

**Shadows, Masks and the Illusion of Learning**

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**By**

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## ABSTRACT

In this investigation, the researcher explored the construction of conceptual knowledge within the discipline of science through a review of related theory and research.

Following a review of literature that emphasizes the theory of social constructivism as well as critical pedagogy as significant to learning; and utilizing a working definition of the six strands of language as established by Saskatchewan Education; the researcher observed and interviewed three Grade Five students and their teacher throughout their involvement in a science unit.

In-class observations of the strands of language as well as the information from the interview transcripts were triangulated with the literature to provide validity for the theory and support the researcher's implications for an inquiry model of teaching and learning.

Findings suggest an absence of explicit language being modeled and expected within the course of study as well as the absence of a framework of science concepts. Disconnections and fragmentations throughout various levels of pedagogy within curriculum, resources, strategies and activities were revealed. The unintentional illusion of a rich learning experience was created through collaborative, hands-on activities, demonstrations and modeling by the teacher,

fluency and accuracy in reading as well as the correct completion of activities. In reality these acts merely masked the absence of deeper transformational experiences which are required for students to build the conceptual knowledge and linguistic competence needed for academic success.

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For Mum

With Love

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*A word devoid of thought is a dead thing,  
and a thought unembodied in words remains a shadow*  
(Vygotsky 1962, p. 153).

## CHAPTER 1

### INTRODUCTION

“Children, we must never forget, are not repositories for adult ‘knowledge’ but organisms which, like all of us, are constantly trying to make sense of, to understand their experience” (Steffe, Cobb & vonGlaserfeld, 1983, p. 83).

#### Crucial Moments, Critical Questions

##### Vignette January 1976

“Mother took David’s hand and they walked across the street.” Penny reads fluently from the workbook page that is part of my Grade Two basal program. “That’s right,” I smile warmly, “Now just answer the question.” I point at the sentence. “*Who did Mother take across the street?*” Penny looks up at me puzzled, “Me not know,” she whispers. “Well, read it again,” I say pointing at the first sentence. She reads it again, along with the question that follows it. “Well?” I wait. She shrugs timidly. “Me not know,” she repeats. I sigh in frustration. “Penny, come on now, you just read it! Who do you think is going shopping with mother?” She looks down at the floor. It dawns on me. Except for the odd word to signal a request for assistance or some other basic need, Penny, a seven year

old Cree-speaking resident of this fly-in community in Northern Saskatchewan doesn't speak English, yet reads from the school books with precision and fluency. I begin to deconstruct the sentence: "Mother...street ...." What would Penny's image of these words be, living in this water-bound community with no vehicles save for bikes, boats or the odd snow machine?

Vignette January 1982

Alex, at 13 years, is one of the older students in my Grade Five classroom in this Indian Band-Controlled school in Northern Saskatchewan. We've been exploring the seasonal effect of the earth's rotation and as students move around the room in and out of science activities I join him at the back table. His hands are gently spinning a globe but his eyes are excited. "Hey Val," he says, "I just figured...I thought we lived inside the world." His brow furrows as he rubs his fingers around the sphere, "I just now figured we live on top of it! That blue stuff...I thought it was sky on here but its water!"

I am dumbfounded. How many other assumptions do I have about student learning and why, in spite of my best efforts to be in tune to what students know and how they see the world, is it still so difficult to find time in a class to genuinely listen and build upon their individual and collective knowledge?

Vignette May 2005

As the Grade Seven language arts teacher in a small rural school, I administer the English Language Arts provincial Assessment for Learning project to my class, confident in their abilities to perform well. I have been committed to an integrated, process-oriented, inquiry-based program where students are offered choice; discourse and collaboration are valued as ways-of-learning, reading and writing as acts interpretation. To ensure a solid program, specific learning objectives have been taken from the province's curriculum as well as two initiatives from our school division: an electronic report card and a developmental reading assessment. We have studied the art of viewing and representing through graphs, charts, content area material and internet pages, made explicit our meta-cognitive strategies, set goals for oral reading fluency and articulation, and practiced strategies for reading and writing. We have analyzed and compared genres, literary styles, themes, characters. We've held writing conferences, had papers published locally, shared reading across the grades, and presented dramas from literary characters' various viewpoints, spoken publicly to a wide range of audiences, and established criteria for self and group evaluation. We have learned to consider various perspectives, purposes and audiences, studied literary terms and devices and spelling patterns. We have celebrated our province's centennial through integrated Saskatchewan themes, authors and personal projects; and questioned, critiqued and debated complex democratic issues from gangs and racism in our community to the Holocaust and the Beijing massacre. The students' questions have pushed our learning deeper and beyond the classroom as



they've taken the initiative to share books from personal libraries, search out documentaries, research individual wonderings and relate discussions from home about the themes and issues we have been studying. They have worked collaboratively in groups or teams to support members whose reading and writing skills hamper understanding and contributions. At the foundation of our program has been my attempt to build upon students' knowledge and guide them through discourse and further reading and writing to insights and growth as literacy users and thoughtful, democratic citizens.

As I score my students' multiple choice and short answers before passing the assessment papers on for further analysis, I am dismayed to see they have had some difficulty. Questions are coded into Literal, Interpretive and Critical Levels of Understanding and I attempt to analyze what these descriptors mean and where I may have let my students down. I dig through the curriculum guides, search through the curriculum component on evaluation and share my concerns with other administrators and teachers but there are no answers, only a feeling of professional incompetence.

Vignette August 2005

I am asked to present a workshop on integrating reading strategies across the curriculum for Grade Four through Twelve teachers in a K-12 school in Southwest Saskatchewan. I am warned that those who will be attending consider the teaching of reading skills and strategies to be the responsibility of the Grade

One to Three educators. I know even before I agree to attend that the allotted two hours at the beginning of the school year will, at best, be a frustration for not only me but the teachers, who will no doubt want to be setting up their classrooms and preparing lessons. However, I agree to guide their discussion. The questions I later field show a general concern that so many students have difficulty following written directions, understanding material and retaining concepts although they can read fluently. I present information about the broad, integrated language strands as foundational processes for students' conceptual understandings of curriculum content and we follow with more discussion. Throughout my four hour drive back home I alternately congratulate and console myself, realizing the futility of the afternoon yet also hopeful that the flicker of insights that the teachers had shared will impact on their classrooms.

Vignette November 2005

An email arrives titled Language Arts Workshop for Grades 6-9 Teachers. I am momentarily excited as I anticipate the notion of a forum to discuss issues and concerns, share insights or celebrate successes. Further information reveals that rather than a forum, presentations will be made by the publishers of three commercial reading programs in an attempt to streamline and expedite the decision-making process that additional funding for curriculum renewal has brought to schools.

Returning to the University of Saskatchewan after a 28 year hiatus, I have welcomed my year of educational leave from the Saskatchewan Rivers School Division as an opportunity to harness, delve into, focus, and impose both shape and form to a kaleidoscope of nebulous phrases, images, ideas, constructs, concepts, quotes and resultant questions that comprise the multitude of vignettes. Highlighted for me amongst the vignettes include the issues of curriculum, assessment, culture and technology; related and interconnected to each other as society and schools continue to evolve.

I grapple with questions that go beyond my need to find answers to pedagogical theory and practice, and they are edged with concern about the personal perspective I bring to the educational settings. How limiting will my viewpoint be in my desire to find the truth about the diverse needs of students in today's multi cultural global society? Critical pedagogy (Freire, 1970; Giroux, 1996, 2000, 2001; Giroux & McLaren, 1998; McLaren, 1998 and Shor and Pari, 1999) provides a lens for critiquing educational settings, programs and practices by examining the social, political, economic and cultural ideologies inherent within society, systems and structures including institutions of learning. Ira Shor (1999) suggests it "begins with words that question a world not yet finished or humane" (p.1). And I do have many questions about what is, and what could be.

## Education in a Time of Transition

As an elementary educator with past assignments that span Saskatchewan's geographic and demographic diversity from southern to northern, urban to rural, public to band-controlled communities, I have worked as a classroom teacher, special educator, consultant, curriculum writer and administrator. Over this passage of time I have seen the nature of teaching and learning evolve as schools both reflect and are impacted upon by a myriad of cultural, economic, social and political issues in greater society. Classrooms were formerly comprised of students sharing similar linguistic, cultural and socio economic backgrounds who silently marched through the pages of departmentally-approved texts. Those that kept pace moved up the ranks to the next grade while those that struggled remained behind to either repeat the process or were labeled and relegated to self-contained special education classrooms. Throughout the years, the composition of classrooms and the expectations of educators have changed to accommodate all learners while curriculum initiatives and resulting programs have shifted towards teacher-developed, integrated, activity-based thematic units of study.

Current explorations into curriculum matters recognize the changing compositions of classrooms. The ever-growing diversity of complex and multi-faceted cultural and ethnic backgrounds speaks a need for hearing and understanding not only dynamic heteroglossia or multiple discourses and various perspectives and realities within our schools (Bakhtin, 1981), but also for the recognition of the

power inequities inherent within our society and thus in our institutions and classrooms (Jacob & Jordan, 1993). As Greene (1995, p. 155) says, “We are challenged as never before to confront plurality and multiplicity” and to react with a culturally responsive pedagogy. Thus, the intricate relationships between language, cognition and culture must be acknowledged, along with the social and political issues that are intertwined with language and literacy. At the same time, both the transformative impact of technology’s information society and a business view of education as commodity influence the learning that occurs in Saskatchewan classrooms.

Amidst these social and educational challenges and demands, teachers in the field frequently fight for time to keep abreast of new initiatives as well as for understanding and insight to support their students’ increasingly varied needs. Yet all too often I have felt a sense of disconnection between the energy that goes into teaching and the learning that results, particularly as students move through the middle grades away from contextualized material and rely on the symbolic representation of print. Results from the provincial assessments tend to confirm scores from end-of-the-unit curricular tests that also reflect this disconnection.

And there seem to be fewer moments of joy in the journey

## Diversity in the Classroom

Urban classrooms within Saskatchewan reflect the rich cultural and linguistic diversity of our province and country. Within this linguistic and cultural diversity are also ever-widening socio economic levels including deep poverty.

Poverty can do both immediate and lasting harm to children. Children who grow up in poverty are more likely to lack adequate food, clothing and basic health care, live in substandard housing and poorly resourced neighbourhoods, become victims of crime and violence, be less successful in school, suffer ill health and have shortened life spans....Poverty is inescapably wedded to the degree and consequences of social inequality we are prepared to tolerate or even encourage (University of Regina, 2005, p. 1,2).

A high teenage pregnancy rate of 200 per thousand means many students may have young, and often single, mothers with few resources or supports. Although home may not be safe and food is lacking, there is often a general distrust of agencies like Social Services and the police department.

Statistics for Saskatoon report more than 1400 school-aged children under the age of thirteen are not attending school (Government of Saskatchewan, 2001). Students as young as age eight may make sporadic appearances as they are unable to adjust to a school setting. There are also students that do attend school, which is sometimes the safest place for them, but who arrive too tired and hungry to perform well as 55.9% of this age group live in poverty, a feeder system for exploitation on the streets. Poverty related issues such as homelessness or transiency, silenced voices, abuse, powerlessness, violence and racism may be

reflected in students' abilities or willingness to conform to, and perform within, the formal classroom contexts of our Eurocentric educational institutions.

#### The Need for a Critical Lens

Society has a strong tendency to blame the victim rather than acknowledge the issues that arise from social, political, cultural and economic inequities. While there are many concomitant factors that impact on our students' lives beyond the boundaries of the schools' mandate, schools are also political institutions which perpetuate the inequities and injustices seen in greater society. As such, they can also be sites for transformation through critical pedagogy (Freire, 1970; Giroux, 2000, 2001; Giroux & McLaren, 1987; McLaren, 1998 and Shor & Pari, 1999) that is embedded in a social constructivist theory which recognizes the influence of language and culture in the development of thought and the ongoing construction of an individual's world view.

#### Knowledge in Today's World

The transformative impact of technology's information society has a wide range of pedagogical implications. In conjunction with the potential that technology has shown to "greatly magnify... intercultural learning across both cultural and geographic distances" (Cummins, 1995, p.79), what is often referred to as knowledge has expanded to a remarkable degree. However, knowledge is more than simply facts or a fixed body of information "out there" residing in books or the minds of experts. Rather knowledge refers to understanding ideas. Learners

must be astute and critical thinkers as they determine how to best sort through and make sense of the wealth of data available to them. This has resulted in “a radical transformation of our conception of education away from acquiring information and skills and toward a goal of learning for understanding by constructing ideas” (Murphy, 1991, as cited in Macleod, 1994, p.4). In other words, learning is not dependent upon what source of information is available, nor upon what teacher knows but on what the student thinks. Learners construct and display their own knowledge socially through interaction with others and as a function of their background and purposes. Working collaboratively on an authentic activity leads to the sharing of various skills and perspectives and results in individualized learning. Modeling, discourse and decision-making are crucial elements of active participation to support the negotiation and creation of meaning and understanding (Hasio, 1996).

Thus, curriculum and instruction that reflect our new reality are the first steps in preparing students for their role in a global society, one which requires that citizens are critical thinkers and independent learners, have a broad knowledge of other cultures, act towards others with respect and understanding, and work for equity and social justice.

#### Market-Thinking Commercialized Education

In addition to the impact of technology, our shrinking world means that Saskatchewan classrooms are subject to powerful global trends and influences.



The emphasis on accountability, measurement, outcomes, cost-effectiveness, comparisons with other jurisdictions and so on, are all typical of the world of globalization; while the educational environment around us, which includes privatized options, charter schools, vouchers, and partnerships with business and industry reflects market thinking and language (Saskatchewan Education, 2001). The recent use of high-stakes standardized testing in the United States for school and district accountability that has accompanied the No Child Left Behind Act of 2001 (United States Department of Education, 2001) has resulted in an increase of publishers' materials that stress a teacher-directed, prescriptive, scientific-based view of learning finding their way into classrooms across our province. These resources, which typically focus on small unrelated items of information, and on whether a student has done something right as opposed to learning new and useful concepts, narrow the curriculum and reinforce the role of teacher as technician. While assessment for student learning through various means (projects, writing, discussion, observation) is important in providing feedback to students and teachers, Kohn (2004, p.55) claims that "standardized-tests are positively correlated with a shallow approach to learning" because students are not learning for the sake of learning, students are preparing for the tests.

#### Demands and Sacrifices

The demands on teachers seem to be ever-increasing as expectations for hands-on resource-based, collaborative, learning experiences along with an ever-growing diverse population of students often compete with calls for tighter controls

regarding centrally determined skill-based programs and standards. While the areas of curriculum, instruction and assessment should, in fact, be interwoven through a curriculum of inquiry which celebrates the resources found within the culturally rich backgrounds of students, there is often a reluctance to abandon traditional whole class instructional methods which rely on the transmission of knowledge through memorization and seat work, particularly when supported through commercial materials (Edwards & Mercer, 1987, as cited in Wells, 1999; Graves, 1983; Langer & Applebee, 1987; Nystrand, 1997; Wells, 2000, 1999 and Wells & Chang-Wells, 1992). Meaghan and Casas agree: “Higher-order cognitive skills and problem-solving abilities are sacrificed in order to raise test scores. Instead of approaching topics from a variety of perspectives, students are trained to interpret passages in isolation and to engage in restrictive writing formats” (2004, p. 36).

Teachers’ deeply rooted view of their role as transmitters of knowledge, or what Freire (1970) referred to as *banking education*, brings with it an overarching concern with diagnosing what students need to learn, providing the missing information and testing to evaluate the success of their teaching. This traditional pattern of test/teach/retest leaves little room to encourage students to discuss, question, reflect upon, and develop deeper understandings as they learn broader literacy skills. Saskatchewan Education’s Assessment for Learning project, which uses data for improved learning, begins formal data collection about reading proficiency and strategic reading behaviors at the Grade Five level, and

recognizes that the teaching and assessment of reading crosses curriculum boundaries.

Reading in today's technological world requires a greater sophistication than ever before. In addition to narrative stories and poems, today's reader must be able to access informational and technical texts in a variety of genres from a range of sources, such as newspaper editorials, technical manuals, and the Internet....it takes the reading task beyond the Language Arts classroom to reinforce an increasing awareness that reading is a general competency that supports learning across the curriculum (Saskatchewan Education, 2004a, p.4).

#### Student Diversity, Autonomous Programs and the Fourth Grade Slump

Street (1984, 1995, 2005) refers to pedagogical perspective which disregards the social and cultural assumptions of literacy but rather presents Western concepts as global and universal truths, as *autonomous learning*. Many Grade Four teachers notice that their students fail to continue with previous reading development, particularly as students are required to rely more and more on the symbolic representation of print as chapter books, and less on illustrated and contextualized material (Chall, Jacobs & Baldwin, 1990; Chall & Jacobs, 2003, Meagan & Casa, 2004) This phenomenon, known as the *Fourth Grade Slump*, has been confirmed through the American National Assessment of Educational Progress (NAEP) testing program, with statistics showing that children from more economically advantaged families score significantly higher than the less advantaged, and the gaps becoming greater with increasing age (Meaghan & Casa, 2004).

Socio-linguist James Gee (2001) claims that it is also the types of background literary experiences and knowledge students have outside of the school setting

which align with school literacies that underlie children's success. Educators must realize these two related issues:

- 1) It is the different experiences that have a tremendous impact upon student understanding and achievement.
- 2) The expectations within schools and the prior learning that is valued have been culturally established.

### The Need for a Social Constructivist Perspective

At the heart of instruction, Saskatchewan Education (2002) recognizes that language is basic to thinking and learning in all cultures, just as thinking is central to all modes of language use. How learners hear language used and how they use language themselves will influence what they learn in any given content area.). Social constructivism (Bruner, 1986, Vygotsky, 1987, 1978, 1962) is a cooperative model of building knowledge through inquiry and interaction with others. It emphasizes the connections between language, cognition and culture, claiming that knowledge is not fixed but rather learners construct knowledge and make new interpretations socially through interaction with others using the tools of language, artifacts and other historic/ cultural concepts. Cultural artifacts are made up of signs, symbols, linguistic terms, and humanly produced objects and instruments such as chairs, utensils and books. Other cultural concepts shape our understandings and beliefs about what, how and why things are.

## The Language Strands: A Broad Definition

Language is recognized as the primary medium for learning, meaning construction, cultural transmission and transformation (Britton, 1972, 1982, 1990, 1993; Emig, 1990; Kozulin, 2003; Moll, 1990; Vygotsky, 1978, 1986; Wells, 1999, 2000, 2001 and Wertsch, 1985). Throughout its provincially-mandated curriculum documents, Saskatchewan Education (2006) identifies and describes six integrated, interrelated and interdependent language strands. These include the oral language skills of listening and speaking which are the foundation of literacy enabling students to explore ideas and concepts as well as understand and organize their experience and knowledge. Reading provides students with a means of accessing the ideas, views, and experiences of others to construct meaning and develop thoughtful, critical interpretations of a variety of texts. Writing allows students to explore, shape, refine and clarify their thoughts, and to communicate them to others. The skills of viewing and representing enable students to understand the ways in which images and language interact to convey ideas, values, and beliefs.

## Conclusion

Global and societal changes impact on schools and on the learning that occurs. Increasingly diverse classrooms require educators to reflect upon and reconsider traditional practices of banking education through autonomous learning and commercial programs. Rather, there is a need for teachers to support students as they personally construe knowledge. This construction of knowledge is made possible through the mediation of language.

## Purpose of the Study and Research Question

The purpose of the study was to understand the significance of language during the construction of science concepts. The underlying research question that framed this study is: **How do three Grade Five students use the strands of language as they construct knowledge throughout the course of a science unit?** To answer this question, I interviewed three students and their teacher and also observed them in-class during the course of a science unit. It was my intention to thoughtfully explore the significance of language as it facilitates knowledge building.

My assumption was that the three students would have varying perspectives and background knowledge, unique interests, motivations and idiosyncrasies, personal preferred styles of learning, as well as varying skills and abilities within the language strands and would, thus, make different use of the support and opportunities provided through activities, discussion, reading, writing and viewing to create very unique and personal understandings. Beyond the overarching question: How do three Grade Five students use the strands of language as they construct knowledge throughout the course of a science unit? this query further lends itself to both more general and more specific questions: What role does dialogical inquiry play as students construct and interpret knowledge? What strategies support students' envisionment building as they maintain a point of reference in content area reading? What structures support

students' learning through composing? How do other symbol systems found in the arts support students as they construct knowledge socially? How does their thinking about particular science concepts transform throughout the unit?

