected from the school setting. For the past two years, my school has focused on developing a strong understanding of the inquiry process using the fundamentals of the Reggio Emilia Approach as an entry point. There have been times when this focus has been detached from classroom practice and, in that case, has become an add-on for teachers. To combat this disconnect I would be willing to provide professional development for my colleagues, showing how an action research paradigm draws together the best qualities of inquiry-based teaching and the principles of the Reggio Approach. By illustrating a more eclectic perspective I can encourage teachers to select the elements that work for their context. Following one method or framework is limiting as it restricts the parameters of influence, but offering a blended approach respects the needs and desires of individual teachers.

Another way I would like to share the impact of my efforts is by providing professional development leadership at the provincial level. The Alberta Teachers' Association (ATA) has many specialist councils. I am a member of MCATA – the Mathematics Council for the ATA. This council hosts a provincial conference every year and there has recently been a call for presenters. I will submit an application to present at this conference in October in hopes that my experience will persuade other teachers to extend their learning and take risks in their classroom.

The two other groups with whom I would like to share my new insight are my students and their families. I have been talking with my students throughout the process, laughing when something surprised me and sharing my mistakes. Our learning journey is only marginally revealed in these pages. As the end of the formal part of this process draws near I know I must share what I have learned more formally with my students.

Class meetings are a way of life in our classroom. Whenever a problem arises or something exciting is imminent we meet in a circle to share the news. Upon completing this paper I plan to share my concluding thoughts with my students. I will show them the pictures I have used and explain how their work transformed my understanding. I will celebrate their contributions as a class and then I will invite their families to join in the fun. More on that in Step Eleven: Celebrate.

Last but not least, I would like to consider the possibility of publishing my work. Peer-reviewed journals and professional resources are a great source of information in our profession. I would like to think that my circle of influence has been extended as this project draws to a close as I am able to share, firsthand, the benefits and drawbacks to research within the classroom. I have learned so much about the process of action research that it would be invigorating to share this knowledge on a grander scale.

My journal entry for March 30, 2010:

Well it is almost done. I cannot believe I am finally wrapping up my writing! This process has been restorative in many ways. The vast amount of reading and writing, talking and learning, sharing and observing...it has been deliciously exhausting.

I plan and prepare for my week like many teachers. I look at our literacy and math blocks and see how I can develop skills in these areas. I plan Science and Social Studies with my partner teachers, incorporating group work and projects among the curricular outcomes but there is just something to be said about dissecting an intentional exploration step-by-step. I have learned more about my methods of observation and my ability to analyze student learning in the past few months than I have in the past five years!

My gut instincts about teaching ELLs are on the right track but they could use some tweaking. I employ some of the strategies supported by brain-based learning, (Lombardi, 2008), and I have worked hard at understanding and implementing Krashen's theory of comprehensible input, or i+1 (as cited in Garrison & Mora, 1999). As a linguistics major, I spent a great deal of time learning about language acquisition during my undergrad degree. The difference for me now is that I am learning with how to apply the fundamentals of language acquisition in a content-based teaching context.

Step Eleven: Celebrate

This journey has held many revelations for me. I feel as though I know my students and colleagues more deeply than ever before. By putting myself out there I have learned more about my own teaching philosophy and how it influences the kind of work I do. Having to verbalize my thought process has been eye-opening; this is something I expect of my students yet it is not something I find easy myself. I always say that much of my teaching seems to just come naturally to me...but is that really a cop-out? Being intentional is not just about being prepared, it is about being open to what develops.

As a class, we have started making preparations for a math-focused parent evening. The idea of sharing the results of this work with the families in my class is very exciting. When I asked my students what math-related learning they wanted to share they came up with a very extensive list! Some children were convinced that parents should see their final products. They want to share our *I Spy* book, our abacuses, and all the stages of our patterns exploration.

Other are more focused on showing the processes they have experienced. They want to share their math journals, their labs, and various manipulatives. These explorations will offer parents an insider's view of what it feels like to be a mathematician in our classroom. In our theatre space there will also be a film showcasing our journey this year. Similar to the film we produce as a complement to the report card, this film will share photos and video of this project (see Appendix O). The children will help me select the images and develop the flow and text for each section. By building this presentation together they will further understand how learning can be made visible and how their choices help mould the story shared with their families. In keeping with my promise to honour their voices they will have full power of veto for any component. The process will be transparent and very student driven.

Our parent population is accustomed to being actively involved in the sharing and celebration of their child's work. They are welcomed into the building several times throughout the year to view the world through their eyes. These moments can be magical, so in the spirit of documentation I have several colleagues filming and photographing the evening. FOIP considerations are always at the forefront of my mind so proper protocol will be followed throughout the evening.

The last official component in the celebration step of this project will be sharing this final paper. I have offered a copy of it to each of the five families involved in the study and will leave a copy with my administration as well. I plan to share the analysis and concluding thoughts sections with my team in hopes that it can inform decisions we make as we look towards the coming year. The process of applying for a field study and the way we want to incorporate our support teacher are all important factors in determining the way our year unfolds as a team. With a more extensive understanding about the effects of project-based learning in mathematics, and a heightened sensibility about the ways in which ELLs are most successful, our team could strengthen its collaborative skills and enhance the program we offer to young students in our building. It has been an exciting journey and I can think of no one else I with whom I would rather share it.

My journal entry for April 9, 2010:

Offering my work to parents, administration, and colleagues is both exciting and intimidating. I want this project to reflect intention, care, and respect for student learning. I want to ensure I have represented the stories of my classroom in a way that sparks conversation and intrigue. Most of all I want to be true to my own learning and the process through which I came to these conclusions. My last section: *Concluding Thoughts* will be where I can express all my new learning and share all my freshly acquired insights in a succinct and concise way. It will behave like the teaser on the back cover of a novel. Read the blurb and decide if this piece of writing has something of value to offer!

ELL students need our time but, more than that, they need our understanding. These students come to school in Canada surrounded by the unknown. They face language barriers and cultural separation. They are removed from family and friends and the safety of knowing what awaits them most days. Many do not know the language, the culture or the customs that make Canada such an amazing place to live. Some students have very little experience in formalized school settings and those that do often have negative associations with school and educators.

Helping create environments where these students can overcome their trepidation and be efficacious learners is imperative for their success as both students and citizens. We cannot possibly teach these children to read and write if we have not addressed their needs for safety and belonging first (Maslow, 1954). If, at the end of the school year, my students feel that school is a safe place and they are excited to see what lies ahead then I consider our time together successful.

To me, reading and writing are very personal. People will learn to do these things as they are ready, not before. I have sat with many parents assuring them that their child is on the verge of reading and is just about ready to make the leap. Often, it is mere weeks after the conversation that these children take that first step and sees themselves as readers. As an educator, I value listening to my students above all else. In doing so, I am able to provide the opportunities they need to take those steps when they are ready. This often entails watching, waiting, gently encouraging, and celebrating. There is nothing better than the moment a

child sees him or herself as a reader, an author, a mathematician. It is truly awe-inspiring.

Concluding Thoughts

Throughout this process I have read, questioned, and grappled with issues that are dear to my heart. Although the answers I found were not exactly simple or straightforward, they have been enlightening. A very highly respected colleague once said to me "good teaching is good teaching ELL or not" and I believe in his words unequivocally. As this paper draws to a close, I feel it would be judicious to share the most significant of these insights now. If there is one thing I have learned in working with young children it is everything is more exciting with a countdown! Below is a list of the top ten things I have learned about project-based mathematics in an ELL context.

10. Use realia/authentic materials

There is something magical about the buzz of excitement young children exude when something wholeheartedly captures their attention. The sound is unmistakable as they touch, examine, and inspect, making connections with the object long before you have even been given a chance to speak. Using realia and authentic materials engages students from the very first moment. These provocations, or thought provoking experiences, help ELLs create context for the concept they are about to explore. If ELLs have a sense of how the object or artifact relates to an idea they can begin to understand its role and function within it. Context is an essential component in making meaning for all students but it is particularly important for ELL students.

I have found that combining authentic materials and student interest make for a compelling start to any new investigation. Students use their hands, eyes, and imagination to decipher an object's purpose, often making and sharing cultural connections along the way. For example, when we began looking at animal patterns many of my students were

fascinated with a tiger's stripes. Many of these children come from India, where tigers are a very important and revered animal. They wanted to understand why a tiger's stripes were so important and how they were different from a zebra's.

Realia offers teachers an active and meaningful way to enter into investigations with students. By incorporating authentic materials and student interest, teachers will have an excellent base from which to develop project-based learning opportunities deeply rooted in real-world application. This level of intention helps lead ELLs through challenging and sometimes abstract concepts with a greater sense of meaning and connection.

9. Consider linguistic load

Krashen's model of comprehensible input has guided much of my work with ELL students (as cited in Garrison & Mora, 2008). Teaching one level beyond their current understanding helps stretch an ELL's linguistic and content-specific proficiency. There are many ways to go about this and just as many supports to offer (more on that in a bit) but the one thing I have taken from this study is the idea of setting both content and language goals for each lesson.

Vocabulary development is a very important language objective. If ELLs are to thoroughly understand a concept they need a working understanding of the key words used in its application. I now use key word banks to make content specific vocabulary explicit for my ELL students. I model how these words are used and offer my students the opportunity to repeat and practice using them both with assistance and independently.

Bresser et al. (2009) offer many valid suggestions, such as sentence frames, for practicing vocabulary and grammatical structures specifically in mathematics. Language

specific constructs have helped me enhance the conceptual understanding my ELLs have

in many of the content areas of the curriculum. Linguistic load is a primary concern and,

by planning with this awareness, my students benefit from learning opportunities that

address language and content-specific proficiency.

8. Engage in cross-curricular learning opportunities

Project-based learning offers many exciting alternatives to the more traditional

approaches to teaching and learning. In essence, PBL encourages teachers to step away

from a regimented schedule where subjects are slotted into 30-45 minute increments and

opens learning up to more extensive, cross-curricular investigations. My initial focus for

this project was math-based but once I listened to my students I knew we were going to

be uncovering science, language, and technology curriculum. I was excited to see my

students engage in such diverse learning!

At the beginning of the year, I develop an outline for the year. These plans are not

strictly adhered to and are in fact a living document. As my students express interest in

topics and ideas I go back to my outline and see where we can make connections. In this

way my curricular content is easily accessible and becomes a springboard to further

student understanding. I am not one to sit down with outcomes and check them off as

each are achieved. I prefer to work more organically with students, helping their ideas fit

into the curriculum, not the other way around. Cross-curricular projects are an effective

way to bridge the distance this sometimes creates.

7. Intentional assessment

Formative assessment and the triangulation of data have transformed my teaching

practice (Gregory et al., 1997). When I plan, I use assessment tasks as a way of ensuring

my curricular objectives and performance tasks are aligned. I offer students a variety of ways to share their knowledge and I encourage them to explore many ways of expressing new learning. When collecting this evidence I am cognizant that I need to do so in more than one way. Products and observation are two of the three components of triangulation, conversation is the third.

One of the things I struggled with in this study was my assessment strategies for arts-based projects. I thought I had a decent repertoire of assessment tools but many of them do not feel quite right in this kind of a PBL setting. The biggest mistake I made was not making the assessment process more formal. I should have posted the criteria we discussed as a class and provided examples of excellence. Looking back, I wish I would have worked a little more intentionally on using conversation as an assessment tool. This additional step would have been very helpful for my entire class but most specifically for my ELLs. These students need examples of finished products to visually represent the steps required and to compare and enhance their work. Assessment guides the work; it is not the grand finale. If I had to do it all again I would spend more time making assessment more accessible and transparent for students.

6. The hundred languages of children

In Reggio influenced schools one will often hear the phrase "the hundred languages of children." This refers to the ways in which children naturally express their learning and curiosity regardless of heritage language. They are drawn to materials that some would deem developmentally inappropriate but, in a Reggio setting, these are not off-limits. Teachers and artists work hand-in-hand to offer children safe and inviting

ways to explore new and authentic materials (Abramson et al., 1995). This kind of work has opened my eyes to the value of taking risks in art.

Students in my school are very comfortable using art as a medium for expression. By the time they reach the sixth grade they have an extensive portfolio showcasing chalk and oil pastels, watercolour, sculpture through clay and wire, animation, and a variety of sketching techniques. In working alongside colleagues and ELL students in this way I have enhanced my understanding of how I can honour the hundred languages of children of which Reggio-inspired educators speak.

Through this project I have tackled my fear of sculpture and used photography in new and stimulating ways. Some may look at filmmaking and assume it is inaccessible for young ELL students but when they are accustomed to using images to enhance their discussions or improve their understanding of an idea then filmmaking can be a natural progression. In preparation for our parent evening my students are helping create a film documenting our adventures in mathematics. They will share their efforts with their families, narrating in any language they choose, and will inspire many up and coming students in the process. Heritage languages will be respected and parents will see that math has many different faces. For me, digital documentation has become a language, one that communicates beyond the limitations of the spoken word.