Through observation and questioning, I followed the learning process as it unfolded for each child. Bruner, Oliver, and Greenfield (1966, p.1) state: "Conceptual development is characterized by gradually more sophisticated representations of the world rather than by the gradual acquisition of separately identifiable skills that do not necessarily occur in a sequence as the process unfolds." This is not unlike the concept of envisionments that Langer (2003) uses to describe the cognitive and linguistic processes used by readers and writers which are at any time a mixture of understandings, questions, connections and hypotheses which become more refined as interaction with text and with other readers and writers continues.

The literature search highlighted the value of language as the mediational tool for all learning and supported the use of authentic dialogic discourse as a means of, not only communicating and sharing information, but a tool for shaping thinking. For the purpose of this study, which is ultimately intended to provide support to teachers in the field, Saskatchewan Education's perspective and definition of six strands of language was applied.

The theory of social constructivism provided a framework with which to view both knowledge construction and the strands of language. A social constructivist learning theory (closely aligned with socio-cultural or socio-cognitive theory) in which knowledge is built upon language in a social/cultural context is supported by Wells (1999, 2000, 2001) who identifies language as “the medium in which the learning and teaching of all subjects is actually carried out” (2000, p. 51). Dewey’s philosophy of an inquiry approach to learning and Vygotsky’s (1978) insights into human learning as a socially (and therefore culturally) mediated activity are foundational to this study. The constructive nature of learning within subject disciplines, particularly those of science and mathematics has also been recognized by Bruner (1990) and von Glasersfeld (1989).

### Organization of the Thesis

Chapter 1 of this thesis provides the background to the study and introduces the research question. Chapter 2 is a critical review of the literature available in respect to the social construction of learning and the role of language and literacy within this learning. Chapter 3 is a detailed description into the research design as well as the qualitative methods incorporated to execute the research. Chapter 4 includes the research data that was collected along with brief analysis while Chapter 5 involves the interpretation of the data as well as its implications, and considers recommendations for future pedagogical research and practice.



## CHAPTER 2

### A REVIEW OF THE LITERATURE

#### Introduction

The embedded nature of my quest to understand the significance of language in the construction of science knowledge led me through a wealth of multidisciplinary literature. The overarching theory of social constructivism provided a much needed framework as I searched for answers in the areas of language, cognition, and culture. First described by psychologist Lev Vygotsky in 1938, the central tenets of social constructivism, also referred to as both a theory of child development and a theory of education, have become the cornerstone for current debates in literacy research. These tenets, which include the centrality of language in culture and individual development, as well as the inherently social nature of learning and higher order thinking, are being increasingly cited as educators search for deeper understandings into social and cultural issues inherent within the growing diversity of today's classrooms. Kozulin, et al. (2003) believe that rather than providing us with a model "Vygotsky prompts us to inquire into the nature of knowledge used in the classroom, for example, knowledge as

information versus knowledge as concept formation” (p. 1-2). Reflected in this literature review and foundational to this study, is a recent resurgence of Vygotsky’s ideas through authors and researchers that span both time and place in disciplines that include psychology, cognitive science, socio linguistics, mathematics, science and sociology as well as education. The common thread in these works is the support they lend to, or that they build upon, Vygotsky’s rich theory of socialization and internalization.

In particular, the wealth of writing published by Gordon Wells on social constructivism within educational contexts became integral to my understanding of Vygotskian theory and its’ classroom implications. Dewey’s (1938) ideas on the need for inquiry in education and Bruner’s (1966, 1986) concept of a spiral curriculum are referenced by Wells and obliged my further investigation. Additionally, the edited texts by Kozulin, et al. (2003), Lee & Smagorinsky (2000), Moll (1990) and Wertsch (1985) led me to a succession of contemporary writers and researchers inspired by Vygotsky.

Cummins (1981, 1995), Halliday (1978, 1993) and Moffett (1989, 1985, 1982), along with twenty years of research by Britton and his colleagues’, shared their insights into language and learning which aligns with social constructivism and wound their way through my review. Similarly, research by Emig (1983), Graves (1985), Langer (numerous publications) Applebee, et al. (2003), and two decades of work by Nystrand in the areas of writing and reading, value a constructivist approach and consequently, informed my thinking and understanding. My question was also addressed through

ideas on discourse and literacies by Gee (1999, 2000, 2001) and Street(1984, 1995, 2005) while authors such as Greene (1990, 1995) and Bakhtin (1986) united to provide further notions into how we situate ourselves contextually as we construct knowledge through language.

Critical pedagogy has its birthplace within the theory of social constructivism. Through critical pedagogy, the classroom is not the place where information is dispensed by teachers and consumed by students, but rather becomes a site for the production of new knowledge grounded in students' personal realities. Therefore, I could not ignore the challenge sent forth by Freire (1970), Giroux (1994, 1996, 1997, 2000, 2001), McLaren (1998) and Shor and Pari (1999) who examined issues of power as they related to education intertwined with economics, politics and culture, and who called for critical education as praxis; as it nested so completely within a constructivist theory, simultaneously carving a critical edge into my own pedagogical beliefs.

The notion that language and literacy are historical and cultural tools, supported through socialization and internalization, has tremendous implications for understanding its development in children and how its growth can best facilitated through pedagogical practice; hence it stands as the framework for my literature review as well as my research. as well as my research.

## Social Constructivism

Constructing and interpreting knowledge within a social context is referred to as *social constructivism* (Bruner, 1986; Vygotsky, 1978). Based upon socio-cultural or socio-cognitive theory which emphasizes the origin of intelligence through interactions, *social constructivism* states that knowledge is not fixed but rather learners construct knowledge socially through interaction with others through the mediational tools of language and artifacts. This includes speech, concepts, content knowledge, strategies and technologies that have been embedded in cultural history. *Social constructionism* views language or discourse as a prime mediator (or intervening factor) in terms of what children will understand about a particular concept as well as the way discourse functions within social relationships.

Vygotsky's (1962, 1978, 1986) insights into human learning as a socially (and therefore culturally) mediated activity, Bruner's (1966) framework for instruction, Dewey's (1938, 1962) philosophy of an inquiry approach to learning and Britton's (1969, 1982, 1990, 1993) concepts on language and learning are foundational to this study. A social constructivist theory in which knowledge is built upon language in a social/cultural context is also supported by Cummins (1995), Kozulin, Gindis, Ageyev & Miller (2003), Lee & Smagorinsky (2000), Moll (1990), Wells (1999, 2000, 2001) and Wertsch (1985).

Wells identifies language as “the medium in which the learning and teaching of all subjects is actually carried out” (1999, p.51). How learners hear language used and how they use language themselves will influence what they learn in any given content area. People learn new knowledge and make new interpretations using the tools of oral language (speaking and listening, which in their broadest sense are referred to as dialogic discussion), written texts (reading as an act of envisioning), the act of composing (writing) and the skills of viewing and representing other symbol systems (like those in the arts). The people, tools and the resultant cultural construction of tools are inseparable, which suggests that learning is social even when others are not present. In fact, while Vygotsky identified the importance of language as the primary medium for learning, meaning construction and cultural transmission and transformation, and which today takes in advanced technological aids in the form of calculators and computers, Bruner (1986, 1990), Moll (1990), Wells(2000) and Wertsch (1995) expand this concept to include non-language tools such as art and music.

Wells (2000) creates an outline for educational practice which unites conceptualizations from various authors and disciplines through Vygotsky’s theory of child development. These include: 1) the central role of language as the medium in which the teaching and learning of all subjects is carried out, 2) the whole language movement, 3) writing across the curriculum, 4) the constructivist nature of learning and the emphasis on an inquiry approach and 5) cooperative learning. Similarly, Cummins (1995) advocates for a transformative pedagogy which includes an emphasis on active and critical student

inquiry and a vision of social democratic goals. He credits this model to the works of John Dewey (1962) who considered the process of integrating new information with existing knowledge through student experience as central to learning.

With a slightly differently perspective, I also recognize social constructivism as the overarching theory which, by the very nature of its description, is a cooperative model of building knowledge through inquiry and interaction with others using the strands of language and artifacts. The central role of language can be described through the six strands which include: 1) the tools of oral language (speaking and listening also known as dialogic discourse), 2) written texts (reading as an act of envisioning), 3) the act of composing (writing) and 4) other symbol systems such as those found in the arts (viewing and representing). A holistic language philosophy, which embraces the developmental and integrated nature of learning about language and through language, is interwoven among these strands. Embedded within this theory, various concepts and practices such as process writing, writing across the curriculum, collaborative learning, and an active, inquiry approach to learning, which on their own may have been seen as innovations or fads, become essential, integrated and interdependent components (Wells, 2000). The transformational cultural-political tool of critical pedagogy (Freire, 1970; Giroux, 1996; McLaren, 1998) can also be utilized within this framework of social constructivism as educators make explicit the political, economic, social and cultural issues that impact on classrooms, schools and society, and work towards equity

and democracy. I consider this multi pronged, integrated and interrelated conception my “*Valgotskian*” framework.

## Language as a Central Tool in Social Constructivism

### Socialization and Internalization

Language is an instrument, a means of organizing and representing the world (Britton, 1972, 1984, 1988, 1990, 1993; Bruner, 1986; Cummins, 1981a; Halliday, 1993; Moll, 1990; Wells, 1999, 2001; Wells & Chang-Wells, 1992 and Wertsch, 1985). Individuals create a unique world view as they select and match new information based on previous expectations. It is through this construction and then the reconstruction of what has occurred that creates unique life experiences and also establishes our internal schema or ways of categorizing and organizing. Goodman, Smith, Meredith and Goodman (1987, p. 138) refer to this as *schema theory* in which thought clusters, made up of connections of inner speech, meanings, images, assumptions and feelings that form into structures, concepts or schemas, influence what we attend to and what we remember, and become extended and enriched through experiences and with maturity. Gusdorf, cited by Britton (1993, p. 317), states: “Man interposes a network of words between the world and himself and thereby becomes master of the world.” While events take place and are gone it is a person’s personal interpretation and subsequent symbolic representation (including language) that creates their frame of reference of reality. Through talk (narrative speech) individuals revisit the events to make sense of them, and they engage

in discourse with others as they modify each others' representations. Kelly suggests that our world view or construction system is built through our reflection and subsequent interpretation of events.

Experience is made up of the successive construing of events. It is not constituted merely by the succession of the events themselves ...It is not what happens around him that makes a man's experiences; it is the successive construing and reconstruing of what happens, as it happens, that enriches the experience of life (Kelly, 1963 as cited in Britton, 1993, p. 17).

Cole and Griffin (1986) argue that language gives us the world twice. As participants, language is used to interact with people and things. As spectators, language is used for contemplating what may or has already occurred (Britton, 1993). Moll (2000) suggests that literacy (especially writing) may serve its most important mediating function, not by facilitating communication or obtaining information, but by helping students create new worlds that have never existed before.

Vygotsky (1978) believed that children first think without language (pre-linguistic thought) and then learn concepts through interaction with others before internalizing these concepts as inner speech. Language development, accordingly, follows three stages: 1) from external language as a social tool, to 2) egocentric speech, and 3) finally it becomes internalized as inner speech. Vygotsky describes this theory of socialization and internalization as occurring on two planes and suggests that:

Any function in the child's cultural development appears twice, [or on two planes.] First on the social level [plane] and later on the individual level [the psychological plane]. First it appears between people as an inter-psychological category, and then inside the child as an intra-psychological category.... Social relations or relations among people genetically underlie all higher functions and their relationships (1978,



p. 57).

Thus, learning is first shaped through social interactions and discourse before the child internalizes concepts through a reconstruction of their own world view. Socio linguistic James Gee (2001) describes (capital D) Discourses as identities and traditions that people are born into and develop. More over, when they work with more capable peers, adults or artifacts, children are able to internalize higher level thought processes such as logical memory, reflective awareness and deliberate control, and are, as a result, capable of carrying out more complex, problem-solving tasks. This process of learning with others through interaction (especially talk) is described by Vygotsky as taking place in the *zone of proximal development (ZPD)* which is:

*the distance between the child's actual developmental level determined by independent problem solving...and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978, p. 85; emphasis in the original).*

The more a child takes advantage of this support, the wider is their ZPD. This rich theory of socialization is supported by Brown and Ferrara (1985) who build upon twenty years of research by Feuerstein. Feuerstein claims that the principle means by which children develop the cognitive operations needed for independent learning is through the shaping of their early mediated learning experiences by an adult. Through an interactive style of questioning and extending their language, children begin to internalize skills such as focusing, predicting, mapping and evaluating. Thinking about their thinking and articulating it supports the transfer or bridging of learning from one context to another.

Feuerstein believes this interactive style of communicating between adult and child is typical of middle class social patterns and may be less obvious in certain cultures or even in particular families depending upon various factors including past child rearing experiences. Students who have benefited from the mediation of rich early experiences are able to profit from the mediated experiences that occur when they meet similar activities at school. Furthermore, studies show that these students are often encouraged by teachers to articulate their thinking which builds their skills of reflecting, generalizing, focusing and selecting while students who may have had less exposure are not called upon to save everyone embarrassment (Brown & Ferrara, 1985, p. 278).

Information, rather than being fixed, is catalytic and leads to new knowledge through interactions with teachers and peers (Britton, 1993; Bruner, 1986; Cummins, 1995; Halliday, 1978; Lee & Smagorinsky, 2000; Vygotsky, 1978, 1986 and Wells, 1999). As Cummins suggests:

Classrooms oriented to collaborative critical inquiry draw on...research showing that cooperative learning and active student inquiry are highly effective in promoting higher- order cognitive and academic skills....transformative approaches also incorporate an explicit vision of the social goals toward which instruction is directed (1995, p. 157).

Cognitive changes occur during this process which can be described as an interplay between novice and more sophisticated thinkers negotiated through language and the use of artifacts (Bruner, 1986; Cummins, 1995; Lee & Smagorinsky, 2000; Vygotsky 1962, 1978, 1986; Wells, 1999, 2000, 2001 and Wertsch, 1985).

Bruner (1968) presents three systems for processing information internally to allow people to create mental models of their worlds. He says we learn through 1) action or locomotion such as riding a bike which demonstrates knowledge without using imagery or words, 2) imagery or graphics also referred to as iconic, and finally progress to

learning through 3) symbols and language: abstract, arbitrary and flexible which enable individuals to deal with what might be and what might not. This “symbolic mode of representation of thought” (Spencer, 1991, p. 3) becomes increasingly important for individuals as they mature and is a major tool in reflective thinking. Britton’s theory (as cited in Nystrand, 1977) also incorporates both systems of imagery and symbols when he states: “The ability to speak and to reason are ... both ...dependent upon the ability to generate symbols, the ability to create representations of actuality” (p.40).

Three types of experiences support these systems and contribute to a person’s changing world view as they interact with the technologies of culture (Bruner, 1968). These include: 1) direct mediated experiences 2) vicarious learning through observation and 3) vicarious learning through symbols. Direct and mediated learning presupposes that a person’s perception of reality is subject to the actions s/he performs upon it. Therefore, activity always mediates learning and requires both the knowledge of a particular concept as well as information about the activity or skill used to gain that knowledge. While observational learning often takes the form of modeling or demonstrations, when used as an instructional tool it is more powerful if alternatives are provided and reasons for each are discussed. Successful modeling does not necessarily mean copying; rather the individual constructs behavior to create a meaningful (and personalized) performance, thus demonstrating understanding.

Symbolic learning through words, numbers, graphs, diagrams and maps is prevalent in classrooms for teaching and learning out of context. Because learning in this manner places a high demand on literacy, meaning taken from the symbols will be interpreted by, and thus limited to, the individual's existing knowledge. Developing knowledge through these de-contextualized learning experiences relies heavily upon collaboration with peers, particularly in the middle grades when instruction moves from directed mediated experiences, demonstrations and highly illustrated resources to a reliance on the symbolic representation of print.

#### Speaking and Listening: Dialogic Discourse

*"Talk is the ocean on which all else floats"* (Britton, 1969, p. 47).

The oral language skills of listening and speaking (also referred to in this paper as *dialogic discourse*) are the foundation of literacy enabling students to explore ideas and concepts as well as reflect upon, understand and organize their experience and knowledge. Discourse can be seen as a powerful structure that positions the actors involved. Bakhtin (1981) believed that dialogue shaped both language and thought. He saw discourse as utterances that are continually woven together as speakers respond to what has been said and anticipate successive responses. He described discourse as being dialogic; structured and shaped by the tension and sometimes through the conflict of the participants' various perspectives. Rather than meaning being shared between participants, it unfolds during interactions. This '*shaping of dialogue*' according to

Bakhtin (1986, p. 72) “lies at the heart of understanding a dynamic sociocognitive event.” He described all language as inherently dialogic, it is only the intent of the message that can cause it to be univocal. Lottman as cited in Nystrand (1997) suggests that utterances that are referred to as univocal focus only on the accurate transference of knowledge whereas dialogic utterances are the equivalent of thinking devices. *Transmission-oriented* teachers see their function as providing information to students, while *interpretation-oriented* teachers who recognize the transformative nature of learning attempt to stimulate students’ thinking to go beyond the information given. These contrasting stances are further elaborated upon by Freire’s (1970) distinction between *banking education* through which knowledge is mechanically acquired and *critical education* in which learners become active participants in constructing knowledge relative to their personal experiences.

In addition to dialogue providing structure to language and thought, Bakhtin (1986) saw dialogue as being shaped by the social organization of the roles of the conversants stating, in fact, that a given utterance could not be understood outside the organized relationships of the conversants. Thus the roles that are established in classrooms have a tremendous impact on the opportunities for students to create meaning. Dialogism, then, becomes more than a theory of interaction as it provides insight *into* interactions as the foundation for the comprehension and interpretation of events.

Nystrand (1997) studied the exchanges of Grade Eight and Nine students in classrooms where dialogue, specifically questioning, was used to increase their depth of understanding in reading and writing. He focused on Bakhtin's (1986) notion of dialogic interaction as a reciprocal relationship necessary for authentic interaction in contrast to monologic question/answer discussion typically found in classrooms. He found that teacher evaluation and the follow-up to students' answers were significant to the process. He identified specific features: 1) authentic questions posed to discover deeper understandings, 2) time for open whole class discussions, and 3) more uptake or follow through to extend students' answers which all contributed positively to student learning.

Verbalization, according to von Glasersfeld, is an obvious means to encourage reflection, review and deeper understanding of concepts, and is consistent with Vygotsky's description of the stages of language moving from external socialized speech toward inner speech. Von Glasersfeld suggests that:

By far the easiest way is to get students to talk about what they are thinking. The act of verbalization requires a review of what is to be verbalized. This review is a form of reflection and often brings to the surface inconsistencies or gaps in a train of thought. Hence it is crucial to initiate conversations whenever a problem is to be solved. It may be students explaining their thinking to the teacher or explaining it to their classmates. Both lead to reflection and are the beginning of what Ceccato called 'operational awareness'. After a while this becomes a habit for the students, and then all problem-solving can turn into a conversation with oneself (2000, p. 8).

## Writing and Reading as Acts of Literacy

*“Literacy is an active phenomenon. Its power lies not in a received ability to read and write, but rather in an individual’s capacity to put those skills to work in shaping the course of his or her own life” ( Paulo Freire, 1970, p.12).*

The permanence of text is one feature that establishes print as an important tool for communicating ideas and information over time and space. As Britton (1972, p.102) suggests “written language forms a gateway to most further learning.” Reading and writing in their broadest sense are meaning-making acts whereby thoughts are developed and transformed by text and into text through the active construction of knowledge. Researchers (Applebee, Langer, Nystrand & Gamoran, 2003; Calkins, 1991; Graves, 1983; Langer, 1995; Langer & Applebee, 1987; Nystrand, 1986, 1997; Rosenblatt, 1995 and Smith, 2004) examining the interactive nature of reading and writing, describe readers and writers collaborating via the internal representation of meaning that is created even as the individuals intersect at a point, namely the text. Authors carry an audience within their subconscious as they seek to be understood while readers use the subsequent text and their personal realities (context) to build interpretations.

Nystrand (1986) explains: “Researchers see both reading and writing as constructive interpretive activities ... cognitive processes in which the individual builds internal representations of experience and interprets subsequent encounters in light of

expectations entailed by these representations” (p.9). Reading provides students with a means of accessing ideas, views, and experiences of others to construct meaning and develop thoughtful, critical interpretations of a variety of texts. Writing allows students to explore, shape, refine and clarify their thoughts, and to communicate first to oneself and then to others. The extended processes are dynamically related to each other through the active, constructive nature of language and thought processes.

Using the term envisionment building to describe the cognitive and linguistic processes used by readers and writers, Langer (2003) found that these envisionments are at any time a mixture of understandings, questions, connections and hypotheses which become more refined as interaction with text and with other readers and writers continues. Whether one views reading and writing as disciplines or as literacy acts to further knowledge and concepts within specific subjects, researchers recognize the importance of sharing multiple perspectives and interpretations through discussions as participants negotiate meaning.

## Writing

Writing is a complex, cognitive social activity requiring the balancing of myriad factors. It allows students to explore, shape, transform, create, refine and clarify their thoughts, and to communicate them to others (Applebee et al., 2003; Britton, 1993; Calkins, 1991; Emig, 1983; Graves, 1983; Langer, 1987; Purves, 1988; Tynjala, Mason & Lonka, 2001 and Vygotsky, 1978, 1987). The emergence of written speech appears only



after the development of inner speech. Britton (1990) places writing within the developing continuum of language skills. “A *child’s language is the means*: in process of meeting new demands- and being helped to meet them- his language takes on new forms that correspond to the new powers as he achieves them” (1990, p. 125, italics in the original).

Writing, however, with its unique structure and mode of functioning, is much more than the translation of oral speech, more than a complicated motor skill, and mastering it requires much more than simply learning the techniques of writing. Vygotsky proclaimed, “its mastery heralds a critical turning point in the entire cultural development of the child” (1978, p. 107). The similarities between oral and written speech obscure the fact that there are “differences between the two processes which are a function of the fact that the later process occurs on a higher level” (Vygotsky, 1978, p. 185). Thus, it is only after the development of higher cognitive processes that the emergence of this complex act can be seen:

Written speech is the algebra of speech. The process of learning algebra does not repeat that of arithmetic. It is a new and higher plane in the development of abstract mathematical thought that is constructed over and rises above arithmetic thinking. In the same way, the algebra of speech (i.e. written speech) introduces the child to an abstract plane of speech that is constructed over the developed system of oral speech (Vygotsky, 1987, p. 203).

The theory of social constructivism recognizes the significance of language as a tool for communication, and considers social interaction a motivating force in the development of higher mental functioning. Both through oral and written communication, one must

think conceptually to organize one's ideas. A "mutually articulated need" for social interaction between children and adults has an important role in a child's earliest writing stages, pointing out the need for authentic purposes in writing meaningful communication (Vera John-Steiner, 1985, in Everson, 1991, p.8) An abstract level of thinking must be reached before children are able to use and gain meaning from the symbolic representation inherent in print and other symbols...

...until they learn to exchange abstract meanings children cannot gain entry to education, because without this one cannot become literate. Writing is learnt as a second-order symbolic system, with symbols standing for other symbols, hence the learner has to recognize two sets of abstract entities, and also the abstract relation between them (e.g., *word, letter, stand for, spell, ...*). So when children learn to read and write, they have to enter a new phase in their language development, moving on from the general to the abstract. This then enables them to attend to language itself, a necessary condition for becoming a reader and writer.... In the process of becoming literate, they learn to reconstitute language itself into a new, more abstract mode (Halliday, 1993, p. 106).

While inner speech is maximally contracted, abbreviated and telegraphic, the transformation to written speech, which needs to be maximally detailed and highly organized, requires a deliberate structuring of ideas, or 'elaborating the web of meaning' (Vygotsky, 1962, p.100). "Even the most minimal level of development of written speech requires a high degree of abstraction....Written speech is speech in thought, in representations" (Vygotsky, 1987, p. 202).

Everson (1991, p.11) describes writing as 'a synthesis or pulling together of ideas, images, disarrayed facts and fragmented experiences' while Moffett referred to the collection of thoughts and images that comprise inner speech as the "well spring of

writing” (1982, p. 231) and suggested that all writing is really inner speech that has been revised for a purpose and an audience. In other words, written speech is an abstract cognitive activity, as ideas are taken from thought, without a ‘present’ listener, another abstraction for the writer. This is accompanied with different motivating factors than speech and direct conversation provide, as well as the lack of immediate context from which oral language naturally flows. Attention must also be given by beginning writers to each sound they print. Written speech must convey the concepts, the intonation and the context that are present in oral speech.

Vygotsky believed that while children are taught to trace letters and make words from them, they are generally not taught written language. Vera John-Steiner (1985, as cited in Everson, 1991, p. 8) describes writing as “the product of a creative, dynamic learning process that spirals naturally upward and outward toward limitless possibilities ...when... fostered by example overtime.” Students must learn to utilize their inner speech to enhance their writing while at the same time becoming aware that it’s compacted and fragmented design can interfere with written expression. Instruction requires supporting students as they work through the processes of planning, decision making and problem-solving while composing for authentic contexts. As they make connections initially from talk and play to writing as well as later to understand the uses and purposes of writing and to master its conventions (Moll, 1990) students need time, adult support and mediation within an environment that encourages risk taking.

## Writing to Construct Knowledge and Strengthen Voices

Emig (1983, p. 125) claims that, “because writing is often our representation of the world made visible, embodying both process and product, writing is more readily a form and source of learning than talking (is)” and represents a unique mode of learning:

...writing as process-and-product possesses a cluster of attributes that correspond uniquely to certain powerful learning strategies... higher cognitive functioning, such as analysis and synthesis, seem to develop most fully with the support system of verbal language- particularly it seems, of written language” (1983, p.123) .

By deliberately gaining facility with the abstract, complex process involved in composing, students develop these higher levels of cognitive functioning. Talk, then, becomes a valuable support prior to writing as it can assist students with thinking in concepts, ordering and sorting information, focusing, narrowing, selecting and editing ideas from the pure meanings of their ‘great ongoing inner panorama’ (Moffett, 1982, p. 231). Britton suggests that by sharing their experiences either orally or in writing, children are shaping them and making them more accessible for their own learning. “Expressive talk and writing are means...rather than ends” (1972, p. 108). As students continually develop their representation of experiences and of the world, writing can create a form of permanence, allows them to revisit, rethink and reflect. To extend this, writing as a tool for learning supports deeper conceptual understandings and facilitates the integration of ideas, as students reflect upon experiences, re-examine and further explore ideas, refine their awareness of what has been learned, and reason through the establishment and restructuring of relationships among concepts. Writing in content

areas provides an opportunity for students to 1) gain relevant knowledge and experiences for new activities, 2) review and consolidate what has been learned, and 3) think deeply and more complexly within contexts as they reformulate and extend ideas and experiences. Writing is seen as most effective when it is judged based on its adequacy which encourages deeper understanding (evidence of learning), rather than accuracy which relies on simply gathering information or on memorization (Langer & Applebee, 1987).

When writing is used as a learning tool Tynjala et al. (2001) suggest it is more useful to deploy it in combination, and integrated with, other forms of learning and discourse such as classroom or group discussions. Everson explains:

Inner speech is our students' first true perception of reality, and because of its interactive nature, it serves our students best when it's had a chance to develop socially. Translated into classroom terms, a student's language develops socially first, individually second. As a result our young writers will be better able to make meaning if they are able to work in an atmosphere where they may interact with their teacher and classmates before going to their writing alone (1991, p.10).

The importance of small groups for interaction prior to writing supports Vygotsky's notion of language that moves from external and social toward inner speech, and which he observed as young students moved from "exchanged verbal activity in peer response groups to isolated verbal activity" (Everson, 1991, p. 9). This 'isolated verbal activity' or 'personal rehearsal time' refers to the egocentric speech or verbalizing students do for themselves as they plan, direct and regulate their thinking during the process of

composition. A classroom diary, journal, writing log or notebook (Calkins, 1991) helps students capture and organize fragments of ideas prior to scribing.

Metacognition or talking about the process provides insight for students as they bridge their proficiency in oral language to written proficiency. As a child extends reading and internalizes more and more of the patterns of written language they will naturally appear in writing. Most importantly, teachers must occasionally leave their role as evaluators, and become co-collaborators in learning as it is easy to silence the writer's inner speech or voice.

Reading, writing and talking go hand in hand. And development comes from the gradual internalization of the written forms so our standards, the standards we apply to their writing, must be such that we don't cut the writer out of the writing; or to put that another way, cut the writer off from his resources (inner speech and thought) at the spoken level (Britton, 1972, p. 110).

#### Reading: The Great Debate

Since the mid 1980s a debate has been raging in North American over the most effective way to teach students how to read. The two sides are typically referred to as: 1) the scientific view which advocates for direct instruction of scripted phonics and 2) a holistic philosophy that supports students as they acquire strategies through developmentally appropriate, meaningful, literature-rich, language-based instruction.

#### One Size Fits All: A Prescriptive Phonic-Based Perspective

The United States' No Child Left Behind (NCLB) Act of 2001 requires those American schools seeking federal program funding to implement scientifically-based reading

programs of scripted phonics, decoding and controlled vocabulary on the basis of studies supposedly conducted by researchers of the National Reading Panel who have a vested interest in basal programs such as Open Court Reading ©2001 (McGraw Hill) which espouse the aforementioned components. The Acts states:

...a comprehensive reading program anchored in scientific research from kindergarten to second grade will be eligible for grants under a new Reading First initiative. The findings of years of scientific research on reading are now available, and application of this research to the classroom is now possible for all schools in America” (United States Department of Education, 2001, p.10).

The NCLB Act continues in stating that the National Reading Panel (NRP) reviewed 100,000 studies on how students learn to read before concluding:

...effective reading instruction includes teaching children to break apart and manipulate the sounds in words (phonemic awareness), teaching them that these sounds are represented by letters of the alphabet which can then be blended together to form words (phonics), having them practice what they have learned by reading aloud with guidance and feedback (guided oral reading), and applying reading comprehension strategies to guide and improve reading comprehension” (United States Department of Education, 2001, p.12).

In reality the results are based on a research study by three researchers who, according to Taylor, 1988, skewed the data when findings indicated that students fared poorly with phonemic-based programs as compared with students involved with literature rich, discussion-based reading. As well, Taylor and several other researchers believe the results of the executive summary of the NRP report miss-stated the findings. One of the researchers, Elaine Garan, a well-known author and expert on reading, states:

If *Teaching Children to Read* were a typical research study, published in an education journal and destined to be read only by other researchers, then I could

simply end my analysis by saying that the panel's own words have established that the research base in its report on phonics is so flawed that the results do not even matter. However, as we have seen, this study has clout. It has a public relations machine behind it that has already promulgated the results throughout a very wide, very public arena as representing unbiased scientific "truth." Both Congress and the National Institute of Child Health and Human Development are committed to ensuring that the findings of the NRP report affect classroom instruction (2001, p. 501).

The NRP report does have enough influence that it has promoted Open Court Reading as well as similarly scripted, phonic programs (some packaged as individualized computer-based courses like Accelerated Reading ® from Perfection Learning) for schools not only in the United States but, as their clientele has grown, the market has reached into Canada and our own province and school division.

Bracey (2004) states that the NCLB law uses the phrase “scientifically-based research” 111 times and demands such research from educational researchers, but no scientifically based research—or any research—supports the law's mandates. While reform efforts have shown some positive results in improving reading achievement for children in the primary grades, many are not moving beyond basic decoding skills—deciphering and/or sounding out—to fluency and higher-order comprehensive skills that contribute to critical literacy such as inference, interpretation and reflection as they advance to the fourth grade and classes in history, mathematics, and science (DeLeon, 2002). Thier (2002) agrees that mechanical reading, particularly in content areas, will not assist students’ in their search to make new meanings. I believe that this going through the motions of reading by saying the words actually misleads teachers, as well as students,



who equate the act with interpretation and understanding. In the end, this approach ignores the goal of reading as a meaning-making activity as students only learn to read words, but do not become critical, life-long readers.

#### A Holistic Interpretive Perspective

A “scientific” view of reading is in sharp contrast to the perspective described by Rosenblatt (1938, 1995) and other researchers (Angelis, 2001; Applebee et al, 2003; Applebee, 1981; Beach, 1981; Angelis, 2001; Cole and Lindemann, 1990; Fish, 1980; Langer, 1987, 1995 and Probst, 1987) that have built upon her work. Aligned with a holistic view which nests within the framework of social constructivism, Rosenblatt describes the transactional and transformative processes of understanding print through a social context. She suggests that a reader moves back and forth along a continuum between literary and cognitive stances.

Meanwhile, Langer (1987) illustrates two unique orientations to reading that explain how readers build an envisionment. These orientations require readers to use very different sets of cognitive and linguistic strategies. While engaged with narrative text, readers explore an ever-evolving horizon of possibilities. In contrast to this orientation, while studying expository text, readers focus on maintaining a point of reference that is elaborated and clarified as the reading, writing, discussion and reflection continues. Langer recognizes three main purposes for reading: 1) reading for literary experience during which readers explore the evolving possibilities 2) reading to be informed

through maintaining the point of reference and 3) reading to perform a task. She suggests that: “Reading to perform a task is more authentically reinforced in the areas of math and science than during language arts” (1997, p.2).

### Reading for Information

Reading for information and consequently, constructing knowledge from science material or other expository text, requires more than having a storehouse of subject specific vocabulary. It also relies upon an understanding of the domain's:

- 1) Organizational patterns such as cause and effect, classification, experimental, definition or explanation, compare and contrast, sequencing, problem-solution
- 2) Syntax
- 3) Background knowledge
- 4) Style
- 5) Lexicogrammatical use of metaphor and
- 6) Other linguistic idiosyncrasies found in specific content area texts so that students can maintain a point of reference and build their envisionments about concepts.

Students need to be able to read and monitor their understanding of content area material for its contribution to their conceptual change. This sometimes leads them into uncomfortable territory as they search and stretch beyond their boundaries to make meaning. Roth (1991, p. 62) claims:

To read for conceptual change students must 1) recognize the similarities and the differences between their own ideas and those in the text, 2) struggle with those differences, and 3) reorganize their own conceptual framework to accommodate the scientific explanations. This process requires a sophisticated reading strategy in which students carefully monitor their own thinking and weigh the evidence to decide if a change is warranted.

### Reading to Perform a Task

Reading to perform a task through procedures, instructions, recipes and manuals is a critical life skill that can be modeled authentically through science lessons. Langer (1989) suggests four stances that can be taught to students to increase making sense of text. These stances have been adapted by the Montgomery County Public Schools to support growth in scientific literacy when students are reading to perform a task. The first stance is labeled Global Understanding, a stage during which students form an overall impression about content. Developing Interpretation is enhanced through revisiting the text. A Personal Response, the third stance, connects prior knowledge while the final stage, taking a Critical Stance, has readers analyzing text for its' supporting ideas and for how meaning was created by the author.

### Viewing and Representing as Acts of Literacy

Viewing and representing can be considered foundational to the theory of social constructivism as the human mind has the ability to represent experiences through both icons (images) and symbols. Symbols enable students to understand the ways in which images and language interact to convey ideas, values, and beliefs. This is supported by Bruner's (1966) systems for processing information which he claims allows people to create mental models of their worlds so that they may move beyond concrete objects to consider propositions and alternative possibilities. Britton (1970) explains that we

construct a unique representation of the world through our personal and interactive viewing of experiences and events and then employ drawings, maps, charts, diagrams and other symbol systems such as those used in the arts, along side of speech and writing and other artifacts, to represent and record our experience. Our world representation is an accumulation of all of our representations, and hence unique for each person. Britton (1970 as cited in Nystrand, 1977) states:

The ability to speak and to reason are ... both ...dependent upon the ability to generate symbols, the ability to create representations of actuality... [Language is but one way of symbolizing our encounters and] ...we cannot explain the particular workings of language unless we see their relations with other ways of symbolizing and with the nature of the symbolizing process itself (p.40).

Saskatchewan's English language arts curriculum recognizes that: "Being literate in contemporary society means being active, critical, and creative users not only of print and spoken language but also of the visual language of film and television, commercial and political advertising, photography, and more" (Government of Saskatchewan, 2002, p.5). I would also add the visual language and symbolism of computer graphics, images and the relationships and meanings inherent in these visual displays. This is supported by the works of Wertsch (1991), Bruner (1990) and Moll (1990) as they expand Vygotsky's theory that we learn through the mediational tools of language and the use of other artifacts, to include non-language tools such as computers, art and music.

Viewing is an important part of literacy as students comprehend and integrate visual data with other literacy knowledge through the areas of multimedia, digital and technological literacy. Students need to construct meaning from images, print and other

media messages, connect the meanings in those messages to their prior knowledge and experiences and respond personally, critically, and creatively so they make well informed choices in various areas of their lives.

Representing refers to creating, constructing, and communicating meaning to demonstrate learning and understanding through a variety of media and forms including drawings, sounds, pictures, movements, illustrations, charts, graphs, posters, murals, photographs, dioramas, puppets, sculptures, models, dramas, videos, sounds, and electronic text/graphics and be prepared for our increasingly technological society with its' demands for proficiency and expertise.

#### Learning, Community and Culture

Vygotsky (1978, 1986) identified the importance of language, specifically speaking and listening, as the primary medium for learning, meaning construction, and cultural transmission and transformation. Interdependence of learning, as opposed to independence, is central to his view of an individual's interactions with others and society as each creates and is created by the other. As Cole and Griffen (1985, p. 148) state: "Cognitive development was treated [by Vygotsky] as a process of acquiring culture." At the same time, Vygotsky believed that cultural development was a historical process, as noted through his emphasis on the significance of artifacts. This is echoed by Bruner who suggests that language and culture cannot be separated. He

claims "...thought is shaped by the language in which it is formulated and/or expressed" (1996, p. 18). Moreover he states, "Culture shapes the mind... it provides us with the toolkit by which we construct not only our worlds but our very conception of our selves and our powers" (1996, p. x). This orientation presupposes that human mental activity is neither solo nor conducted unassisted, even when it goes on:

'inside the head'...learning in most settings is a communal activity, a sharing of culture. It is not just that the child must make his knowledge his own, but that he must make it his own in a community of those who share his sense of belonging to a culture (Bruner,1986, as cited in Britton, 1993, p. 306).

Societies use language to classify their surroundings according to their own needs and purposes (Malinowski, as cited in Britton, 1993). Similarly, Britton describes the unique labeling of particular elements such as colors or snow conditions as examples of how language and perception influence each other and evolve through cultural significance. Classifications create a system which includes relationships amongst words such as synonymy, oppositeness and a hierarchy which help to order our thinking and allow for higher level thinking such as reasoning. Thus, it is through language and culture that children acquire both knowledge and the processes of making sense of this knowledge, which in turn can be used to create those mediational tools of language and artifacts, also referred to as the tools of intellectual adaptation; speech, concepts, content knowledge, strategies and technologies which have been embedded in cultural history.

Bruner (1996, p.3) states:

Although meanings are in the mind, they have their origins and their significance in the culture in which they are created...Meanings provide a basis for cultural exchange. ...On this view, knowing and communicating are, in their nature, highly interdependent, indeed virtually inseparable.... It is culture that provides the tools for

organizing and understanding our worlds in communicable ways.

Formal instruction in school develops a continuation of growth and refinement of a child's language. However, this instruction "must merge into the processes of learning that begin at birth and are life-long" (Britton, 1993, p.129) in order to build upon and extend the child's existing schema and ultimately, his or her unique world view.

Consequently, Britton suggests that "the notion of 'providing vocabulary'" (1999, p. 163) to students during reading is both limited and misleading as it is in the flow of language and contextual use of words throughout many oracy and literacy experiences that words take on meaning and students develop personal understandings. Rosenblatt, 1995, claims that understanding even one word requires a "framework of ideas about humankind, nature and society" (p.196). In fact, the most powerful words (*love, have, reason*) grow in their usefulness for readers and writers as they seek to understand and be understood. Students must continue to use their own language to make sense of the world and not to simply repeat what has been taught to them. Experiences require a construction so that interpretation of these events can take place. "Interpretation implies making something new of the experience in the light of what is already familiar: but it implies, in addition, modifying the total picture towards being consistent with the new" (Britton, 1993, p. 73).