5. Support and scaffold

ELL students require specific kinds of support. Teachers cannot always rely on an ELL student's ability to ask clarifying questions or express confusion so we must find ways to make the learning process more successful for them. Lombardi (2008) and Furner et al. (2005) all suggest that educators use graphic organizers and visual cues to

help ELLs with new material. These are particularly important in content-heavy subjects like mathematics.

When an ELL student is learning a new concept it is essential to consider context and vocabulary issues. Garrison and Mora (1999) suggest using a known to teach an unknown. For example if the vocabulary is new teachers should try to use it in a context that is familiar. If the context is new, use vocabulary that is familiar. This helps teachers monitor the amount of new material and it ensures ELL students are less overwhelmed in linguistically difficult subjects such as math and science. This process is called scaffolding, and it is imperative that educators are aware of and proficient in its application.

4. The role of collaboration

Collaboration is one hallmark of project-based learning. Within a PBL environment, students are encouraged to co-construct knowledge and test their theories together. Tudge and Winterhoff (1993) juxtapose Vygotsky and Piaget's thoughts on the social construction of knowledge:

> Both theorists believed that collaboration was most likely to be effective when both participants share the goal of attaining joint understanding, and that resolution of a difference in perspectives or problem solving strategy was the key to development, rather than disagreement *per se.* (pp. 243-244)

ELL students need collaboration for success. They need environments where they can ask questions and test theories without fear or anxiety and this may be more easily achieved among peers.

If collaboration is to be effective, students need to understand its purpose. Teachers need to take the time to deconstruct the expectations of group work, allowing for role modeling and questions. Once the groundwork is laid, collaboration can become a daily interaction among students encouraging them to explore difference in perspective with a more open mind. For ELLs this opportunity to hear the ideas and explanation of peers is crucial. These conversations model appropriate problem-solving and enhance their language proficiency beyond basic communication skills. Academic vocabulary is more authentically incorporated when students work on projects that build understanding together.

Collaboration is also an essential component of community outreach. Extending invitations to parents and various members of the community is an excellent way to involve children in the world outside their window. They are able to learn from experts and visit sites that offer rich, meaningful learning experiences. My team is hoping to use the *Open Minds* school programs to experience firsthand the nature of field study opportunities. The children will work together; teachers will work with on-site experts and with one another to provide an innovative and exciting learning environment. The sky is the limit, one just needs to be brave and reach out to others along the way.

3. The power of disequilibrium

Borasi (1994) and O' Donnell (2009) suggest that effective math teachers overcome personal doubts about letting students struggle. The process of grappling with challenging tasks helps students become more confident problem-solvers especially when errors and misconceptions are used to further inquiries. This kind of disequilibrium is important for intellectual growth in both teachers and students. So often I have had to

stop myself from jumping in to "rescue" a student when they appear to be struggling. Now, after years of practice and many, many conversations with my students, I no longer feel the need to step in right away. Students will figure it out and will ask if they are truly stuck. I am not teaching anything but dependence if I jump in too quickly.

Once students understand that they are responsible for the solution, they begin to think differently. They take risks more readily and turn to each other for support. I want my students to understand that I am by no means the only teacher in our classroom and that they are just as likely to get help from a peer as they are from me. In my opinion, disequilibrium fosters collaboration and an intentionality in the kind of work in which my students are engaged. In an odd sense, disequilibrium cultivates balance within classroom.

2. The role of the teacher

Looking back on my initial teaching practicum I am astonished at how much my personal teaching philosophy has evolved. My favourite teachers were those that engaged my sense of humour and my sense of adventure but I honestly do not remember a whole lot of choice as an elementary student. My view of the role of the teacher has changed markedly over the past decade. When I look back at how I saw my teachers and the way I see myself in the classroom now it presents quite a dichotomy.

As a student, I remember teachers assigning textbook pages with the follow-up questions for homework. There were no hands-on projects, no attempts at real-world application. I ended my high school math career with a basic knowledge of formulas and algorithms and absolutely no sense of how and why they were important in my daily life.

When I became a teacher I vowed to make math accessible and knew it would be a worthwhile but taxing journey.

After years of teaching and many heartfelt conversations with parents, colleagues, and students I see my role in the classroom very differently. Teachers need to understand the content to such an extent that they can predict how students may connect with the material and they need to be open when students throw a curveball. Being open to student interests and queries helps me understand the unique needs of each student, ELL or not. In understanding their questions I can provide authentic materials to provoke inquiry and reflective investigation. Being a facilitator of learning has shown me the power in letting my students guide the exploration.

1. The importance of honouring student input and voice

Throughout this countdown I have discussed the importance of honouring students. It is the cornerstone of my teaching philosophy and it is the lens through which I look each and every day. Will this offer my students choice? Will it help them see learning in a different way? If the answer is no, we don't partake.

Documentation is one way I ensure my students are heard. Capturing images of the learning process helps children see themselves as efficacious, successful students. Sharing these images with parents has helped bridge the gap between spoken languages and has opened the door to more informed conversations about learning. Parents have a greater sense of the kinds of tasks we use to investigate curriculum and they understand how their child is being assessed. Documentation has been one of the most powerful additions to my practice.

Modes of expression and collaboration have helped me address the needs of my ELL students more effectively. By offering students a choice about how, and with whom, they would like to work I am able to operate from a strength-based paradigm. I would rather look at children and see what they can do rather than make notes about all they cannot. Project-based learning is the perfect vehicle for this kind of exploration. ELL students can take risks and develop proficiency in language and content areas through hands-on tasks and when they are involved in selecting the topic or focus they become emotionally invested in the process. It is a very powerful experience for everyone involved.

Collaboration, project work, and the hundred languages of children are all important concepts but, in the end, if we do not honour the voices of our children in the way we plan, implement, and assess then who is it all for?

My journal entry for April 10, 2010:

It seems surreal that the end of this project is near. Our parent evening has been scheduled and plans are well underway for the event. My students are brimming with excitement as they prepare to share all they have accomplished. The focus of the evening is not just an exploration of patterns; it will encompass all the mathematical investigations we have completed. From *I Spy* collections to weaving and chess, my students have shown a spirit of adventure in mathematics.

My colleagues are coming out in droves to help and support and enjoy the work my students have done. This project has done more than build a community of learners in my classroom; it has reached out into the hallways and common spaces of our building. My young students have shown how courage and faith in

the process span the distance often created by language, culture, and experience.

In my eyes...they are heroes.

"You have brains in your head. You have feet in your shoes. You can steer yourself in any direction you choose. You're on your own. And you know what you know. You are the guy who'll decide where to go" (Seuss, 1990, p. 2).

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Appendix A

No Way. The Hundred is There.

The child
is made of one hundred.
The child has
a hundred languages
a hundred hands
a hundred thoughts
a hundred ways of thinking
of playing, of speaking.
A hundred always a hundred
ways of listening
of marvelling, of loving
a hundred joys
for singing and understanding
a hundred worlds
to discover
a hundred worlds
to invent
a hundred worlds
to dream.
The child has
a hundred languages
(and a hundred hundred hundred more)
but they steal ninety-nine.
The school and the culture
separate the head from the body.
They tell the child:
to think without hands
to do without head
to listen and not to speak
to understand without joy
to love and to marvel
only at Easter and at Christmas.
They tell the child:
to discover the world already there
and of the hundred
they steal ninety-nine.
They tell the child:
that work and play
reality and fantasy
science and imagination
sky and earth
reason and dream

are things
that do not belong together.

And thus they tell the child
that the hundred is not there.
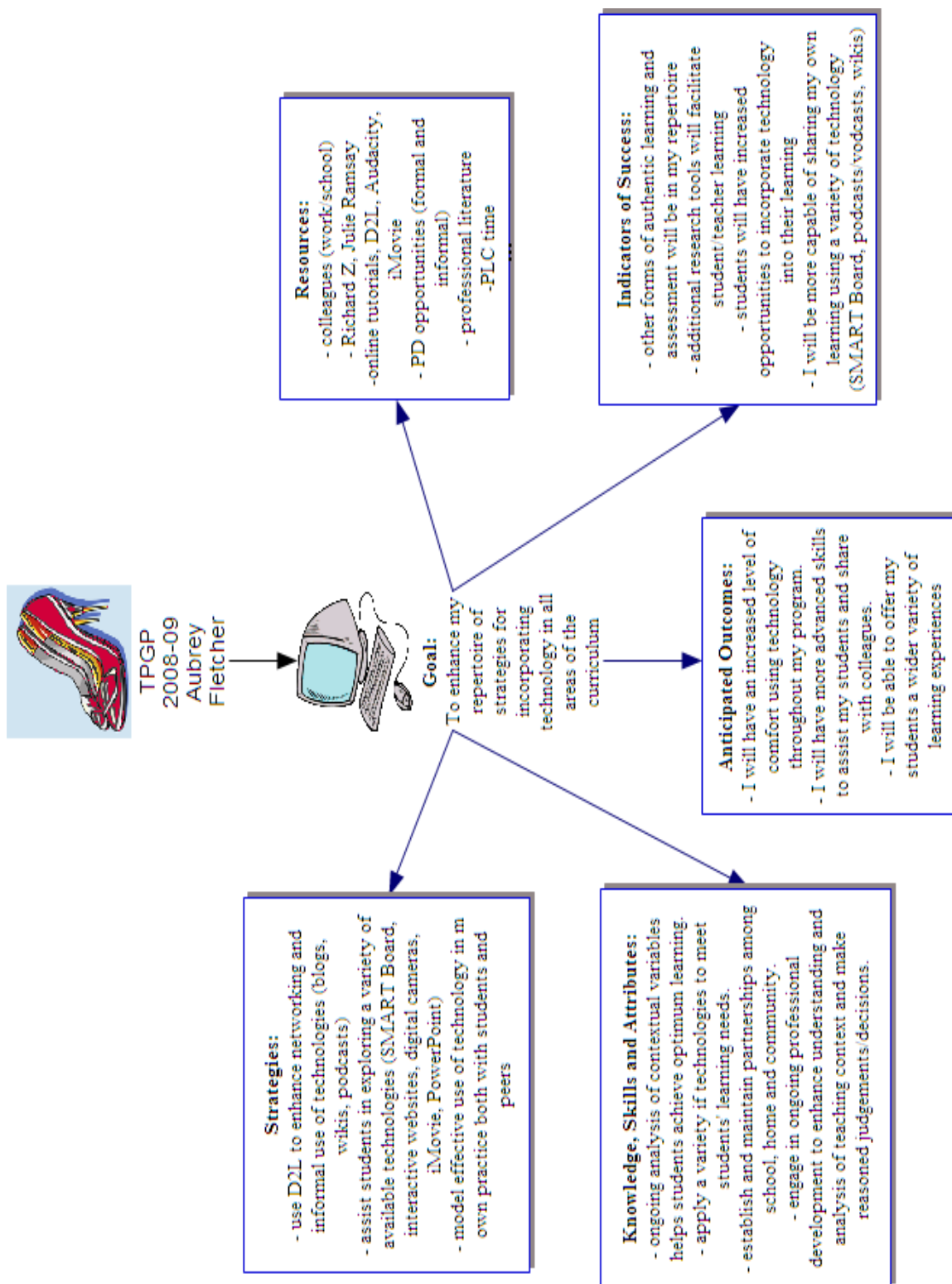The child says:
No way. The hundred is there.

- Loris Malaguzzi (as cited in Wurm, 2005, pp. x-xi)
(translated by Lella Gandini)

Appendix B

Student Survey

1. What is math?

2. Where do you see math?

3. How do you feel when you are doing math?

4. What helps you understand math?

5. What is frustrating about math?

6. What is exciting about math?

7. What is more helpful for you: seeing the idea on the board, hearing about it, or building it?

8. How do you show what you know in math?

9. Is there more than one way to do that?

10. What happens if someone else has another way of showing what they know?

11. Who is the teacher?

12. Where do we use math? Is it important?

13. What makes math different from science? Writing? Computer time?

14. Is math something you are good at?

15. Are you a mathematician?

Appendix C

Teacher Professional Growth Plan 2008-2009

TPGP
2008-09
Aubrey
Fletcher

Goal:
To enhance my repertoire of strategies for incorporating technology in all areas of the curriculum

Resources:
- colleagues (work/school)
- Richard Z, Julie Ramsay
- online tutorials, D2L, Audacity, iMovie
- PD opportunities (formal and informal)
- professional literature
- PLC time

Indicators of Success:
- other forms of authentic learning and assessment will be in my repertoire
- additional research tools will facilitate student/teacher learning
- students will have increased opportunities to incorporate technology into their learning
- I will be more capable of sharing my own learning using a variety of technology (SMART Board, podcasts/vodcasts, wikis)

Anticipated Outcomes:
- I will have an increased level of comfort using technology throughout my program.
- I will have more advanced skills to assist my students and share with colleagues.
- I will be able to offer my students a wider variety of learning experiences

Strategies:
- use D2L to enhance networking and informal use of technologies (blogs, wikis, podcasts)
- assist students in exploring a variety of available technologies (SMART Board, interactive websites, digital cameras, iMovie, PowerPoint)
- model effective use of technology in m own practice both with students and peers

Knowledge, Skills and Attributes:
- ongoing analysis of contextual variables helps students achieve optimum learning.
- apply a variety if technologies to meet students' learning needs.
- establish and maintain partnerships among school, home and community.
- engage in ongoing professional development to enhance understanding and analysis of teaching context and make reasoned judgements/decisions.