## Cultural Capital and the Creation of Self-Identity

Residing within each child's unique, verbally-organized world schema (Britton, 1993, p.28) are elements such as culturally-rooted behavioral, interactive and communicative norms as well as the social values that influence these norms. Examples of these behaviors and ethics include non-verbal cues and mannerisms such as conversational wait-time, turn-taking and making eye contact during conversation, the ways information is shared, and the ethics of non-competitiveness and non-interference. Because of the role culture plays in developing these norms, expectations may differ between the home and school experiences of a child (Huffman, 2001 as cited in Nickels & Piquemal, 2005). Aronowitz & Giroux (1993) refer to those sets of linguistic and cultural competencies such as communication [discourse] styles, language forms, modes of thinking, tastes and styles that make up specific social class interests as *cultural capital*, a term coined by Coleman (Moll, 2000). They suggest that schools legitimize, confirm and reproduce the forms of knowledge, ways of speaking and relating to the world used by the dominant cultural group through teachers' pedagogical styles, curriculum, and expectations while ignoring, disconfirming or devaluing the cultural experiences, and identity of less dominant groups. Cultural discontinuity arising from differing norms and values may have a significant effect on students' school experiences due to conflicts and misunderstandings and can even lead to school failure. "Students whose culture differs from the mainstream culture experience difficulties in their school experiences because they do not conform to how schools define what constitutes learning." (Nickels & Piquemal, 2005, p. 3). As Dewey (1963) suggested,



“Those to whom the provided conditions were suitable managed to learn...If [the pupil] engaged in physical truancy, or in mental truancy of mind-wandering and finally built up an emotional revulsion against the subject, he was held to be at fault” (p. 45, 46). This is supported through the work of Gee (1989, 1999, 2001a, and 2001b ) who describes how persons become socialized into many ways of communicating, including multiple literacies. He refers to the initial, family-based vernacular as a child’s primary discourse. Discourses are also related to the distribution of social, economic and political power in society, with dominant literacies referring to those comprised of powerful public sphere. Primary discourses are closely associated with a child’s sense of self, while secondary discourses build upon and extend the primary base. Gee also claims that reading and writing are shaped and transformed within various value-laden, sociocultural practices of thinking, knowing and believing as “people adopt different ways with printed words for different purposes” (2001b, p.30).

Tharp and Yamauchi (1994) group possible discordant cultural factors under sociolinguistics (the discourse, conversational or communication styles already described), cognition, motivation and social organization. Cognition relates to the particular manner of learning that is valued in a culture. Traditional classrooms tend to encourage a verbal, analytic cognitive style while some students may prefer strategies that relate to a holistic visual way of thinking.

The valuing of one set of cultural expectations over another creates what Erickson (1987, in Hufmann, 2001) calls cultural borders. Minority students that actively resist and reject messages of cultural inferiority demonstrate resistance theory in which they move from alienation to disengagement in a series of stages that Huffman (2001) refers to as a Process of Estrangement. However, students whose cultural capital is affirmed and valued, and who come to understand the discontinuity that he or she might feel, may learn to operate within two cultural systems and reach full participation in schools. Gee (2001, p.22) claims, “What upper-middle class parents create for their children and what... schools reproduce is a certain “way of being in the world”...to which only certain people have access or allegiance.”

Social constructivism recognizes that all learning is socially, and thus culturally, mediated through persons, language tools and other artifacts. In addition to the cultural background(s) that comprise a student’s home life and community, each school and classroom also creates a culture based upon expectations, norms and means of interacting.

Wells (2000) describes learning as transformations that occur during engagement in activities with others. These include the transformation of an individual’s identity and in their way of participating collaboratively as well as the transformation of the tools and their uses, and transformation of the situation itself. Learning thus is part of community participation and not necessarily dependent upon teaching. Participants contribute to

solutions and also provide support and encouragement to other group members who may achieve more than they might individually. The role of language is central to this zone of proximal development (ZPD) to 1) coordinate and interpret joint activity as well as to 2) understand and reflect upon actions, persons, artifacts and their relationships (Britton, 1993; Bruner, 1990; Halliday, 1978, 1993; Lee & Smagorinsky, 2000; Vygotsky, 1962, 1978, and 1986 and Wells, 1999).

### Un-silencing Voices through the Tool of Critical Pedagogy

Schools play a role in legitimizing inequality, blaming victims (especially youth) and thereby further socializing students to accept political, economical, social and cultural injustices that are seen in our greater consumer-driven society which shapes education into commodity and trains students as workers to fill the needs and demands established by the corporate world (Freire, 1970, 1998; Giroux, 1992, 1994, 1996, 2000 and McLaren, 1998). Minority groups in particular are susceptible to factors associated with inequities such as homelessness, poverty, hunger, racism, unemployment, transiency, violence, abuse and powerlessness. While there are many concomitant factors that impact on our students' lives beyond the boundaries of the schools' mandate, the traditions and ways of doing things that are found in our Eurocentric educational system through the overt curriculum such as instructional methods, the resources and materials, the tracking and assessment practices; as well as the ways of interacting, the formal and

informal discourse and the roles assigned to the players which make up the hidden curriculum reinforce students' cultural capital and tend to perpetuate inequities.

Gee challenges educators to understand that the dominant and primary discourses of mainstream culture prevent non dominant groups from becoming full participating members despite the fact that these discourses may be learned as secondary ones. He believes that while primary discourses are acquired, secondary discourses (including literacy skills) are learned. He argues for educators to “ focus ...on how people, from childhood to adulthood, learn to leverage new school-based (and other public sphere) social languages- in speech, writing and action- to participate in, and eventually critique and transform, specific socio cultural practices (1999, p. 371) and to support both acquisition and learning through use within purposeful scaffolded activities as well as meta cognitive reflection. “To develop powerful literacy, students need to learn to critique the dominant or mainstream cultural discourse with its world view, through the lens of a secondary discourse” (Gee in Miller, 2003). This approach to language and literacy recognizes the myth of literacy as a cure for social and economic problems (along with the myth of education) and connects the perceived literacy crisis in the United States with the political and cultural issues of racism and poverty.

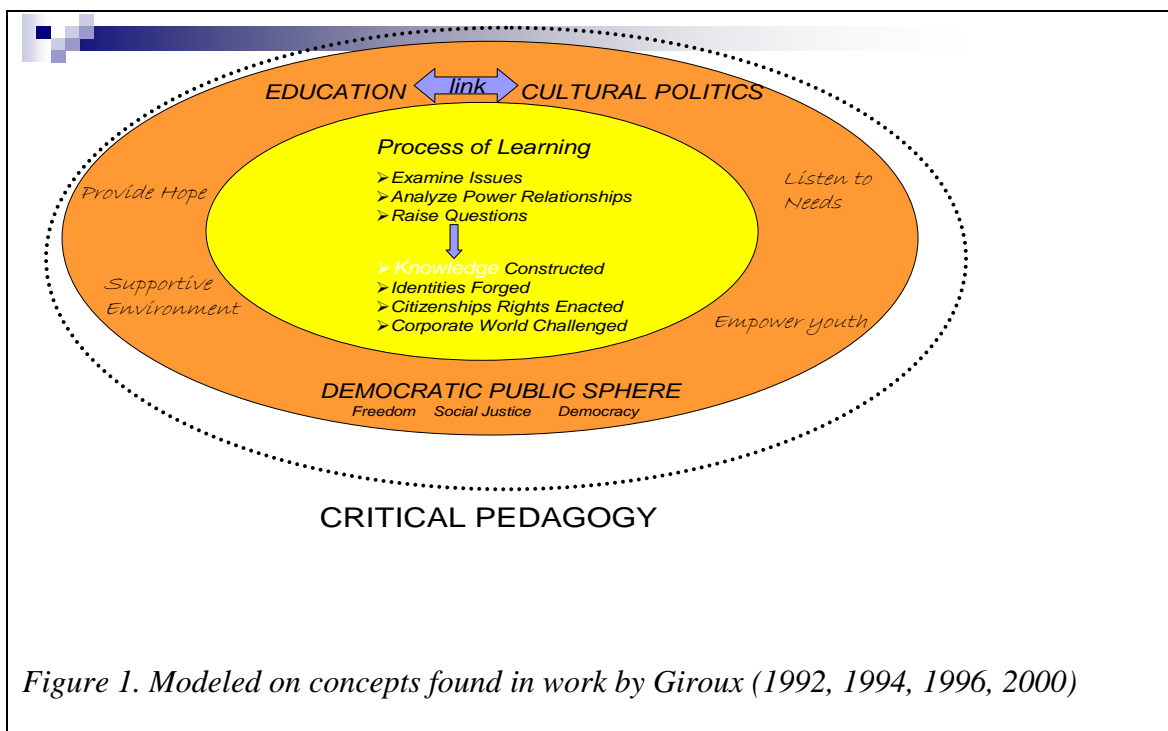
The theory of social constructivism, with its foundation of learning as conceptual transformation, supports the cultural-political tool *critical pedagogy*. Critical pedagogy attempts to change the structures of schools that allow inequities and can be a powerful

vehicle for teachers to support students in finding their voices and understanding the political, social, economic and cultural dynamics that impact upon their lives. The goal of critical pedagogy is to recreate those institutionalized practices and relations which reinforce particular values and obstruct active social membership. It seeks to release the oppressed and unite people in a shared language of critique, struggle, and hope to end various forms of human suffering. Through critical pedagogy, the classroom is not the place where information is dispensed by teachers and consumed by students, but rather becomes a site for the production of new knowledge grounded in students' lived lives. As such, it links social constructivism to issues of ethics, politics and power. Giroux (2000) suggests that it is teachers' responsibility to listen to students' stories, so that together they might begin to understand and give a language to the political, economic, social and cultural issues that impact upon their lived reality. Friere (1998, p. 72-73) claims:

Educators need to know what happens in the world of children with whom they work. They need to know the universe of their dreams, the language with which they skillfully defend themselves from the aggressiveness of their world, what they know independently of the school and how they know it.

To support students as they develop powerful literacy and learn to critique the mainstream discourse and worldview (Gee 1996), teachers must first unlearn their biases and decolonize their perspectives (McLaren, 1998). They, then, can support students as they learn secondary discourses of academic language. They can also, with their students, raise fundamental questions about issues that impact on society which arise in text, and consider these events within broader historical/social contexts. These

can then be connected with the stories of students' lives for at the heart of teaching for critical pedagogy is the witnessing and testimony of both students' and teachers' lives (Felman & Laub as cited by Giroux, 1996). This challenge proposes that "if teaching does not hit upon some sort of crisis, if it does not encounter either the vulnerability or the explosiveness of a (explicit or implicit) critical and unpredictable dimension, it has perhaps not truly taught" (Giroux, 1996, p. iv). As such, schools can also be sites for transformation through critical pedagogy that is embedded in a social constructivist theory which recognizes the influence of language and culture in the development of thought and the ongoing construction of an individual's world view.



### Critical Literacy: Helping Students Find the Edge

Embedded within Critical pedagogy is the concept of *Critical literacy* is an active, challenging approach to reading text which includes written, visual, spoken and

multimedia sources (Giroux, 1986). As a tool for bringing critical pedagogy into the classroom, it involves the analysis and critique of the relationships among texts, language, power, social groups and social practices. Critical literacy includes understanding that texts, like education itself, are not neutral but that they represent particular views and influence people's ideas while at the same time silencing other perspectives. Friere insists we need to teach children to 'read the word and read the world' (1998, p. xiii). The belief underlying critical literacy is that if language from multiple sources helps shape us into who we are, we can use it to remake ourselves and our cultures; to reconstruct ourselves in society.

Auerbach (1996) suggests a shift towards critical pedagogy and critical literacy takes commitment, time, a classroom atmosphere of trust to gradually encourage deeper student participation and a structured framework for eliciting issues. According to Giroux (1996) critical literacy as an active process includes a) providing time and support for critical engagement of text which emphasizes multiple readings, b) having students take a stance on issues c) providing students with opportunities to question and challenge the attitudes, values and beliefs that lie beneath the surface of the text and consider and clarify their own attitudes and values as they take social responsibility and d) by providing students with opportunities to take social action. Teachers can model this process for students as together they consider the purpose for the text and the composer's motives. Through this course of action, knowledge is constructed, identities are forged, citizenships rights are enacted and the corporate world with its' hypnotic

emphasis on consumerism can be challenged. Thus, further implications for school instruction point to critical pedagogy and critical literacy which identifies the deeper, covert factors that cannot be separated from literacy; nor from social action. For, as Gee claims, we cannot discuss literacy "...without discussing issues of identity, class, race, gender, privilege, equity and access" (Gee, 2001a).

### Learning in the Various Subject Disciplines

Since reading and writing are basically mental activities, and for the most part unobservable, students need to be engaged in talk about the processes as well as meta linguistic talk to make explicit the strategies involved. However, when students are learning within specific disciplines such as science with its own organization of thinking "talk assumes the greatest importance as the mediator of higher mental functions and in the appropriation and internal reconstruction of cultural knowledge" (Wells, 1992, p. 31). The constructive nature of learning within subject disciplines, particularly those of science and mathematics has also been recognized by Bruner (1960, 1990) and vonGlaserfeld (1989).

Bruner, Oliver and Greenfield (1966) view the great disciplines of history, mathematics, physics and other sciences as methods for the mind to use. Rather than a storehouse of knowledge, each provides a structure that gives meaning to the details of its discipline. Once a general understanding of a particular subject is reached, hypotheses could be



generated and then tested against experience. Therefore, the object of education should be to expose that structure as quickly as possible...to penetrate the subject by spiraling into it: a first pass to get the intuitive sense of it, and later passes over the same domain to go more deeply into it. And once the structure of the discipline has been absorbed there can be massive general transfer of learning. This demonstrates the generativeness of knowledge. As Bruner (1983, cited by Spencer, 1991) says “Knowing how something is put together is worth a 1,000 facts about it. It permits you to go beyond it.” To instruct someone should result in that individual understanding how to take part in the process of learning such as thinking mathematically or scientifically. Knowing is a process not a product (Bruner, 1968). A demonstration of understanding of concepts, of being able to embed an idea or construct within a broader framework of knowledge, is therefore, more important than mere performance (such as copying or reciting) in classrooms (Bruner, 1996).

#### Scientific and Everyday (or Spontaneous) Concepts

Concepts are abstract ideas that refer to objects within a particular category determined by their similarities, phenomena or the relationships between them. Vygotsky (1987) probes deeply into the relationship between what he refers to as, ‘everyday’ or ‘spontaneous’ concepts and scientific concepts. He believes that instruction in scientific concepts plays a critical role in the child’s mental development. To begin with, understanding the development of science concepts in children brings clarity to our understanding of conceptual development in general:

The development of scientific concepts in the school-age child is primarily a practical issue of tremendous importance for the school's task of instructing the child in a system of scientific concepts. However, it is also an issue of tremendous theoretical significance. Research on the development of scientific concepts...will inevitably clarify the most basic and essential general laws of concept formation. This problem contains the key to the whole history of the child's mental development (1987, p.167).

Scientific concepts differ from everyday concepts in four significant ways: 1) generality 2) systemic organization 3) conscious awareness and 4) voluntary control. They also contrast in the manner in which they are attained which is significant when considering the relationship between instruction and development (Wells, 1994). While everyday concepts develop spontaneously by the child through social interaction, and a growing consciousness of a particular object (from object to concept, an outward movement, from lower or simpler characteristics), scientific concepts develop along a different path (from the concept to the object, an inward movement from above or more complex characteristics) (Vygotsky, 1987, p. 219) and can "only be acquired as a result of deliberate and systematic instruction in an educational setting" (Wells, 1994, p.2).

Vygotsky (1987) explains how "The development of scientific concepts begins with the verbal definition," (p.168). Since "the development of concepts and the development of word meanings are one and the same process" (p.180), instruction can bring the meaning of language to a conscious level when it unveils the systematic relationships between word meanings. This enables the child to make the transition to a higher level of thinking (Wells, 1994). However, Vygotsky (1987) also emphasizes that

Instruction is only useful when it moves ahead of development. When it does, it impels or wakens a whole series of functions that are in a stage of maturation lying in the zone of proximal development. This is the major role of instruction in development....This is also what distinguishes the instruction of the child which is directed to his full development from instruction in specialized, technical skills such as typing or riding a bicycle (p. 212).

Certain points in the zone of proximal development (ZPD) appear to be more sensitive to instruction. "...these sensitive periods are associated with the social processes involved in the development of higher mental functions...which are an aspect of the child's cultural development and have their source in collaboration and instruction" (Vygotsky, 1987, p. 213). This notion has strong implications for utilization of Bruner's theory of a spiral curriculum to ensure that major tenants of a discipline are presented frequently to ensure that instruction meets the zone of proximal development of all students within a classroom.

Vygotsky (1978) also clarifies that the processes for the development of scientific and everyday concepts are "internally and profoundly connected with one another" (p. 219). In particular, the everyday concepts must attain a level of conscious awareness before the child can learn scientific concepts. Symbiotically, everyday concepts are also dependent upon scientific concepts which have already undergone a series of operations to create a conscious awareness of the concept. The link between these two lines of development represent "the link of the zone of proximal development and actual development" (1978, p.220). I believe this means that the process of intentionally

developing scientific concepts supports the transformation of the child's everyday concepts into a more complex system of relationships.

Research conducted by Panofsky, John-Steiner and Blackwell (1990) in a Grade Five classroom focused on the acquisition of scientific concepts and revealed the importance of teachers organizing knowledge in, what they refer to as, powerful and consistent categories so that students might come to understand the relationships among concepts. Students with the structural system in place were able to better able to process information and recognize, as well as group, new knowledge accordingly. This instruction must always build upon students' framework of understandings and model the process of coming-to- know. For, as Halliday and Mathiessen (1999) advocate, when we describe *knowledge* as *construing meaning* we replace the perspective of learning through transmission with a view of an active, interpretive journey of transformation for both students and teachers.

#### The Discourse of Science

Just as literacy is attached to specific cultural and social groups (Gee, 2001), literacy is also unique to various subject domains and contexts. The discourse within each domain is comprised of its own unique characteristics that reflect a particular way of thinking or conceptualizing and doing. In addition to its' unique conceptual framework and terminology, the passive voice, persuasive style and syntax of science differs from that of social studies or mathematics. Both the theories and practices of various disciplines

are created, developed, modified and maintained through the discipline's spoken and written dialogue; therefore, acquiring specific subject literacy is supported by an apprenticeship view in which literacy is acquired rather than learned as students use language to organize, recognize and internalize the principles, concepts and information they encounter (Thier, 2002).

The written domain of science, for example, presents unique features that can create challenges; especially for students whose primary discourse reflects a non-dominant world view. With its hierarchical system of relationships and concepts, metaphorical and analogical lexico-grammar, specialized sentence structure and field specific style (Smolken & Donovan, 2004) students may have difficulty gaining conceptual knowledge through science text and, consequentially, with using writing to further shape and share that knowledge. Barber, Catz & Arya (2006) claim:

The specialized language of science, or, linguistically speaking, the discourse of science, has its own vocabulary, structures of logical argumentation, and organization, that are embodied in the ways scientists communicate about their work (Duschl and Osborne, 2002; Kuhn, 1992; Lemke, 1990; Toulmin; 1958; Yore, Bisanz, and Hand, 2003). Postman (1979) even went so far as to say that "Biology is not plants and animals. It is language about plants and animals. Astronomy is not planets and stars. It is a way of talking about planets and stars" (p. 165). Osborne has placed special emphasis on the discourse of argumentation as central to scientific pursuit and suggests that "science without literacy is like a ship without a sail"(p.5).

Bybee (2000) describes Dewey's address to the American Association For the Advancement of Science in 1910. Dewey's theme, according to Bybee was that science teaching placed too much emphasis on content and the acquisition of information and

not enough focus on science as an attitude of mind, a method of thinking. “Science teaching has suffered because science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject-matter” (p.25).

The linguistic and conceptual features associated with science literacy practice will only contribute to constructing subject knowledge and sharing that knowledge when viewed and understood within the relationships that exist between language, identity, and subject learning. Brown, Reveles and Kelly (2004, p. 800) believe that:

... identity should be understood as a resource as well as an artifact of classroom interaction. As students’ position themselves via discourse, they allow themselves to access specific knowledge and conceptual understanding that might otherwise be out of their reach. In this sense, science learning involves learning to construct one’s discursive identity in order to participate in science and its associated discourse. The appropriation of a scientific identity is demonstrated through students’ engagement in the classroom conversations, as well as the broader discursive practices that lead to the development of new conceptual knowledge. In this way, science literacy development can be seen as a dynamic social process that is co-constructed through dialogic exchanges that also include choices and positionings regarding cultural affiliation.

They further state that:

...when considering the notion that all forms of discourse come to symbolize cultural membership and identity, science educators should not presuppose that all students access the literate practices of science free from complication. The use of scientific discourse, because of its presuppositions regarding sociocultural practices, challenges science educators to understand the complex affiliation between language, identity, and science learning (2004, p. 800).