Appendix D

Math Curriculum Checklist for Grade 1

Strand: Number							
Sub-strand: Number Sense							
Say numbers in order from 1 – 100 by: 1s, 2s, 5s and 10s							
Name familiar arrangements of objects from 1 – 10 (like 6 on a dice)							
Show how you count by: counting things in a set, counting on, skip counting							
Show numbers 1 – 20 with objects, pictures, and numbers							
Compare sets (up to 20 objects) use words like fewer and many, and more							
Use 'smart guessing' for sets with up to 20 objects							
Show how changing the way a set looks does not change how many objects are in it							
Name numbers that are one more, two more, one less and two less							
Sub-strand: Number Operations							
Show how you can add and subtract (to 20) using objects, pictures and symbols							
Add and subtract to solve number stories							
Use math tools like counting on and counting back, making groups of 10, using doubles							
Show how adding and subtracting can work together to solve problems (2+2=4 is like 4-2=2)							
Strand: Patterns and Relations							
Sub-strand: Patterns							

Show how patterns repeat by: describing, copying, continuing, and creating patterns using objects, pictures, sounds, and actions							
Show how patterns can go from one form to another (Eg: from pictures to actions)							
Sort objects using one sorting rule (colour, shape, size)							
Explain your secret sorting rule							
Sub-strand: Variables and Equations							
Show how 'equals' means balanced, and unequal means imbalanced using objects and pictures							
Show how sets of different objects cans be equal (0 – 20)							
Show how the equals sign means numbers or objects on the left side are the same as those on the right side							
Strand: Shape and Space							
Sub-strand: Measurement							
Show how measurement helps compare objects (use height, weight and capacity)							
Order objects using height, weight and capacity and explain the rule							
Compare two objects using words like taller/shorter, heavier/lighter							
Find out which of two objects is larger (by covering) and explain why							
Strand: Shape and Space							
Sub-strand: 3-D Objects and 2-D Shapes							
Sort 3-D objects and 2-D shapes using one rule, explain your rule							

Name and make 3-D objects and 2-D shapes from a set of shapes (Eg: what do you need for a cube? A pyramid?)							
Show how 3-D objects found in the classroom, community, and world have similar parts to 2-D shapes							
Sub-strand: Transformations							
(no outcomes for grade one)							
Strand: Statistics and Probability							
Sub-strand: Data Analysis							
(no outcomes for grade one)							
Sub-strand: Chance and Uncertainty							
(no outcomes for grade one)							

Appendix E

What We Already Know About Patterns
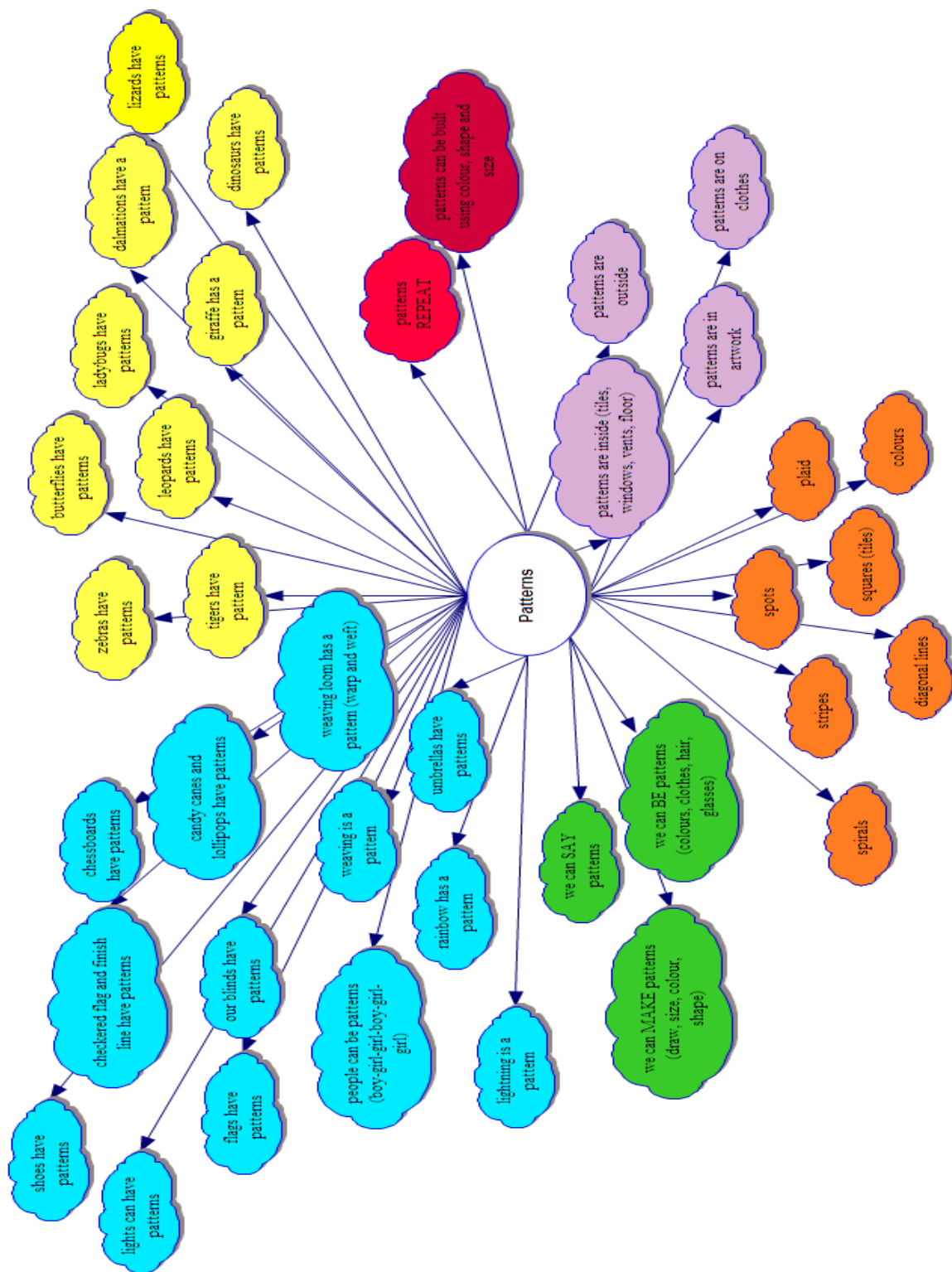
Appendix F