In other words, science, like all discourses, is a cultural perspective, tightly interwoven with issues of language, identity and learning. Traditionally, school science has present-

ed an ideology that holds Western science as superior to other ways of knowing, according to Aikenhead (2000). He further states that the values and principles within this perspective include a view of science as non humanistic, objective, rational, empirical, universal, impersonal and free of cultural values. Our schools and classrooms are no longer the homogeneous groupings they may have been fifty years ago and within our transient and pluralistic society, where people move from one community to another, cultural perspectives may be at odds with these principles.

Aikenhead (2000) and Cajete (1986) suggest conflicts are created for students whose world view differs from the perspective of Western science. Cajete (1986, p. 189) describes this clash as the “mutalistic/wholistic oriented mindsets of ... the traditionally Aboriginal world view... on the one hand, and the rationalistic/ dualistic mindset of Western science which divides, analyzes and objectifies, on the other.” When assimilation into Western science is forced upon students who may not share similar meanings, values and beliefs, they many de-value their own cultural views, or they may reject Western science and as a result “will not possess the cultural capital to participate effectively in Western society” (Aikenhead, 2000, p.2). Thus, schooling continues to perpetuate the social and racial inequities of society through this cultural imperialism. In addition to the conflicting values and beliefs student may experience, scientific concepts are also typically presented from a Western science view. This perspective may present an entirely different system of conceptual relationships and constructs than the ones a child has identified with (Cajete 1986, p. 15).

## Student Inquiry

Inquiry-based learning has been widely advocated in subjects such as science, social studies and mathematics (Bruner, 1966; Dewey, 1938, 1962; Langer & Applebee, 1987, Wells, 2000; Well & Chang-Wells, 1992). While many teachers recognize the value of hands-on activities and experiences, it is often more expedient to have units, lessons and programs prepared ahead of time rather than involve the students in the process of inquiry. Dewey (1938) first and foremost maintained the importance of both student involvement and student purpose in initially determining which particular concepts to explore. Thus inquiry is as much about wondering and formulating questions to explore as it is about understanding a body of information. When students have ownership and purpose, and the goal of activities is on making (artifacts, explanations, ideas) learning is an outcome. Wells (1999) writes that interest in the material to be learned is the best stimulus to learning, rather than such external goals as grades or later competitive advantage. Bruner states this clearly:

The will to learn is an intrinsic motive, one that finds both its source and reward in its own exercise. The will to learn becomes a problem only...where a curriculum is set, students confined and a path fixed. The problem exists not so much in learning itself, but in the fact that what the school imposes often fails to enlist the natural energies that sustain spontaneous learning. - curiosity, a desire for competence, aspiration to emulate a model, and a deep sensed commitment to the web of social reciprocity (Bruner, 1966, in Cummins & Sayers, 1995, p.141).

Interestingly, Britton (in Nystrand, 1977) suggests that all learning is approached in a scientific manner. He uses ideas from George Kelly (1963) who believes that all men behave in what is essentially the way a scientist behaves. Formulating hypotheses, or making predictions, putting them to the test and then reframing them is a process of



scientific inquiry characteristic of most human behavior. If this is a natural way of learning, it presupposes that learning in the various disciplines, particularly in science should be based upon an inquiry approach.

### Dialogic Inquiry

Not all hands-on activity is inquiry-based, nor does it guarantee meaningfulness. Many classrooms encourage students to engage in a variety of activities, and knowledge is constructed by individuals but talk is only used for expression of thought and to communicate, not as the medium to shape, develop, validate and modify learning in transaction with others. Wells and Chang-Wells (1992) refer to this as the construction of meaning through dialogic inquiry. They state, “Even in the most traditional classrooms, teachers make provision for some hands-on experiential learning and include discussion as part of the repertoire of activities, though in both cases keeping firm control over the knowledge that is constructed in the process” (p. 28). There still exists the prevailing view that knowledge like a commodity can be stored either in minds, texts and other artifacts; that it can be transmitted from one person to another; that it can also be itemized, quantified and measured. On this transmission-oriented view, classroom dialogue is, not surprisingly, seen as an unnecessary waste of time; all that students need to do is to read and listen attentively to the knowledge conveyed through authoritative texts and lectures and absorb and remember it for subsequent reproduction.

Wells (2001) refers to two notions of Bakhtin's work on dialogic discourse which ties in with Vygotsky's theory of language and thought: 1) "Responsivity" describes every utterance as relating to, and in anticipation of, the next response and 2) every utterance is "multi-voiced", our meanings and intent are taken from other individuals' constructions as well as our own. The mediating role of dialogue for the co-construction of knowledge between students and teachers is called the discourse of knowledge (p.186). Written discourse is another means of mediating this knowledge building process and contains a dual dialogue as the writer anticipates the audience while directing himself. "...*knowledge building takes place between people doing things together* and at least part of this doing involves dialogue" (Wells, 2001, p. 186, italics in the original).

#### Implications for Instruction

Social constructivism obliges a curriculum that is both exploratory and collaborative, and includes negotiated activities along with various supports to challenge students as they stretch to reach meaningful, personal goals. This notion of organizing for an inquiry community allows for learning of all content, concepts and skills independent of culture. Classroom practices can validate the experiences students bring to school and can encourage them to have an active voice rather than silencing them by ignoring their cultural capital (Aronowitz & Giroux, 1993). Understanding and honoring the norms and values that may have shaped students' earliest behaviors and building upon the

resources found within their communities provide students with a better chance for academic success (Aikenhead, 1996, 2000 and Cummins, 1986 as cited by Nickels & Piquant, 2005) and encourages all students to learn about and be respectful of various backgrounds, perspectives and styles within our pluralistic classrooms, neighbourhoods and greater global society.

### Conclusion

The literature review clarified theories and concepts for me. It supported my growing envisionment of a social constructivist conceptual framework for classroom practice, and the significance of language, particularly dialogic discourse and inquiry in learning. Through my interpretation of the ideas within the literature review, I developed my own perspective which I refer to as my “Vygotskian” social constructivist framework. This framework included a) Knowledge as understood through Schema Theory b) construed through the central mediating role of the strands of language which are interwoven within a holistic language philosophy and c) the transformational cultural-political tool of critical pedagogy. These are orchestrated through an active, collaborative inquiry approach to learning. This ideal framework provided a lens with which I examined the reality of classroom interactions.

The role of language within this social constructivist framework could best be explored through qualitative research where students developed concepts within an authentic

classroom environment. As I performed classroom and student observations and sought to describe the science lessons, activities, and the three students' interactions with the strands of language, I had a theoretical grounding to heighten my awareness and continue to direct my own learning.

## CHAPTER 3

### METHODOLOGY

#### Introduction

The query framing this research was: How do three Grade Five students use the strands of language as they construct concepts throughout the course of a science unit? This qualitative research study used observation, open-ended questioning, interviews, discussion and field notes to learn about the literacy lives of three students including their interactions, understandings, assignments and related artifacts.

Qualitative research design was deemed most appropriate for this study in order to thoughtfully explore and understand the significance of language as three students developed knowledge in science. The primary goal of qualitative studies, which are descriptive, inductive, and naturalistic, is to make meaning of and to understand people's experiences (Bogdan & Biklen, 2003).

The participants attended a public elementary school in a mid-sized Western Canadian city. The school had been designated as a Community School, named so for the enhanced funding allocated to it through a provincial program which addresses

Aboriginal poverty in areas where there is a critical mass of students and families living in vulnerable circumstances (Saskatchewan Education, 2004). A classroom in this urban Community School was chosen to ensure that the participating students were from a variety of background experiences. In addition to being members of Saskatchewan Learning's *Assessment for Learning* project, a Grade Five class was selected in order to gain an understanding of the learning that occurs as children leave behind the world of picture books and move into chapter books and more formal content area learning. The need for students to be able to rely on the symbolic representation of print to create their own visual images as they build knowledge and concepts through increasingly decontextualized material is critical for their academic progress.

The Grade Five science teacher, chosen by the principal of the Community School, was the best source for providing me with the names of three students representing both genders, as well as varying backgrounds, interests and academic abilities.

During the course of the four week science unit I used various sources of data to learn about the language and literacy lives of these three students as related to the construction of science knowledge. As a teacher with more than twenty years of experience in the classroom, I observed these students during their class lessons, interviewed them individually, and met with them as a group to discuss and observe their interactions, understandings, studying, assignments, projects, language and literacy abilities and

related artifacts so that I might better come to know the influence that language had on their learning.

Three major sources of data were collected for this research:

1) I met individually with the three students on two separate occasions to build up a profile of each child's facility with language, as well as their conceptual understandings in science, through two semi-structured interviews, open-ended questioning, and several language-based activities. Data from these sessions was gathered via audio recordings, observations, artifacts and field notes.

2) In-class observations of students learning through language were made over the course of a science unit during four double science classes. For this reason, much of the data is presented within Chapter Four in a sequential manner, with several partial transcripts of in-class sessions so that the reader might follow my research journey as I attempted to build a sense of the ongoing development of conceptual understanding.

3) Additional data that influences this study is derived from an interview I undertook with the teacher, Mr. Stephens, regarding his philosophy and pedagogical practice, as it is the classroom context and culture established by the teacher that influences the reciprocity of the strands of language and supports the students as they construe meaning. The open-ended discussion format interview assisted me in gaining background information and understanding regarding the priorities and expectations of

the science program. (see Appendix F: Sample Questions for Semi-Structured Interview With the Teacher).

The participants were observed during class lessons for dialogue, which included formal lectures as structured by the teacher, as well as spontaneous talk that arose during activities either between the students and their teacher or amongst the three students. I was also prepared to collect data during reading and writing activities so that I might gain understanding of the learning that was being developed through these language tools. Likewise, I anticipated observing and describing activities of viewing and representing as students worked on computers, as well as studied and created charts and diagrams.

In addition to observing the students as they learned about science, I used a combination of a semi-structured and in-depth conversational interview (Mishler, 1991) as a data gathering tool to provide a more complete picture. Semi-structured interviews in which the same general questions or topics were raised with the participants gave confidence of obtaining comparable data. In response to participants' comments, I also used open-ended questions along side the interviews as a probe in order to gather a wide range of perspectives. This also allowed me to obtain a richer and more in-depth understanding of the participant's way of thinking. These interviews were less structured than a typical interview and involved probing into topics that the participant brought up. (The semi-structured interview is the mode of choice when a researcher *knows what he or she*



*doesn't know* and can therefore frame appropriate questions to find out while the conversational interview is used to elicit discussion about opinions or values that the participant deems relevant or meaningful to the topic. Conversational questioning alerts a researcher to aspects of their topic that might otherwise be overlooked.) Questions related to the students' perspectives on learning science (see Appendix A: Sample Questions for Students) as well as the teacher's view of science teaching (See Appendix G).

The interviews (10 minutes per child and 30 minutes for the teacher) were audio-taped and transcribed. In keeping with respectful research, participants had the opportunity to read the transcribed interviews for clarification and signed a Transcript/Data Release (Appendix E). The participants had the opportunity to read what is said about their participation but identifying information was excluded.

Analysis was ongoing as I sifted through the data of both observations and interviews looking for similarities, patterns and connections using a constant comparative methodology. Through analytic induction, I was able to infer that events or statements were instances of the same underlying theme all the while keeping the research question in focus. As a researcher, I asked, "*Is this theme similar to or different from other themes?*" A similar technique was used in looking for patterns between the themes and categories by using the researchers' insights and knowledge of the subject area. The grounded theory that emerged was based

on the interviewee's inside view and the original voice of the interviewee was never abandoned nor compromised. Using social constructivism as the frame, the intent was that the research would highlight the role language and literacy plays in the construction of science concepts.

More intensive than the summary of the patterns was rendering the interpretation of the study which required the researcher to think in new and dialogical ways. Interpretation involved redesigning old categories, formulating new relationships by combining elements in novel ways, projecting beyond what actually existed, and conjuring up probable connections. The interpretive practice of sense-making was both artful and political. In this project, observations, interviews with teacher and students, and the involvement of research would provide triangulated data for trustworthy and authentic interpretation. It was critical that the findings were integrated with those of related and relevant studies, to establish how these results related to broader theoretical frameworks, to explicate what the study meant outside of the one context, and to make recommendations and transfer of knowledge to the local schools and policy makers.

### Ethical Considerations

Approval of research protocol was accepted by the University of Saskatchewan Behavioral Research Ethics Board, following the guidelines and templates that are listed on the website for University of Saskatchewan Office of Research Services

(2003). The proposal outlined the purpose and procedures, potential risks, potential benefits, storage of data, confidentiality, right to withdraw, questions, and the consent to participate (See Appendix R for Ethics Approval).

The researcher met with the families (parents and children) individually, as well as the teacher, to inform them about the research study and explained consent in detail and assent for children. Participants were informed about the expectations for the study. The participants were also informed of the data collection methods, the data analysis techniques, and the dissemination of information. Every effort was made to ensure the confidentiality and anonymity of the participants. In addition, it was explained to participants that they were free to withdraw at any time without a penalty and if so, all their data sources from interviews and observations would be destroyed. Informed consent was obtained from each participant who was read the consent form and given opportunity for questions. The participants signed the consent form to indicate their agreement to participate before the study proceeded. In the same manner, children had the consent read to them step by step. (See Letter of Consent Appendix C-Parents, Appendix D -Assent for Children and Appendix F for Teacher).

### Summary

This chapter included the introduction, research design, description of the population, research instrument, procedures for data collection, the data analysis, and the ethical procedures that I followed. All of these items constitute the

methodology that was used to research “*How do Three Grade Five Students use the Strands of Language as They Construct Knowledge through the Course of a Science Unit?*”

## CHAPTER 4

### DATA AND ANALYSIS

#### Overview

Data for the investigation of this paper were both collected and viewed through a framework of social constructivism which acknowledges the mediating role of language and literacy in conceptual development and knowledge building, as well as the social nature of learning and the significance of the role of culture in all learning. As well, critical pedagogy became a lens with which to view and consider the power issues that are interwoven throughout the integrated stands of language and literacy. In this way literacy is, in fact, multiple literacies which are deeply intertwined with issues of “identity, class, race, gender, privilege, equity and access” (Gee, 2001a, p. 30). For the purposes of data collection however, the definitions of six language strands as described by Saskatchewan Education (2002) as the mandate for provincial schools will be used.

Through observation and questioning I gained insight into each student’s facility with the language strands. While being in proximity to the students, I developed an understanding of the science concepts learned throughout the unit; attempted to

understand the science program, and followed the learning process as it unfolded for each child.

### The Students

I met with the parents as well as the students to share with them first hand the intent of the study. This also provided some insight into the students' backgrounds which was expanded upon through subsequent observations of the students as they were engaged in science sessions, language-based activities, and through individual interviews.

Tanya:

Tanya had attended the same school since prekindergarten. A brother in grade seven attended classes down the hall from her while, most days, her mom volunteered in the Community Room. With a history of excellent attendance, Tanya arrived for class every morning looking prepared for the day, hair usually held back in a tidy pony-tail. She had a shy manner along with a quiet voice. Her work was typically done in an exemplary manner. Mr. Stephens occasionally referred to Tanya's science binder as a model for me to examine.

Emily:

Another eleven year old student, Emily was a middle child in a family of three. She had a three year old sister as well as another one in high school not living with the family. She also had excellent attendance and little transiency. Emily had attended this school for grades 1 through 3. She then spent part of grade 4 in a northern community before

returning here to begin grade 5. She displayed a willingness to engage in conversation with me and an interest in the materials and activities in the science classes.

Jason:

Jason had been an only child in his family until the arrival of a new baby brother two months prior. Also eleven years old, he had attended the same school with the exception of grade 1. That year saw his program disrupted as he moved partway through the year and then returned in the spring. Mr. Stephens described Jason as a weak student, smart but disorganized. On a rating scale which described attendance as Perfect, Excellent, Good, Fair or Poor, Jason rated a Good. In addition to this, even though he lived less than a three minute walk to the school, Jason arrived up to forty-five minutes late many mornings as well as after lunch. This meant that while he was considered present for the day he often missed much instructional time.

### An Exploration into Scientific Concepts

Understanding how science concepts develop assists teachers to comprehend how concepts in general come to be learned. Furthermore, that understanding is necessary so that teachers can support students as they gradually construe meaning to create and recreate their representations of the world. For these reasons, I felt it was necessary to explore the manner in which the three students organized both everyday concepts and scientific concepts.

Believing that the three students would each have had diverse cultural and linguistic experiences and, as a result, their own unique world view I introduced two card sorting activities, as suggested by Panofsky, John-Steiner and Blackwell (1990). In their study, students sorted science cards, creating groupings that were either script-like (following familiar situational events such as a restaurant script or going-to-the-beach script) or organized by scientific taxonomies. In conclusion, the researchers believed that an analysis of the everyday concepts found in kitchens is a better indicator of home and out-of-school language influence on conceptual development, while categorizing the science cards is more likely to be influenced by past teaching. The activities I introduced included:

- 1) everyday concepts presented through a collection of kitchen items, and
- 2) scientific concepts which focused on common plant and animal labels.

Results of the sorting activities did indicate very individualized and unique ways of conceptualizing, organizing and labeling categories with various connections, relationships, and linguistic terms unique to the students' own perceptions. There also seemed to be a correlation between the students' linguistic abilities and their ability to group items conceptually and justify broad meaningful categories.

#1 Everyday Concepts: Tanya sorted the kitchen cards into three piles which showed broad categories of related objects which she was able to define in a manner that spoke to those relationships; at one time even using the word "relate" in her heading.



<b>1. These are food and things that relate to food.</b> <i>(food)</i>	<b>2. These are things to put food on and to eat food with</b> <i>(dishes and kitchen linens)</i>	<b>3. These are things that cook and cool food</b> <i>(appliances)</i>
- cereal - salt - flour - ice - chicken - cat food - onions - ice cream - sugar - apples	- bowl - spoon - plate - knife - cup - tea towel - tea pot	- microwave - oven - blender - fridge

The activity also revealed possible language needs. For example, the word “appliances” would have been a handy label for the items *microwave, oven, blender* and *fridge* which Tanya grouped under the heading: “Things That Cook and Cool Food”. She also might have made use of labels such as “dishes” and “utensils” rather than “These are Things to Put Food On and Eat Food With.”

Emily created eight groupings of the twenty cards.

<b>1. Food</b> - cereal - chicken - ice cream - cat food	<b>2. Fruit</b> - apple	<b>3. flavor</b> <i>(baking ingredients)</i> - sugar - flour - salt	<b>4. Cold</b> - ice
<b>5. tea</b> - tea towel - teapot - cup	<b>6. plates</b> <i>(dishes)</i> - bowl - plate	<b>7. Plugins</b> <i>(appliances)</i> - blender - oven - microwave - fridge	<b>8. forkspoone, knife</b> <i>(cutlery)</i> - knife - spoon

The activity revealed surface relationships amongst the concepts. Four of categories: 1) “Food” 2) “Fruit” 3) “Flavor” and 4) “Cold” could have been grouped under one heading as all are edible items. The other four headings: 5) “tea” 6) “plates” 7) “Plugins” and 8) “forkspoon, knife” needed more accurate terminology or specific vocabulary to show broader relationships. The “tea” category, which included the words “teatowel”, “teapot” and “cup,” is a script-like grouping (tea as an event). The numerous categories indicated fewer relationships being recognized than revealed by the other two students.

Jason classified the kitchen items into six categories, requesting help from Emily as he was running out of time due to his late arrival.

<p><b>1. its sharp</b></p> <ul style="list-style-type: none"> <li>- blender</li> <li>- knife</li> </ul>	<p><b>2. cold</b></p> <ul style="list-style-type: none"> <li>- ice</li> <li>- ice cream</li> <li>- fridge</li> </ul>	<p><b>3. glass</b></p> <ul style="list-style-type: none"> <li>- cup</li> <li>- plate</li> <li>- bowl</li> <li>- spoon</li> </ul>	<p><b>4. get hot</b></p> <ul style="list-style-type: none"> <li>- oven</li> <li>- microwave</li> <li>- teapot</li> </ul>
<p><b>5. Food</b></p> <ul style="list-style-type: none"> <li>- chicken</li> <li>- onions</li> <li>- cereal</li> <li>- apple</li> <li>- cat food</li> </ul>	<p><b>6. Flavor</b></p> <ul style="list-style-type: none"> <li>- salt</li> <li>- sugar</li> <li>- flour</li> <li>- tea towel</li> </ul>		

However, he also spent some valuable time clowning (“Hmmm, a spoon could be glass.”). The labels were mainly one word titles such as “cold” and “glass”. Two of the categories may have been connected with safety (“sharp”, “gets hot”) and might reflect that focus from Jason’s recent babysitting course. One of the categories was script-like (“cold” was comprised of “ice”, “ice-cream” and “fridge.”) At least two items were

placed in questionable categories: “Tea towel” was classed as “Flavor” (a term he borrowed from Emily) and he hastily included “spoon” in the “glass” group. The labels used by Jason were very basic terms which lacked the sophistication or formality that Tanya used to convey relationships.