What We Want to Know About Patterns
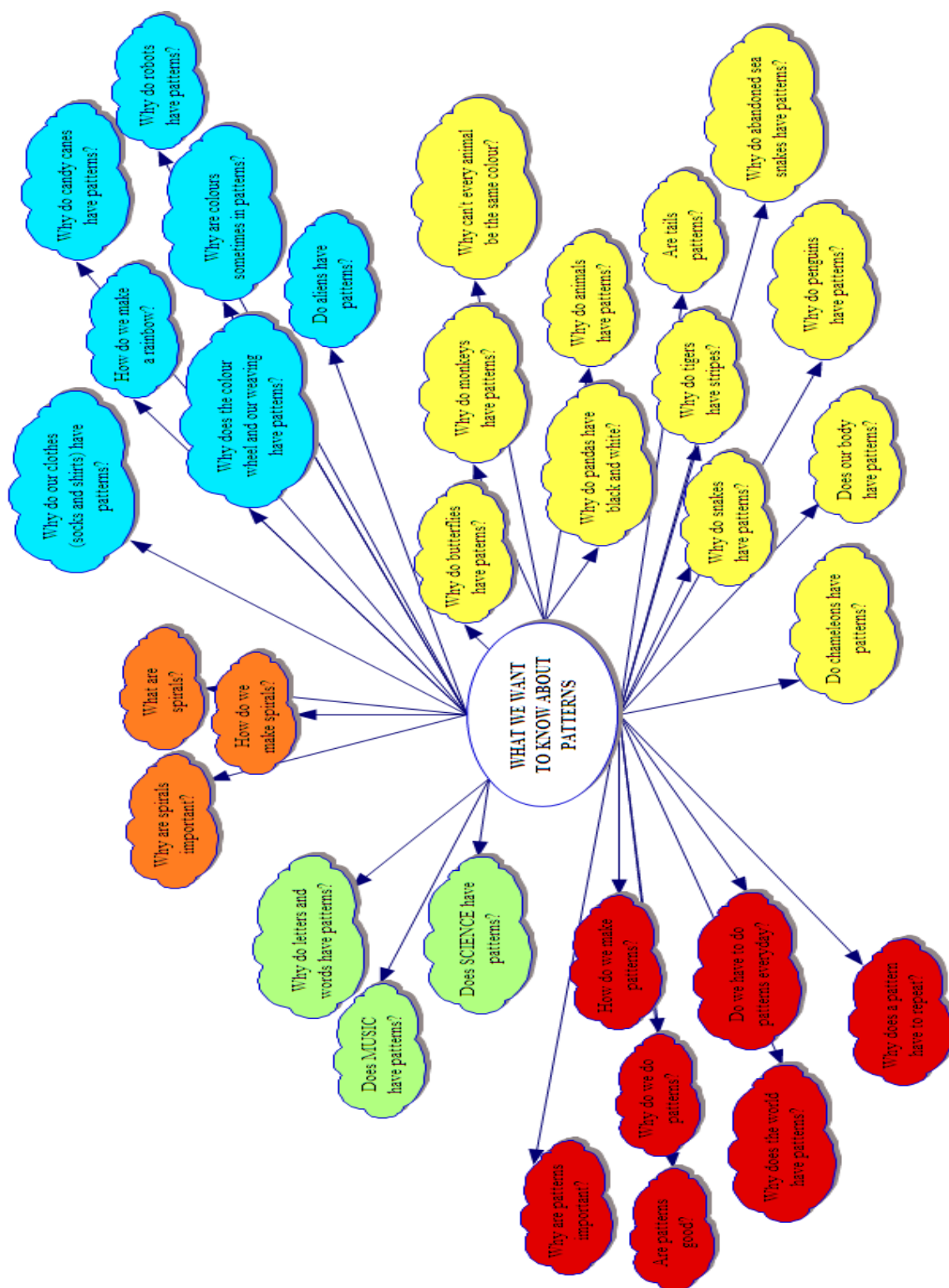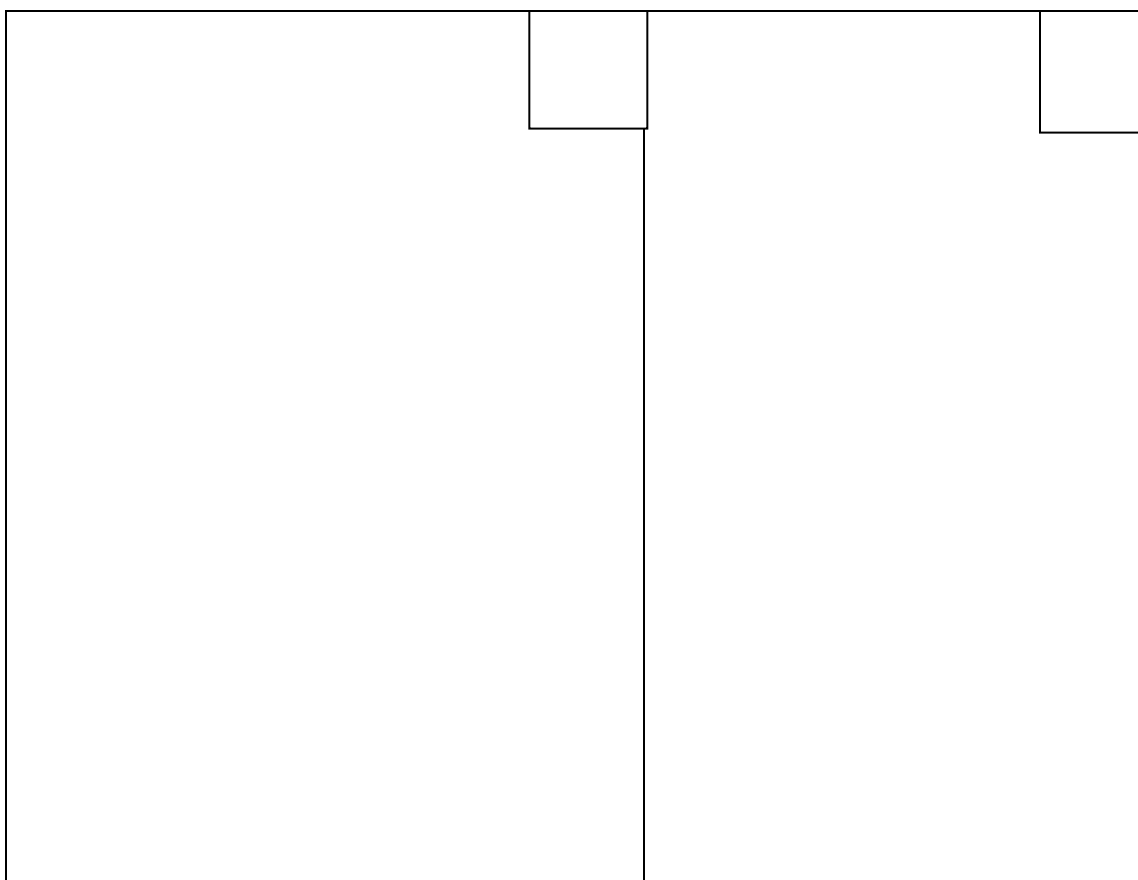
Appendix G