#2 Scientific Concepts: Twenty-nine labeled plant and animal cards were presented to each child with the instructions to classify or group them in as many categories as they thought seemed right. The students then sorted the cards into envelopes and they wrote their unifying concept on the back of each one.

Tanya created five formal categories, organizing them along scientific or taxonomic categories.

1. These are plants. - carrot - cattail - dandelion - apple tree - pine tree - fern	2. These are things that fly. - owl - butterfly - fly - robin	3. These are things that don't fly - lion - ostrich - cat - dog - horse
4. These are wild animals. - mouse - squirrel	5. These are sea animals and bugs. - bullhead fish - sunfish - spider - alligator - turtle - snail	- frog - crayfish - snake - lizard - salamander - earthworm

Her categories distinguished plants from animals and included a pair of antagonistic categories (fly/ don't fly), as well as overlapping categories

Emily created 9 taxonomic categories:

1. They all are plants. - dandelion - apple tree - pine tree - fern	2. They fly. - owl - butterfly - fly - robin	3. They run fast - ostrich - dog - horse	4. Because they look the same - lion - cat -cattail
5. They both go slow - salamander - lizard	6. They climb up trees - spider - mouse - squirrel	7. They slither around - earthworm - snail - snake	8. They both swim -bullhead fish - sunfish - crayfish - alligator - turtle - frog
9. It's a fruit - carrot			

Her categories distinguished plants from animals and included a pair of antagonistic categories (fly/ don't fly), as well as overlapping categories. The numerous categories indicated that Emily sorted objects into more isolated groups that showed fewer relationships or connections than shown in the categories made by Tanya or Jason. Six of these categories related to locomotion. She apparently did not know the meaning of "cattail" although the word is not uncommon in a community that includes nearby river and slough land. It is unclear why she used the word "both" to label a category with six items.

Jason created 6 taxonomic categories. Two of these categories related to habitat while three categories were associated with locomotion or function. The "underground" for the plant category is not an appropriate label but perhaps used as a parallel to the grouping of animals that live underground.

<b>1. They all grow underground</b> - dandelion - apple tree - pine tree - fern - carrot - cattail	<b>2. They all fly</b> - owl - butterfly - fly - robin	<b>3. They run fast</b> - ostrich - squirrel - mouse - salamander - lizard
<b>4. They all swim</b> - sunfish - bullhead fish - crayfish - snail - frog	<b>5. They all have teeth</b> - dog - lion - cat - horse - snake - alligator	<b>6. They live underground</b> - earth worm - spider

A third type of card sorting activity was done in an attempt to see how the students negotiate grouping the items and possibly influence each others' conceptual thinking. I referred to this as Group Sorting of Science Concepts. Rather than discuss and negotiate headings and groupings, the students each determined a heading similar to one they had sorted the cards into before, and then looked for cards to fit within their heading. In fact, the activity became somewhat competitive as each student attempted to sort as many cards into categories as they could before the others could take them for their groupings.

<b>1. Plants.(T)</b> - dandelion - apple tree - pine tree - fern - carrot - cattail	<b>2. Things that fly. (T)</b> - owl - butterfly - fly - robin	<b>3. It swims (J)</b> - turtle - bullhead fish - sunfish - alligator - crayfish
<b>4. They climb up trees (E)</b> - spider - mouse - squirrel - salamander	<b>5. They slither around (E)</b> - earthworm - snail - snake	<b>6. They jump (T)</b> - cat - lion - horse - frog

Sorting and classifying the kitchen as well as the science objects did demonstrate visibly that, even with concepts that the students may have had instruction with, all three created unique and individual groupings, indicative of their own view of the world. As they develop more awareness of the concepts along with the distinctive features and linguistic descriptors of objects found within specific subjects, the students will begin to perceive, manipulate and categorize them in more expert ways that are typical of the framework associated with that particular discipline.

### The Setting

Science classes during the unit were always conducted in the school science lab, down the hall from the students' homeroom. The lab had a raised platform or stage in the front of the room with a counter and a sink. This formal area was used only if a group of students needed additional space to work on their activities. Otherwise, lessons were 'conducted' from the front of the classroom, in front of the counter. A small moveable chalkboard was also available at the front of the room but wasn't utilized during the lessons that were observed. Although the perimeter of the classroom was lined with work counters and equipped with various materials needed for discovery learning, science lessons were 'conducted' from the front of the classroom as the students listened to the teacher while sitting in desks lined up in single rows.

## The Science Program

Mr. Stephens had previous experience teaching science in the middle years. Observations of his classroom practice as well as his answers to open-ended interview questions revealed a pedagogical philosophy and practice shaped by a transmission-oriented perspective of teaching. This was manifested through routines which relied upon commercial kits or handouts accompanied by univocal lectures as groups of students were guided through activities. Units of study were described as a myriad of, what appeared to be, stand-alone activities rather than as concepts to be learned. Mr. Stephens' views on curriculum integration reflected the course of science as a subject separate from other disciplines and not connected with students' prior home and community experiences.

Organizing the class into groups facilitated the set up and distribution of materials for experiments and helped him teach new students class routines and how to complete activities. While group work has proven to be a powerful strategy for generating questions, facilitating discussion and exploring ideas and sharing and shaping conceptual knowledge as students dialogue amongst each other (Applebee, et al, 2003; Britton, 1993; Bruner, 1990; Everson, 1991; Halliday, 1978, 1993; Lee & Smagorinsky, 2000; Moll & Greenberg, 1990; Wells, 1999, 2000; Halliday, 1978, 1993; Nystrand, 1986; Vygotsky, 1962, 1978, 1986) these benefits were not mentioned by Mr. Stephens.

Activities such as note taking, vocabulary study, completing the steps and procedures on lab sheets, and reading study sheets, for the most part, indicated a narrow definition of language and literacy in which the strands were seen as tools to support the completion of assignments on a superficial level rather than as linguistic and cognitive processes to support the inquiry and construction of science concepts and competencies.

Mr. Stephens' comments indicated his desire to include and involve all of the students and to ensure their success on tests. However, the perceived efficiency of whole class instruction, which is often justified by teachers who consider this to be a means of inclusion (Edwards & Mercer, 1987 as cited in Wells, 1999; Graves, 1983; Langer & Applebee, 1987; Nystrand, 1997; Wells, 1999, 2000 and Wells & Chang-Wells, 1992) ignores each student's background knowledge, learning styles, specific abilities as well as the unique linguistic and cognitive needs of each child. Adaptations and modifications of instruction, materials, environment and assessment, which are used to address the unique needs of individuals, were thus not seen as necessary features of Mr. Stephens one-size-fits-all program. Street (1984, 1995, 2005) refers to this pedagogical perspective, which also disregards the social and cultural assumptions of literacy but rather presents Western concepts as global and universal truths, as *autonomous learning*.

Evaluation of student learning was primarily through pencil and paper tests based on memorization and seat work. While Mr. Stephens did comment upon the fact that some students had difficulty with tests, he did not support them with alternative teaching



strategies or program adaptations and modifications. Rather, he put the onus on them to try harder. He didn't connect their poor performance with his scripted lecture-based commercial program or with an answer-oriented view of student-success rather than student learning. When discussion revolved around obstacles or frustrations, no mention was made of issues which are often related to individual students' success such as transience, attendance, or low language and literacy skills. Rather Mr. Stephens' concerns were about student management and safety. Moreover, when asked about the types of supports that would be helpful in his class he highlighted the need for more time to complete the many tasks involved in researching experiments and purchasing materials for the activities rather than a request for assistance with students who were having difficulty understanding concepts.

While his program could be described as hands-on and activity-based learning through small groups, my growing envisionment of Mr. Stephens' philosophy and practice highlighted science through a transmission-oriented pedagogy where knowledge was delivered to students through commercial materials and the teacher's lectures. These were followed by closed activities and prescribed assignments where students attempted to replicate a model correctly. This illusion of hands-on, collaborative exploration masked the true intent underlying the activities which was ultimately to complete them correctly as defined by the packaged program.

Immediate questions that were raised by this included: 1) what concepts would be presented and 2) how would students develop and display an evolving understanding of

them? 3) How would this learning connect with other units the students had studied? 4) Which language strands would be observed? And finally, 5) why were so many students having difficulty with the tests? Was the learning during the science units authentic or was it related to a Grade Four slump?

### In-Class Sessions I and II

Mr. Stephens invited me into his class for a series of lessons which he called “Solar Cars.” Two related but vague goals that he had for this new unit were for the students to learn a little bit about solar power and to have fun. The series of lessons was comprised of two main components: 1) students in pairs built a solar propeller with the purpose of investigating both wave length and amount of sunlight; 2) students in groups of three assembled a model of a solar car. I was not clear on how building a solar car would support the process of understanding about solar power.

Mr. Stephens then handed a three page document to each student which was a photocopied package called *Project: Effects of Amount and Wavelength of Light on a Solar Cell* (see Figure 2). Set up like an experiment, this commercial document represented a hybrid of literacy with two labeled diagrams, three images of the solar panel, and a chart titled *What Did You See?* nested amongst the text. It framed the instruction for the next several classes (See Appendix I: Solar Project Handout). While the source of this specific document is unknown as Mr. Stephens could not remember how it came to be in his collection of materials, a similar but more basic version of this

document was found within an online collection of solar projects created by Energy Quest, an energy education website of the California Energy Commission (see Appendix J.)

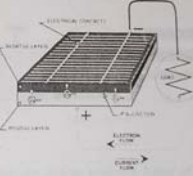
## PROJECT: EFFECTS OF AMOUNT AND WAVELENGTH OF LIGHT ON A SOLAR CELL

You've probably seen calculators that have solar cells - calculators that never need batteries, and in some cases don't even have an off button. As long as you have enough light, they seem to work forever. You may have seen larger solar panels - on emergency road signs or call boxes, on buoys, even in parking lots to power lights. Although these larger panels aren't as common as solar powered calculators, they're out there, and not that hard to spot if you know where to look. You have also seen solar cell arrays on satellites, where they are used to power the electrical systems.

You have probably also been hearing about the "solar revolution" for the last 20 years - the idea that one day we will all use free electricity from the sun. On a bright, sunny day the sun shines approximately 1,000 watts of energy per square meter of the planet's surface, and if we could collect all of that energy we could easily power our homes and offices for free.

### HOW SOLAR CELLS WORK

Solar cells, also called photovoltaic or PV cells, change sunlight directly to electricity. When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back. When a connector, like a wire, joins the two surfaces a current of electricity travels between the negative and positive sides. Solar cells are used to power calculators and watches as well as lights, refrigerators, and even cars.



## GLOSSARY

**Photovoltaic solar cells** - which directly convert sunlight into electricity, are made of semi-conducting materials. The simplest photovoltaic cells power watches and calculators and the like, while more complex systems can light houses and provide power to the electrical grid.

**Solar energy** - Energy from the sun. The heat that builds up in your car when it is parked in the sun is an example of solar energy.

**Direct radiation** - Light that has traveled in a straight path from the sun (also referred to as beam radiation). An object in the path of direct radiation casts a shadow on a clear day.

You will demonstrate how the amount and wavelength of light affects a solar cell.

### MATERIALS AND EQUIPMENT

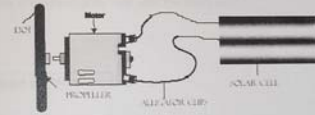
- Solar cell
- 2 alligator clips
- Electric motor
- Electric motor stand
- Propeller
- Double sided sticky tape (2 Pieces)
- Black marker
- Watch
- 1 sheet of black construction paper
- 4 sheets of colored transparency film in a variety of colors (red, blue, green, yellow)
- Pencil or pen
- Piece of cardboard



### PROCESS

#### Setting Up the Experiment

1. Attach the motor to the motor case.
2. Attach one piece of double-sided sticky tape to the bottom of the motor case and stick onto the cardboard so the end with the shaft hangs over.
3. Attach the plastic propeller to the motor by gently pushing the propeller onto the shaft of the motor.
4. Mark a small dot on the edge of the propeller. This dot will be used as a frame of reference to measure the speed that the wheel is spinning.
5. Apply the other piece of sticky tape to the solar panel and stick it onto the cardboard.
6. Attach alligator clips from solar cell to motor.



#### Doing the Experiment

- 1 Place the solar cell, motor, and wheel in normal light. Observe the spinning motion. (If the motor does not spin the wheel, check the wire connections.)
- 2 Using the watch and watching the dot, count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate on a piece of paper.

### HOW THE AMOUNT OF LIGHT AFFECTS A SOLAR CELL

- 1 Shade one area of the solar cell with the black construction paper. Record your observations on the chart.
- 2 Repeat the experiment shading different areas and amounts of the solar cell. i.e. 1/2 and fully covered.



### HOW THE WAVELENGTH OF LIGHT AFFECTS A SOLAR CELL

- 1 Cover the solar cell with a piece of colored transparency film. Count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate in a chart similar to the one below.
- 2 Repeat the experiment with the other colors of transparency film.



### WHAT DID YOU SEE?

How did the spinning motion change when you covered part of the solar cell? The entire cell? Which colors slowed the spinning the most? Which colors slowed the spinning the least?

Colors	Number of Spins per Minute
Sunlight	
Red	
Yellow	
Blue	
Green	
Black	1/2 covered=      fully covered=

Figure 2. Project: Effects of Amount and Wavelength of Light on a Solar Cell

For the next six minutes Mr. Stephens read to the students from the front of the room, occasionally going up and down the rows to make sure each child could see various items he held up that related to the reading, interjecting comments which connected the objects referred to with students' everyday understandings as well as to previous science activities. While he held up the materials referred to in the experiment, he did not demonstrate how they worked together to create solar power. Little to no dialogue accompanied Mr. Stephen's monologue although occasionally he asked closed questions of the whole class which required a specified answer. The students' role appeared to be to *listen* as he read the handout, *respond* as best they could to his comments and questions, and to *observe* his demonstrations. The handout for each child intended for them to follow along with the text and *view* the diagrams, the main purpose of which seemed to be to break up the text rather than add information and clarity to the process or extend an invitation to the students to explore their own or come to know on their own. This instructional pattern was repeated during several of the in-class sessions.

Here follows an excerpt from the first reading I observed Mr. Stephens conduct, along with his additional comments, and demonstrations:

*You've probably see calculators that have solar cells. They look something like this. Here's one from a calculator...you've probably seen some in calculators, even some in watches; look like a little piece of glass (Mr. Stephens held up a small solar powered calculator and walked up and down the rows to ensure each child could see it.) Calculators that never need batteries and in some cases don't even have an off button. As long as they have enough light, they seem to work forever. What happens when you cover them up? Cover up the solar cell, what happens? You may have seen larger solar panels – on emergency road signs or call boxes, on buoys, even in parking lots to power lights ... (So our) GLOSSARY: Photovoltaic solar cells which directly convert sunlight into electricity, are made of semi-conducting materials. The simplest photovoltaic cells power watches and*

*calculators and the like, while more complex systems can light houses and provide power to the electrical grid (See Appendix K for the remainder of the instructions).*

During the formal lecture Tanya, Emily and Jason appeared to be following along, turning the page at the right time, their eyes on the print but focused on Mr. Stephens as he moved between the rows with the calculator and when he asked closed questions of the whole class: *“Remember when we took atoms at the start of the year for those people that were here? And we talked about things like electrons and protons?”* These questions seemed to be asked to help students make connections with past activities and to keep them involved and listening. While they didn’t volunteer any verbal answers, the three responded to questions by acknowledging the linkages through nods or raising hands as if to indicate that, yes, they did remember; or perhaps they were simply responding in the manner they thought was expected of them. It was difficult to know if they were actually engaged in this listening activity.

Referring back to the handout, which included a diagram of a solar panel, Mr. Stephens began to list the equipment needed to build the propeller. As he named each piece, he held it up, occasionally offering further information about it. Students were organized into groups of two. After each pair had collected the needed materials, Mr. Stephens began to demonstrate how to build the model, this time from the side of the room. Students observed and listened for close to five minutes and then began to build a solar-powered propeller with their partner.

Although the teacher didn't refer to the handout again until the students were ready to test their models, the students kept it on their desks. A section called *PROCESS: Setting up the Experiment* listed six steps and was accompanied by a third diagram: an overhead view of the completed model labeled with "dot", "propeller", "motor", "alligator clips" and "solar cell." The last two images were of the solar cell with 1) a black rectangle covering a portion of it (to represent the black construction paper) and 2) the solar panel partially covered with what would be a transparency. None of these were given any explicit mention by the teacher.

The students were observed as they worked with their partners. Emily asked me for assistance with setting up the model. While she demonstrated knowledge of how to use the alligator clips, she needed support from her partner to determine which piece was the solar cell and which component was the motor. She referred back to the steps on the handout as she helped her partner put the model together but it was not clear if she was actually reading them. Jason was busy building his group's solar propeller. He seemed to understand how it would work. He said, "The light makes the energy go through the wires into the motor and makes the propeller turn." Tanya put the model together with her partner, scanning the steps described on her paper although she didn't appear to be actually reading. She showed confusion between the terms *cardboard*, which was needed as a base, and the *construction paper*, used to block the sun, and asked me for help. Her partner provided support through reading the steps and trial and error with assemblage of the components.

When the students had their solar propellers put together and tested in front of the heat lamps, Mr. Stephens organized them to head outdoors with their models and their handout. For approximately 15 minutes they tried their propeller models in the sunlight behind the school and printed a number in one space in a chart on the third page titled: *WHAT DID YOU SEE?*

<b>Colors</b>	<b>Number of Spins per Minute</b>
Sunlight	

In spite of a fairly strong breeze, all three groups had some difficulty getting the propeller to spin. Emily worked intently adjusting the connections but did not hold the solar panel at the best angle to receive maximum or direct sunlight. The students eventually counted the number of spins in 15 seconds and printed the number in the first space of the chart before returning to class. There was no discussion, writing, summary, reflection, wrap-up or closure of the lesson prior to the students being dismissed for recess.

#### Student Interviews

During interviews that I undertook with the students, individual strengths and interests became apparent as they described past and current science activities and language experiences in school. At the same time, several themes were uncovered including 1) the role of explicit language in learning, 2) disconnections and fragmentations, 3) a perception of learning as completing activities, and 4) the need for authentic purpose to engage students.



## Student Reflections on the Solar Propeller

When asked the following day to describe how their solar propeller worked, all three students relied to some extent on vague, nondescript language and utterances of only a few words, rather than descriptive sentences, about the parts of their solar model and the process of converting light to energy. This suggested that they had learned some labels for the components and had some understanding of the process but were not able to actually explain it. Had they been asked to reflect upon this process during class either by sharing it with another person or through writing about the activity, they would have had more success. As well, part of their reluctance to engage in conversation about their learning may also have come from the belief that school questions have only one correct answer. That, and their unfamiliarity with me and the process of interviewing may have also affected their explanations.

Tanya's Excerpt:

What did you think about the solar propeller?

*It was pretty neat*

Would you like to make a picture?

*Label it? (She decides to not draw) A piece of cardboard and then um...forget the... That piece...*

A solar cell?

*Yah, and then the alligator clips to put onto the solar cell*

Right and what other pieces do you remember?

*The propeller?*

What happened when you took it outside?

*It starts going around. Worked good...*

Can you tell me about your project in order?... start with the sun...

*The sun goes onto the solar cell...and it makes the propeller turn. Because that's energy coming in...*

Emily and Jason drew a diagram first, likely to help them remember the components. Visual reminders, or mediums, give shape and support to this ‘retelling’ activity by contextualizing an event in much the same way language transforms experiences and provides a symbolic means to view, manipulate, describe and further derive meaning from. Miller (1986, p. 32) suggests that “mental imagery is a key ingredient in creative scientific thinking” and should be encouraged in classrooms as students inquire and wonder, analyze, synthesize, reflect and share. Bruner (1983) believes that iconic modes of representation are recognized in the highest intellectual realms, and that they have been instrumental in numerous scientific insights and discoveries. It is of interest to note that both students drew the model as separate components and then attempted to label the parts rather than the completed model. This disconnectedness or view of separate pieces seemed to thread its way through the interviews and was also noticed as students shared their understanding of past activities in science and other subjects.