Pattern Match Images
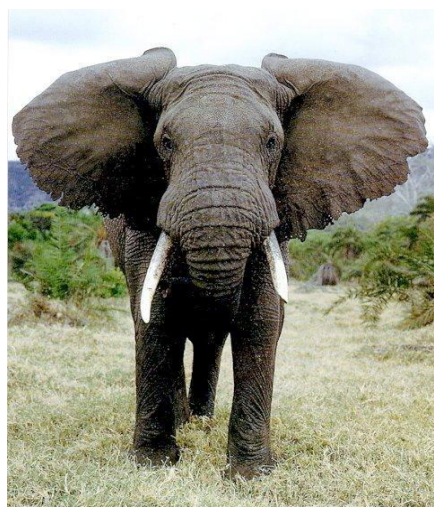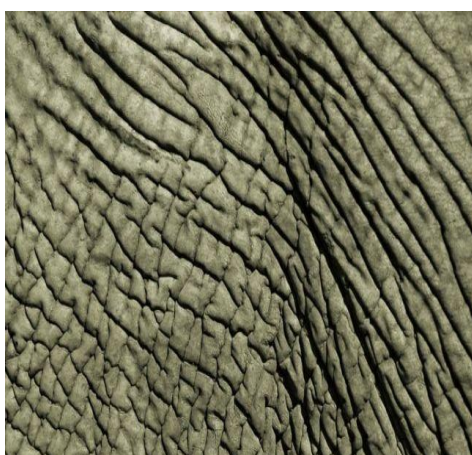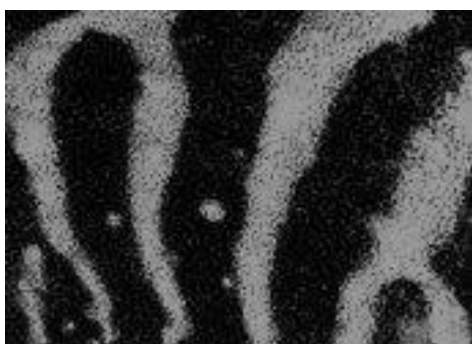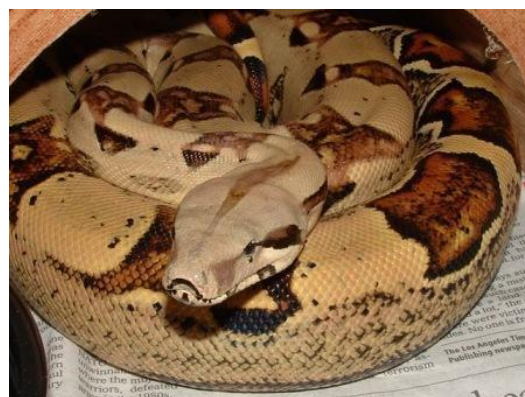
Appendix H

Pattern Match Lab Template

Name: _____

Pattern Match

Draw both parts of a patterned pair, pay close attention to shape and design.

Be sure to share which letter/number you think go together.

What animal do you think this is?

_____

What makes you think so?

_____

Sample Student Lab

Pattern Match

Draw both parts of a patterned pair, pay close attention to shape and design. Be

sure to share which letter/number you think go together.

What animal do you think this is? _Sorc_

What makes you think so?

it ec levs in the see.

it i2 big it has

Sorpp teeth

Appendix I

Hunter vs. Prey Images

Appendix J

Hunter vs. Prey Lab Template

Name: _____

Hunter or Prey?

Look at the 12 pictures. Some of these animals use their patterns to be good

hunters, others use them to hide. Which is which? Draw a line from each

letter to either HUNTER or PREY.

A

B

C

D   HUNTER
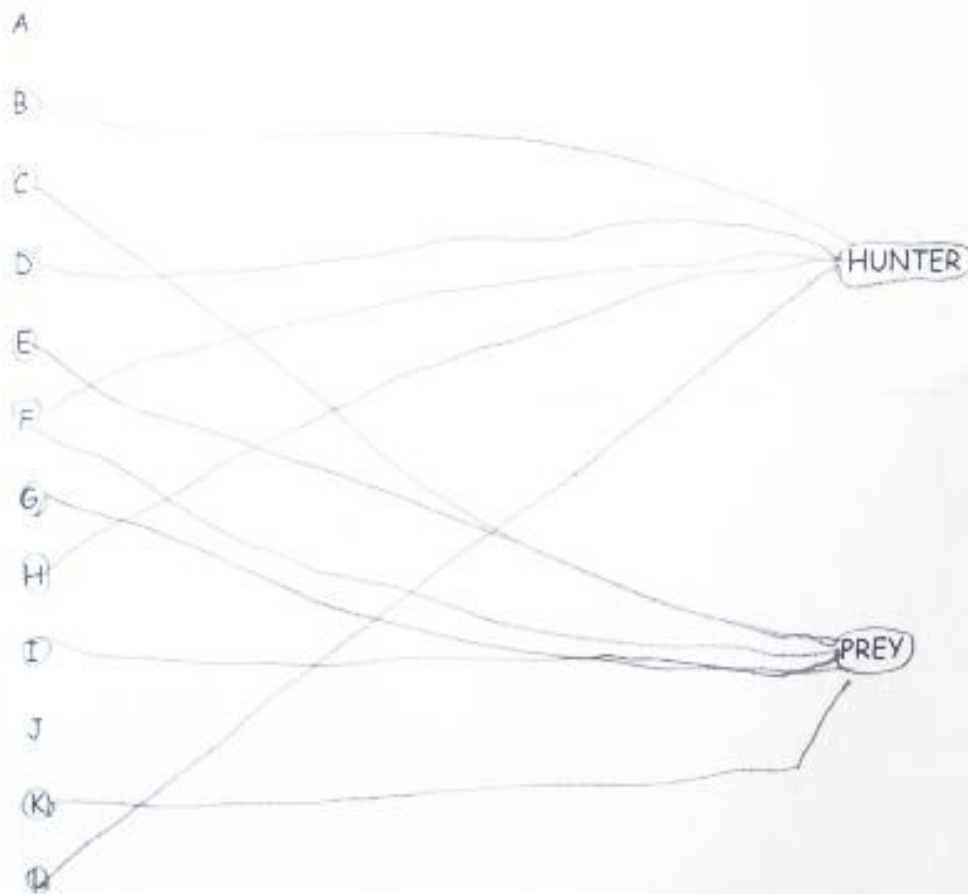
E

F

G

H

I   PREY

J

K

L

What clues do you see that may help you decide? (Think about the SENSES!)