Emily's Excerpt:

The work you've been doing about the solar cell...what do think of that?

*It's cool...*

Would you like to make a picture about it?

*Want me to make a picture...Of all the stuff? (Draws all separate components...)*

Can you tell me about that all? All of the materials we needed ...how did they work?

*You have to connect these two wires onto this thing right here...there's like little things...sticking out...*

Do you remember what that was?

*...um... um.....*

The motor?

*Yah and this is the energy... battery. You connect these two things onto these two and make them connect these things right here onto the wires. And then they use these little sticky tak things. Put them onto here. Connect them to the cardboard and you have to put the propeller on right here*

On the end of the motor...

*You have to use this. You have to put this on. Use one of these things right there and stick this thing right here...*

The propellers on the cardboard here

*You have to use a green marker...to make the dot.*

What were these?

*You have to use these for the sunlight...to be able to see how fast they run.*

Those were...Remember what they were called?

*Transparencies?*

Those color sheets?

*Yah and black construction paper*

What was that for?

*You have to...cover it all the way...cover it...this thing whole... and try to put it in the sun...we didn't have enough time.....*

Do you have an idea how the transparencies would make the solar cell work differently?

*No*

If we start with the sun; the sun shines on the...

*The.... battery...*

And then what happens?

*The energy goes through these things...and to these...*

...The motor ...

*and then connects to that.*

Jason's Excerpt:

Do you want to make a picture about the solar cell with the propeller you made?

*I'll draw...I can't draw too good. This is the panel...*

Do you remember what else it was called?

*...uhhh*

That was a solar cell but the word panel is excellent...

*Alligator clips (as he's drawing)*

What were those for do you remember? The alligator clips...

*Connect the panel to the motor.*

What do you think is inside that motor?

*Gears...should I draw them?*

Just draw what you need to help explain...

*(Jason shades in the propeller with his pencil.)*

It (the propeller) gets dark. Do you remember how come?

*Because the dot's going around.*

Can you tell me, starting with the lamp, how this model works?

*This gets hot...goes through wires into the ...motor...*

That made the gears turn? There was also a piece of construction paper...

*There was construction paper and ...*

Transparencies? The colored ones?

*Yah*

What do you think those are for?

*Make the propeller go.*

Yes good! Why four different colors?

*Hmm. Don't know...To see if they'll get hot...*

Is using transparency different than using construction paper? Would it make a difference in the sun?

*Yah, construction paper is thick*

Would it make the propeller turn faster or slower?

*...Slower*

So what is the paper doing to the energy coming from the sun?

*Blocking it.*

What else can you tell me about solar power?

*Ummm. Not sure.*

## Student Perceptions about the Science Program

I interviewed the students about their science program so that I might gain an understanding of some of the concepts they had been discovering this year and how these concepts would connect with this new unit on solar power. Not unlike their teacher, all three students described science as a collection of numerous hands-on activities; of *doing* but not *learning*. While much learning must have gone on as a result

of the various rich and interesting projects the students had been involved with, there was no hint of awareness that the general objective might be to learn related ideas or concepts. The critical need for reflection and reconstructing their experiences in order to transform information into knowledge through dialogue, drawing or writing was absent in their lessons.

Tanya's Excerpt:

What kinds of things have you learned this year?

*Learned how to make slime: forget what that....but... um...*

Borax?

*Yah and water and...*

Color?

*Yah.*

What other things did you learn besides slime?

*We got to go outside and get bugs and look at them under the microscope.*

What did you find out about bugs?

*Their legs are hairy.*

Were there different groups of bugs? Different kinds?

*Don't know.*

You learned about the light/ color wheel. What can you tell me about that?

*When you mix different colors together you get white.*

Tell me about how colors are made up of wave lengths.

*Don't know*

You learned about atoms?

*Yah and electrons, neutrons and.... protons?*

What else do you know about that? Did you make pictures?

*Posters about electrons, neutrons, protons. With partners*

Emily's Excerpt:

How come you made slime?

*I don't know...we just wanted to make it.*

You also studied about atoms? What can you tell me about them?

*...they are the things on that thing over there.*

Oh, on the periodic table there. Did you learn that chart?

*We got to do that with partners...we did number 14.*

"Si"...? What does that mean?

*I forgot.*

So you had to make a model of it?

*Yah, we had to draw it.*

So, those atoms, molecules, how do they fit into our life? Any idea?

*No.*

Did you learn about bugs?

*We didn't learn it...we just had these little containers. We got to go outside and pick up bugs and got to open them. Got to cut them...cut off a piece of them, put them on a glass thing...or plastic. Put water on it with a little dropper thing on the bottom...this thing...*

Tell me about colors...the color wheel...

*We put all these colors together. It was on that thing right there...we had to spin it...spin it fast and then it turns white.*

Did you make one yourself?

*No.*

What do those colors mean? What were they trying to show you by doing that?

*That thing...where the colors made white.*

That's going to be related to these transparencies here. The solar ideas that you're learning now... is that related to the color wheel?

*Ummm*

With the solar model you made, what does it mean: that you're going to look at the amount and wave length of light?

*Don't know.*

Jason's Excerpt:

Do you like science?

*Yah, learning about temperatures.*

Did you learn that last year too with all the equipment?

*Didn't have science.*

Gr 3?

*No...first year.*

What are your favorite topics or units you've studied? Are there some that you like a lot?

*Slime that was the best one.*

Why did you learn about that?

*To see how to make goo out of borax, water and food color.*

Did you learn about bugs? What did you learn about them?

*We got to go outside and look at bugs...they look different up close under the microscope.*

You learned about Color wheels...? What can you tell me about them?

*All the colors make white.*

What was it trying to teach you?

*How different colors work.*

Tell me what you learned about Atoms: electrons, neutrons...

*We made pictures.*

These solar ideas you're learning right now, how is it like other ideas you've learned?

*Not sure...*

How does it connect with the atoms?

*Not sure...*

### Student Reading and Writing Interviews and Activities

In addition to trying to understand the students' language abilities and conceptual framework for every day and scientific concepts, exploration into the students' competencies in the literacy strands provided me with insight into their ability to use and value print, both through reading and writing, to develop conceptual knowledge. This was important information because it was the document that guided the building of the solar propeller and, ultimately, the learning. While it had a central role in the science unit, I was unsure if the students were able to gain understanding from the text

independently or if they relied on listening to the teacher as he read, lectured and pointed out the components of the model.

Tanya

Tanya shared her reading and writing interests and abilities. She thought she was a good reader because everyone told her she was. She liked to read what she described as “fun stuff”. She had read all of her brother’s Harry Potter books and JK Rowling was her favorite author. When asked what type of books they were she called them chapter books. She explained that if she came to something she didn’t know while reading she would, “Try to sound it out.” But if the ideas don’t make sense she read the text over again. She believed that “sometimes” there was reading to do on a computer.

Tanya could read a paragraph about mass and matter from a handout (see Appendix L) in her science binder called *How Do Scientists See The World Around Them?* (MacMillan/ McGraw Hill Publishers, 1988, p. 112) without hesitation; and she used a variety of strategies such as reading ahead and rereading to complete a cloze activity created from the same passage (see Appendix M). Many of her word choices were either identical to the original ones or meaningful, grammatically correct substitutions which matched the context of the sentence as well as the rest of the passage and showed an understanding of the concepts presented. However, when asked to retell the ideas from the paragraph, she appeared to be searching for a correct answer, finally pointing to the first sentence and saying “This one.”



Tanya also read a sentence that she chose from the solar unit handout (Appendix I) but was unable to explain what the sentence meant:

*“You have probably also been hearing about the solar revolution for the last 20 years- The idea that one day we will all use free electricity from the sun.”*

Perhaps Tanya was not used to explaining her own ideas, as was required in a retelling which is a more difficult activity than filling in the blanks or answering specific questions.

A sample reading passage from Saskatchewan Learning (2004) for students at the Grade Five level was given to Tanya followed by multiple choice questions that required that students weigh all of the evidence to ascertain the best answer (see Appendix O.) After reading it silently, Tanya was able to answer only one of the three questions correctly. Nor did she understand what was meant by the directions “compare and contrast”.

Tanya had used a computer to write a ten a significant role for writing page mystery during her library class. Although she didn’t see herself as a good writer, when asked if she had trouble writing she said only with spelling. Any changes she made to her story were to do with editing the spelling and the apostrophes. She had also written a fairytale at home several weeks ago. She recognized that language arts, math and science might require different types of writing but that all three subjects needed “writing down for information” because, as she explained, “writing gets out more information.” I believe this meta cognitive statement made by Tanya indicated her insight that by writing to

herself, perhaps to organize her thoughts, ideas and opinions, she could figure out what she knew or was learning. Writing could support her when she was on the cusp of learning.

Emily

Emily enjoyed reading but was unsure if she was a good reader. She had read two Captain Underpants books from the library during silent reading as well as Magic Tree House with Jack and Annie. She owned one from this series along with comics but didn't know the names of any authors. Observations of Emily during a cloze activity on a recent science passage (See Appendix M) indicated that while she could fill in the blanks with words that were grammatically correct, her word choices did not always connect with the context of the rest of the sentence or passage. The main concepts that she missed included 'matter' "information' and 'senses.'

Emily read aloud a second paragraph from the handout on mass and matter (McGraw MacMillan Publishers, 1988, p113).

**Sometime scientists use special devices to observe very small things, or things that are**

*micro- microscopes*

*(repeated)*

**far away. They use microscopes to see very small objects such as cells. They use**

*telescorps telescopes star bodies. In space all...*

**telescopes to study the stars and other bodies in space. All the scientists in the pictures**

**on both pages are gathering information about matter.**

Her reading showed a lack of fluency and also incorrect intonation suggesting that she did not read at least two of the sentences as complete thoughts or ideas. Rather, like a phonetic reader, she seemed to pay attention to letters and words rather than ideas, reading letter by letter at the surface level and omitting punctuation which impacts on meaning. She appeared unable to integrate meaning and was still unable to share her ideas during a retelling activity in spite of being prompted.

Emily also chose a sentence from the solar project handout to read to me (Appendix I). She stumbled noticeably over the word *approximately*, sounding it out in chunks. She also missed the period which made the sentence sound like: we could use free electricity but only on a bright sunny day. Of most significance is that even though she knew that she had no understanding of the solar revolution, she did not use the context of the rest of the sentence to develop an idea, nor did she stop reading or show any indication that she was using strategies to make sense of the text. Instead, she just kept reading.

What does that mean?

*If we had the electricity for free... We can use the sun from the electricity.*

Do you now what they're talking about when they say...solar revolution?...

*No*

Emily was able to provide an answer to the first question that followed the silent reading passage by Saskatchewan Education but seemed unable to recognize the content differences in the other two questions (see Appendix O). Emily didn't understand what "similar" meant, nor could explain or give me an example of what was meant by "compare and contrast" as was required by the activity.

Emily volunteered that she had a computer at home but it was for games and didn't require reading. She thought that writing made it easier to learn science, "So you can you remember stuff. Look on your pages." She had written several stories at home from half to a full page in length by hand complete with illustrations. She didn't share them with anyone and they often got thrown away by her parents. She liked writing and illustrating birthday cards for friends. She seldom had problems with her writing ("only a little bit") and couldn't describe any changes that she ever needed to make.

Mention should be made of the interference that reading orally in front of an audience, particularly a researcher, may have on students' comprehension and interpretation. There is no real reason beyond the researcher's request to read, much less interpret the passage. Authentic purpose would presumably encourage a more concerted effort to make sense of text.

Jason

Jason's word choices to complete a science passage from a previous unit were generally not grammatically correct nor did he attempt to create a coherent and meaningful whole within the passage. It appeared the activity was done in haste with little rereading, which is a critical strategy if a reader is reading for meaning and attempting to gain understanding of ideas and concepts through text.

Jason was not available to complete the oral reading/ retelling activity on Matter. He did, however, choose a sentence from the solar handout, reading fluently and confidently:

*“You’ve probably seen calculators that have solar cells- calculators that never need batteries, and in some cases don’t even have an on off button.”*

When asked what it meant, he offered, “They don’t make them with batteries on them.” This was surprising. Rather than summarizing the idea the sentence was conveying (that some calculators rely exclusively on solar energy) Jason chose one aspect of the sentence, likely because it had a tangible feature he could best relate to: the batteries. He also spoke using three pronouns in the eight word sentence implying that I knew the passage and that there was only one correct answer. This vague answer with minimal wording could be interpreted in several ways so one doesn’t really know what Jason was trying to say. Backing up his response with detail from the passage would likely provide a strong challenge for Jason who would benefit from having this critical habit modeled for him.

#### In-class Sessions #3 and #4

Mr. Stephens introduced this session by explaining that the wind had been affecting the propeller movements so the experiment would have to be moved indoors. They could use the school’s overhead projectors because “they have...” Several students chorused: “LIGHTS!” which indicated that they knew the light would provide the energy or at

least help with the movement. However, while Emily, Jason and Tanya were observing Mr. Stephens and appeared to be listening, they didn't call out with the others. Mr. Stephens continued to explain "We're going to do this one step at a time...We're going to test our equipment again and then do our experiment." According to their handout, this part of the experiment was to focus the students on the effect the different wave lengths, made visible by the color transparencies, had on the amount of energy the solar panel produced.

The students moved into pairs and, while one person retrieved their solar propellers and began checking the components and making adjustments, the other set up an overhead projector. Jason knew the alligator clips needed to be attached onto the exposed wire, not on the plastic covering. Emily revealed her curiosity by experimenting with the clips, attaching them all together to see the effect as she wondered "Maybe it will stop."

When asked, the three shared their predictions about using the construction paper and the transparencies to cover on the solar panel which showed they had a fairly good idea of what the experiment was trying to show. Tanya thought the construction paper would prevent the propeller from spinning, Jason suggested the propeller would "kind of work" when covered half way and Emily believed the yellow transparency "...will work good, green will work the least." As they placed the transparencies and construction paper over the solar cell and counted the spins, they filled in the table.

*WHAT DID YOU SEE?*

<b>Colors</b>	<b>Number of Spins per Minute</b>
Sunlight	
Red	
Yellow	
Blue	
Green	
Black	

Mr. Stephens had the students return to their desks and then he spent seven minutes orally summarizing their findings. He had each leader call out the number of spins their propellers had made in each category, and he repeated their answers, comparing the color paper results with the original ‘sunlight’ data. Without a written record of the findings, as in a group chart on the board, it was difficult to stay focused, to see the patterns emerge, or to follow the discussion. Tanya appeared engaged, viewing the handout, and wanting to contribute as was shown by putting her hand up. Emily followed along on her chart while Jason did not appear to be listening. His eyes were down and he did not participate in the exchange of information and data.

Without encouraging predictions, discussion, questions or reflections by the students,

Mr. Stephens summed up the lesson orally:

The transparencies are letting other colors through, and reflecting their color back to us...like the green was reflected back to us. It will let some colors through and block others. It works best when all sunlight gets through. We’ll do further testing next time when we build our cars in teams or groups.

This summary stood alone, fragmented as had the reading and the experiment, seemingly unrelated to knowledge the students may have had about solar power in the world

around them, nor connected with the car they would be assembling. In addition to the valuable activity of writing upon a chart so that all might follow the results and understand the intent of the experiment, this would have been an opportune moment to have the students articulate, either to a partner or in a journal, their own understandings of what this portion of the unit had been about. Nystrand (2006) refers to Vygotsky's theory of sociogenesis which states that "cognitive growth is more likely to occur when one is required to explain, elaborate and defend one's position" (Vygotsky, 1978, p. 158). I believe this can be extended to more than taking a stance on an issue. The moments when much of the learning occurs are during times when students are explaining, elaborating and simply reflecting. As well, a discussion about the scientific process or the terminology of the concepts "compare and contrast" would have made the scientific process more explicit for the students and would thus, have supported further thinking in a scientific manner.

Before dismissing the students Mr. Stephens demonstrated the parts they would need to make their solar vehicle, while making reference to a previous science unit on machines.

This is an axle. Remember we learned all about it? During our unit on simple machines? Axles and gears...Make sure your axles are going to be working smoothly on your car wheels.

He also attempted to extrinsically motivate the students through a competition, promising a prize for the group that could assemble the fastest car.



## In-Class Sessions #5 and #6:

Today there were 16 of the 23 students in attendance. Mr. Stephens organized them into groups of three, placing Tanya, Jason and Emily together. One student handed out a commercial kit for building the solar cars to each group. The students were told to take out the instruction booklet (see Figure 3) called Pitsco's Solar Designer's Kit. (See also Appendix N.) The left half of the sheet featured seven steps to assembling a solar car. The right side had three diagrams (called Figures) of the components and one of a completed model.

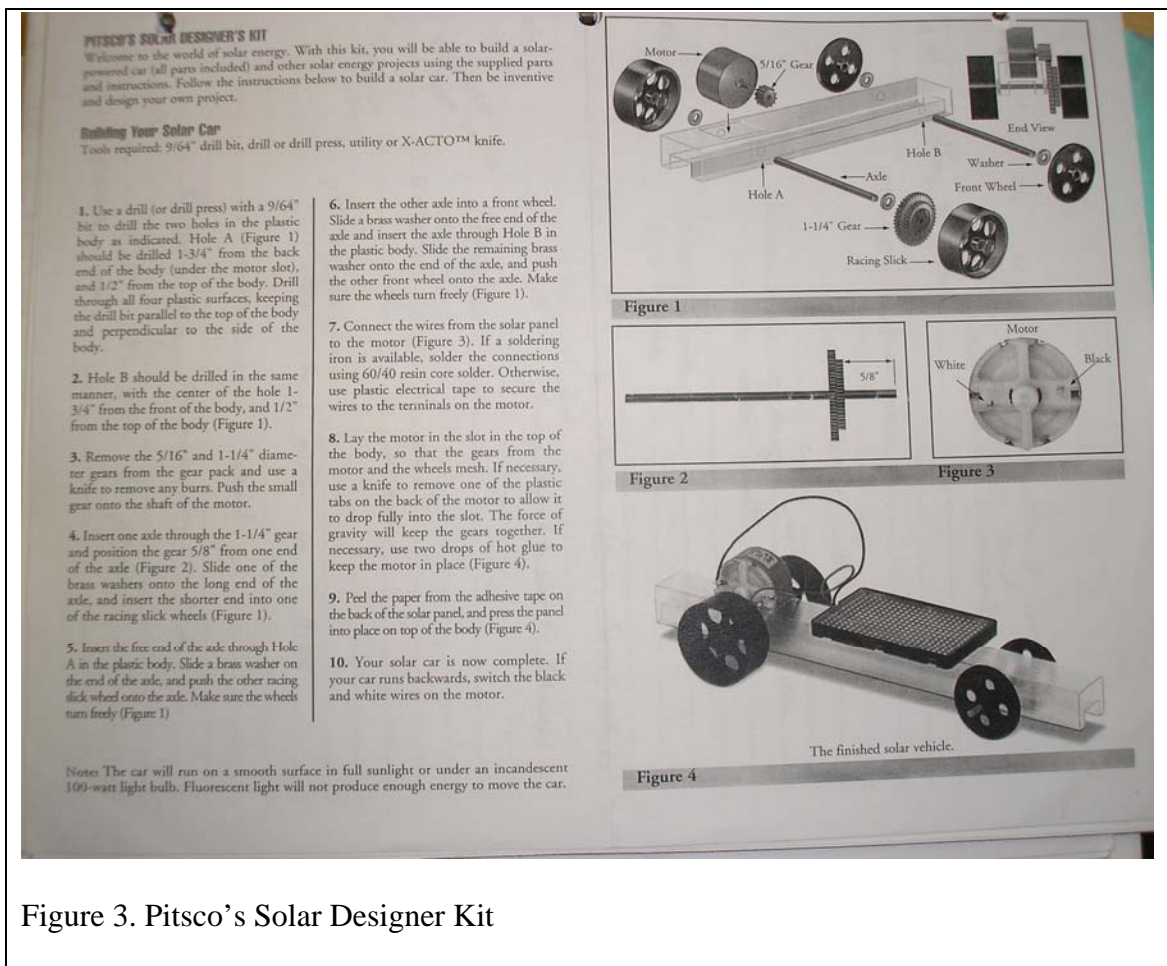


Figure 3. Pitsco's Solar Designer Kit

The teacher then explained the areas where the students would likely need extra support using special materials and equipment such as a soldering gun, glue gun, and knife. “WD40 cleans, protects and loosens the parts....” Having the kits on the desks seemed to distract the students from the listening and observing they were expected to do. Emily and Tanya at first appeared to be listening, watching their teacher while Jason played with the pieces. After several minutes Tanya and Jason tried to remove excess plastic from the wheels while Emily appeared to be listening. Soon Emily was also checking for extra plastic.