_____

_____

Sample Student Lab

Hunter or Prey?

Look at the 12 pictures. Some of these animals use their patterns to be good

hunters, others use them to hide. Which is which? Draw a line from each letter to

either HUNTER or PREY.

A

B

C

D   HUNTER

E

F

G

H

I   PREY

J

(K)

(L)

What clues do you see that may help you decide? (Think about the SENSES!)

Size Colour Pattern

Appendix K

Who Am I Images
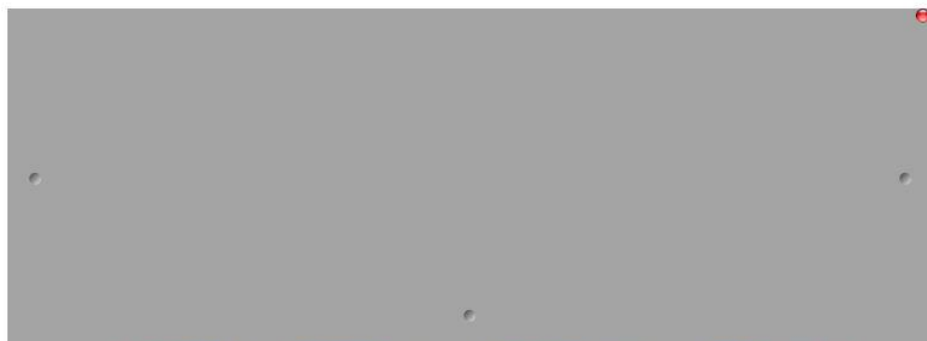
Appendix L

Who Am I Lab Template

Name: _____

Who Am I?

Draw one of the mystery animals from the SMART Board notebook pages.

Don't forget to show WHERE you think it lives and HOW it moves.

	Slide #

I think the animal is a

_____

_____

Sample Student Lab

Who Am I?

Draw one of the mystery animals from the SMART Board notebook pages. Don't

forget to show WHERE you think it lives and HOW it moves.

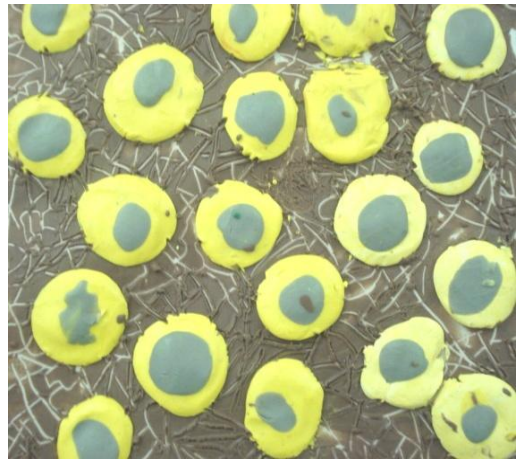I think the animal is a

DraFF

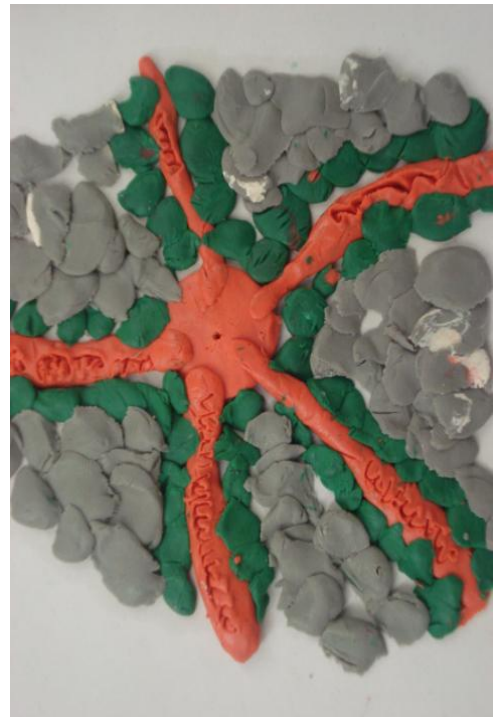Appendix M

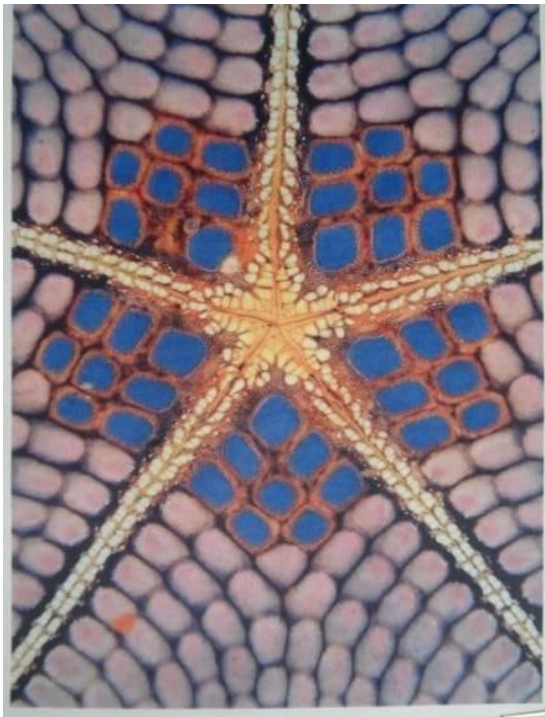Samples of Student Animal Patterns in Plasticene

blue-ringed octopus

Bengal tiger

European wall lizard

starfish

Appendix N

Animal Patterns Debrief

Name: _____

Animal Patterns Debrief

1) What is a pattern?

_____

2) Where can you find patterns?

_____

3) When are patterns important?

_____

4) Draw a pattern:

How do you know it is a pattern?

_____

_____

5) If you had to give this pattern another name, what might you call it? (AB

prompt if nec) _____

Appendix O

Mission: Mathematics Movie

(in Windows Movie Maker format on attached CD)