Meanwhile, Mr. Stephens proceeded with another univocal lecture comprised of a combination of fragmented reading from the kit with many omissions, substitutions and additions, and demonstrations. While no explicit instructions regarding the students’ role were given, I assumed they were expected to listen, jump along with the text and view the diagrams.

*“Use a drill (~~or drill press~~) with ~~9/64”~~ (9/16”) bit to drill the two holes in the plastic body as indicated. And it shows you a picture of what’s going on right here, OK? So the holes have already been drilled. ~~Figure 1~~ (Hole A) should be drilled 1 3/4” from the back end of the body ~~under the motor slot~~, and 1/2” from the top of the body. In most cases that’s been done. It might have been done well enough so you guys are going to have to check. OK? Drill through all four plastic surfaces, keeping the drill bit parallel to the top of the body and perpendicular to the side of the body. In other words straight through- a nice line, straight all the way through....*

A full twenty minutes after he began his lecture, Mr. Stephens said, “Do it now” and the groups began putting the back wheels and gear onto a plastic frame. He then circulated around the room with a meter stick, showing the students what 5/8 inch would look like.

Jason pointed at Tanya and exclaimed, “Leader!” while Emily simply looked at both of them. With the needed parts in hand, and the instructions with the diagrams facing him, Jason began to put the model together. He tried to make the back wheel, which had a gear, slide along the axle. He thought a new axle or lubricant might help and he appeared to be using egocentric speech to guide his thinking, “no pole [axle] ...spray WD40”

Emily, who had been silently observing Jason, pointed at the diagram which was upside down to her view. She indicated the gear attached to the back wheel (it needed to rotate WITH the axle, not slide along it in order to turn the wheel and ultimately the motor). “It works, just that thing [gear].” Jason showed no indication that he heard her. Emily clearly knew how the gear worked with the wheel and axle, and she showed quite an ability to read diagrams, even when upside down!

Tanya tried the wheels and the gear and thought Jason was referring to the bend of the axle. “No it’s not crooked.” Then as if she has some insight, she exclaimed “Jason, Jason, the wheel doesn’t matter, it’s only the washers...”

Jason spun the wheels and pointed the base at me, “Does it have to be tighter?” He checked another group’s model then decided the base had an uneven opening for the rear axle and exchanged it. He and Tanya worked as partners, deliberately ignoring Emily, and attached the back wheels and gear to the new base. They then decided it was still not straight and exchanged it for another base.

Mr. Stephens called for their attention. He presented a hands-on demonstration on how to attach the front wheels, this time without reading. During this vicarious learning experience Emily appeared attentive and to be listening while Tanya and Jason continued working with the wheels. They either hadn't heard (or more likely hadn't understood) some of Mr. Stephens' earlier directions, or had already forgotten them as they neglected to include one of the washers and didn't measure the  $\frac{5}{8}$  distance as required.

Following the demonstration, the students were told to begin putting the front wheels on the base. Tanya and Jason worked quietly, not just with low voices, but also with few words between them. Meanwhile, Emily observed them as they were worked to make the pieces fit accurately. Occasionally she took a piece from the kit and turned it around in her hands. She appeared bored, and perhaps somewhat annoyed at being left out.

Tanya and Jason problem solved how to have a smooth running model as they shared the task of putting together the solar car. They were joined by the competitive need to have the fastest vehicle but, beyond weighing alternatives regarding alignment and smooth running gears, they didn't need to build upon each other's ideas to discover new concepts or create a unique design. They were simply copying or reproducing a model. They were also not looking for answers related to solar energy. In spite of appearing left out, Emily continued to try to be involved with assembling the model. She pointed to the diagram which was still upside down to her view. "That's where the motor is."

She appeared to be deep in thought about the project as she played with both the motor and the solar panel and observed the others.

There was another demonstration as Mr. Stephens explained how to tape the solar cell onto the frame. Emily and Tanya observed the demonstration and appeared to listen.

The students were told to continue building. Emily appeared to see this opportunity as her turn. She took the model from Jason and taped the panel onto the frame by herself. Tanya asked to see it but this time Emily ignored her.

After several minutes had passed, the teacher again stopped the class to demonstrate how to attach the motor to the base. Only Tanya observed this demonstration while Jason visited with the group beside his desk. Emily played with the double-sided tape.

The students continued to build their model. Tanya retrieved the car from Emily and positioned the motor into the opening on the base, adjusting it. She appeared to have a good understanding of how tight or loose it needed to be. Their talk seemed to indicate more of a power struggle than a dialogic exploration of the concept of solar energy.

Emily: Can I see?

Tanya: (Ignoring her) But our gear doesn't turn. There must be plastic on it.

Emily: No plastic.

Tanya: Yes there is.

Emily: No plastic on there.

Tanya: You took a plastic off?

Jason: See if it works. It works?

Mr. Stephens stopped the students one last time and asked them to clean up for recess.

## In-Class Sessions #7 and #8

There were 15 students in class today. Mr. Stephens commented on the increasingly poor attendance. He asked them to find their solar car models and move into their working groups. He then set the expectations for the rest of the period which related to having the models assembled properly with minimal friction, although the term *friction* was not used.

While Mr. Stephens was giving instructions to the students, he reminded them about the care needed when using a hot glue gun. “There’s a reason they call it a hot glue gun... when the glue come out of it, it’s ...” Jason was the first to yell out an answer, “COLD!” While he appeared to be paying attention his motivation seemed to be attention-seeking rather than curiosity or an interest in learning about science.

What **were** the students thinking about when they appeared to be listening? Were they following along or did Mr. Stephen’s univocal lectures result in, at best, brief bits of information to try to store somewhere? If they were not asking questions, sharing knowledge, or solving problems, did they really have to think deeply? What kind of learning could happen without critical, analytical or ‘thoughtful’ thinking?

The students continued to work on their solar model to get it running smoothly:

Emily: *This thing’s not twirling.*

Me: What is that ‘thing’? A gear? (I mistakenly thought she had indicated a gear .)

Emily: *The energy part (Pointing at the motor)...this part’s the gear.*

This brief exchange made me realize that Emily used the word ‘thing’ almost consistently for the parts of the solar model, or she talked around the terms. Was this habit? Or lack of class expectations? Both? How did the students create knowledge, see relationships, compare and contrast features, classify and categorize (and later retrieve that knowledge) without the academic language expected in subject domains? On the other hand, calling the motor the “energy part” was another indication that Emily did seem to understand all of the components and their purpose or function.

Mr. Stephens occasionally referred to terminology from a past unit on machines. While glancing through one of the students’ science binder I came across a unit they had completed called “Machines” that listed the creation of a solar car as a culminating activity. I was beginning to see that these in-class sessions were probably intended as a review for machine parts such as wheels, axles, gears and the like, and that the title of Solar Energy for this unit was a misnomer, or at best, a stretch of the notion.

In an attempt to probe for vocabulary understanding and usage, I laid the instructions from the solar car model in the middle of the three desks. I had removed the labels of the components in Figure 1 of the instruction sheet.

Emily: (**Looking at Figure 1 on the instruction sheet.**) Why did you white-out these?  
 Me: I wondered if you knew these parts...  
 Emily: This is the motor.  
 Tanya: This is the base of the car.  
 Emily: These are the wheels.  
 Tanya: This is a gear.  
 Emily: (**Pointing at a washer in the diagram.**) These are....ho...little tiny little circles....(**Laughs.**)  
 Tanya: They're...um  
 Emily: Oh yah! (**Indicating the solar cell.**) This is the battery.  
 Tanya: (Referring back to the washers)...They're something 'cleaner'

What an interesting connection Tanya made! She somehow used a root word for 'washer', associated it with the concept of cleaning and (unconsciously) mentally filed the word in that category. There are many places a word or label can be mentally filed. She had apparently not yet consolidated its placement in the grouping of components needed to build a solar car.

Emily: It's a ...no, a washer!  
 Tanya: Yah, a washer!  
 Emily: Tiny little washer.  
 Me: (Pointing to axle) and I didn't hear what this is called.  
 Tanya: It's called...I know...is it a...?  
 Emily: W...is it called a wheel?  
 Tanya: A rear axle!  
 Me: So, what do you think is in the motor?  
 Emily: Energy stuff: like these things but tinier...(**Pointing to gears and wheels.**)  
 Me: You mean maybe gears and wheels?  
 Emily: But really, really, really, really tiny...going really fast.

Emily continued to point and use the words 'things' in spite of the fact that she **could** provide many correct labels when asked.



Me: So what was this called?

Emily: The washer! And these are all gears. **That (Pointing at the gear attached to the motor)** goes at the bottom...and something goes at the top and spins it.

While she indicated that she also knew the word ‘gears’, even during this display it did not appear to be a habit for her to use the correct words, as she quickly reverted back to the vague term ‘something’.

Personality wise, Emily appeared to be a different person than she was the other day. She enthusiastically wanted to share her knowledge of the terminology. She also immediately offered to run an errand for Mr. Stephens who had asked Jason to find a taller stand for one of the radiant lamps from the back room. She disappeared into the next room but erroneously brought back a light on a stand. One of the students groaned loudly as if to imply that it was no surprise that she didn’t understand. “Not that one... No, a stand!!” She appeared to be embarrassed but left and returned with the correct one.

Maybe too much is being read into that little incident but when it is held up alongside the way Emily was seemingly ignored at times by her group members, the message to her might have been that she has little to offer. Was this because of her language? Because she didn’t always understand what was expected nor was she always able to explain what she meant? Would Emily know that how she communicates with others might have an affect on how they see her?

Jason also took a turn at the diagram with the missing labels.

Jason: **(Pointing and labeling parts)** Wheels. Gears. Motor.  
Me: **(Pointing at the axle.)**  
Jason: And the little pipes. **(Pointing at the washer)** Those are the...I forget what they're called.  
Me: Maybe Tanya can help you.  
Jason: Tanya, HELP! yah, these little things...  
Tanya: Cleaners!  
Jason: And these? **(pointing at the axle)**  
Tanya: Can I help him? Wheel and \_\_\_\_\_?  
Jason: Axle?  
Emily: **(returning to the group)** Did you try to do all these?  
Me: They're stuck on that ... 'cleaner' one...  
Emily: Oh, that's easy.  
Jason: Did you guys get to help each other?  
Emily: No I got it without having help. I can tell...those little circle things.  
Jason: Wipers? **(They all laugh.)**  
Emily: They're washers.

Working cooperatively, Tanya knew how to prompt Jason to allow him to come up with the correct term. Again, it was interesting to note how Jason chose a 'w' word when searching for 'washers.' Emily appeared to be proud to show what she had learned.

Emily: **(Repeating the labels while indicating the parts)** Wheel and axle. Washer. Gears. Energy... the battery. The wheels.  
Me: And the ...**(pointing at the base)**  
Emily: The body parts!

When Emily heard that another group's car had been running in reverse she again revealed her curious nature as she looked for an answer while struggling to express herself.

Emily: That little white thing and black thing on the motor? What if they never put them in the right spot, red on the wrong spot?"  
Me: The little wires? **(There was a red and a black wire coming out of the solar cell.)**  
Emily: Yah.

The students continued to work on their model. During a test run, the group's car wasn't moving well. The motor was heavier on one side due to the gear attached to it which resulted in the front wheel was not turning properly. Emily and Jason realized this and tried to solve the problem. They used the briefest of utterances:

Emily: Too much weight...(Indicating one side of the model.) Jason: Even-out the sides Emily: Put it together Jason: (Tries different gears)
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The competition was held indoors due to rainy weather. Mr. Stephens set up radiant lamps along the side counter and the groups took turns testing their vehicles. Tanya's group was still having difficulty getting any power to their wheels so the teacher soldered another solar panel to it. They were interested to see how the four wires had to be attached to the two wires coming out of the motor. The final test was in seeing how long it took the groups' models to run the length of the 'race-strip' on the counter. Then Mr. Stephens had the students return to their desks and he spent eight minutes verbally wrapping up the unit. He started with the competition, indicating that Tanya's group was the winner. Mr. Stephens went on to reinforce the intended learning outcome of the unit: how to use radiant heat and a solar panel to create energy to power a model car, rather than a unit on learning about solar energy as he had first explained to the students. Here is an excerpt from his final univocal lecture:

Tanya's group [won]. After group two won, we doubled the engines (or the solar power) on Jason's by putting the solar panels on it...It became quite a bit faster than it was before. It really went quite well. With these you can actually add on more than 2 solar panels. You could add on 10 of them if you wanted. And every solar panel you added on, as long as you did it properly, every solar panel you added on, it would give you more power and more power and more power.

And that's what they do with homes and things like that ...when they're running

power off of homes...or running the home electricity off the solar panels. They collect the sun's energy bending down into...the radiant energy like we were doing...we checked out radiant energy and found out how it moved...that's what happens they use whole bunch of daisy chain...daisy chain solar panels that collect energy and store it in batteries. There also of electrical cars that are coming, too. A lot of great big things happening with solar energy in the years to come...so keep your eye out...really neat stuff happening. you can buy this stuff at Canadian Tire now. You can have these things at the cabin at the lake now...really neat stuff. Wish we had a little bit more time....

During this wrap-up, the three students were sitting in their grouping of desks at the back of the room which meant that Emily had her back to Mr. Stephens. She played with the tape recorder, tried to engage me in conversation and finally took the instruction sheet and began talking to herself. Jason chatted with the group beside him. Tanya watched Mr. Stephens intently and appeared to be listening to his summary, even raising her hand for several minutes. However, when he eventually recognized her, she was only interested in what the prize would be for winning.

### Conclusion

In this chapter, I observed the three students Tanya, Emily and Jason as they participated in listening to lectures, following along with text, observing demonstrations, and constructing two solar models through cooperative groupings. They also shared their ideas about and abilities within the language strands. I further gathered information from them as well as from Mr. Stephens about their perceptions of the science program.

Chapter Five will discuss the findings of this data.

## CHAPTER 5

### IMPLICATIONS

#### Analysis and Interpretation through a Social Constructivist Framework

“Thought is not merely expressed in words; it comes into existence through them”  
(Vygotsky, 1962, p. 125).

#### Introduction

By analyzing and interpreting the data collected through a social constructivist lens, I shall make explicit the links between use of language and conceptual growth. Filtering my classroom observations and data collection through social constructivism and critical pedagogy allowed me to analyze, compare, contrast and interpret my findings. Situating my stance also allowed me to understand the distinct and contrasting view between the two pedagogical orientations of transmission and interpretation and their impact on student learning. While learning can take place within both stances, the most powerful experiences are created when transactional and transformational approaches support an interpretation orientation (Johnson, 2005). Further, critical pedagogy which makes visible the power issues inherent in the language and literacy strands including text, discourses and discussions as well as in the perspectives, routines, classroom dynamics, activities and ways of ‘doing school’ shed light on the inequities education

creates and perpetuates through its process of hegemony and enculturation (Street, 1995, 2005; Gee, 1990, 2001a).

### Pedagogical Perspectives

How teachers view their role influences both the classroom environment and their program. Mr. Stephens viewed teaching from a traditional, transmission-oriented perspective with his role characterized as both a transmitter-of-knowledge and a classroom manager. Whether he was giving students vocabulary words or the correct answers to a test, or setting up the activities so they were ready to go, he kept a firm hold on the knowledge to be learned. At the same time, Mr. Stephens' activity-based, one-size-fits-all science unit was driven by commercial handouts so that, in fact, he was not a decision-maker but rather a transmitter of the information found within a prepackaged kit. While Mr. Stephens' science program was characterized by small groups actively involved with hands-on projects, two commercial documents were at the centre of his univocal, lecture-based classes. Decision-making for Mr. Stephens was reduced to which kit or document to use rather than which concepts and objectives were mandated and how to support and scaffold students. In addition to Mr. Stephens' deskilled role of delivering the program, much like a technician, the students were not required to authentically engage with ideas, or to explore, discuss, reflect, shape and share thinking but rather to complete activities and memorize the correct answers.

These two contrasting philosophical perspectives of interpretational learning and learning through transmission are reflected in the following pedagogical beliefs and resulting practices:

<b>Interpretation-oriented Perspective</b>	<b>Transmission-oriented Perspective</b>
<p>1. Learning as Conceptual Transformations</p> <ul style="list-style-type: none"> <li>- construing meaning</li> <li>- language-based transactions</li> <li>- ideological</li> </ul>	<p>1. Learning as Transmission of Knowledge</p> <ul style="list-style-type: none"> <li>- completing activities,</li> <li>- memorizing answers. (Teach-Test model)</li> <li>- autonomous</li> </ul>
<p>2. Broad Definition of Language/Literacy</p> <ul style="list-style-type: none"> <li>- language for learning</li> <li>- dialogic discussion</li> <li>- open-ended questions</li> <li>- interpretation and defending ideas</li> <li>- use of metacognitive strategies to monitor meaning-making</li> </ul>	<p>2. Narrow Definition of Language/Literacy</p> <ul style="list-style-type: none"> <li>- language for doing</li> <li>- univocal lectures</li> <li>- closed questions</li> <li>- single answer</li> <li>- valuing surface features ( speed, fluency, neatness)</li> </ul>
<p>3. Science –as-Inquiry</p> <ul style="list-style-type: none"> <li>- learning</li> <li>- authentic, purposeful dialogic inquiry</li> <li>- valuing process and products</li> <li>- student and teacher questions</li> <li>- interpreting, creating, developing</li> <li>- developing connections, inner exploration</li> <li>- authentic, ongoing informative assessment</li> <li>- groups for dialogic interactions</li> </ul>	<p>3. Science –As-Activity</p> <ul style="list-style-type: none"> <li>- doing</li> <li>- completing assignments</li> <li>- valuing products</li> <li>- teacher questions</li> <li>- copying, imitating, assembling</li> <li>- receiving knowledge</li> <li>- pencil and paper, end of unit tests</li> <li>- groups for procedure and routines</li> </ul>
<p>4. Science Beyond the Classroom</p> <ul style="list-style-type: none"> <li>- cohesion, integration with other subjects</li> <li>- spiral curriculum over the years</li> <li>- connect with community issues, resources</li> <li>- interconnected with social/ cultural issues</li> </ul>	<p>4. Science in Isolation</p> <ul style="list-style-type: none"> <li>- disconnected, fragmented learning</li> <li>- separated concepts</li> <li>- classroom-based</li> <li>- isolated ideas</li> </ul>
<p>5. Valuing Strengths/ Scaffolding Learning</p> <ul style="list-style-type: none"> <li>- collaborative: supportive</li> <li>- unique world view/ schema</li> <li>- developing self identity, voice</li> <li>- building, celebrating dynamic culture</li> </ul>	<p>5. A One-Size-Fits-All Program</p> <ul style="list-style-type: none"> <li>- competitive: blaming</li> <li>- uniform world view</li> <li>- silenced, conforming</li> <li>- hegemony of dominant culture</li> </ul>

## Language as a Central Tool in Social Constructivism:

### Socialization and Internalization

In Mr. Stephens' class, the significance of language as the vehicle for learning in order for students to create their unique world view and to establish their internal schema of categorizing and classifying information was absent. They needed opportunities to share, negotiate and shape the meaning of experiences in order to focus their attention on, as well as reflect upon, synthesize, and then internalize those perceptions as concepts. Rather, Mr. Stephens provided experiences that required no inquiry, discovery, discussion, analysis, connections, reflection or synthesis. In other words, the notion of conceptual transformations in learning was replaced by a focus on univocal lectures, activities which required copying a model and pencil and paper assessments which valued the memorization of correct answers.

Throughout the lessons, I struggled to develop a conceptual framework for the activities the students were involved with. How would I know if, and how, their learning had changed if I didn't know what they were supposed to be learning in this unit? What was the holistic picture? What types of relationships were going to be emphasized? Was this a unit on energy, or perhaps more specifically, on solar energy? How did it relate to past concepts the students had studied or to concepts they may have developed within their homes and communities? What did students know, individually and collectively, in the first place? And finally, why did so many of the students struggle on their end-of-unit science tests?



While Mr. Stephens' lectures and guiding handout focused on the concept of creating electricity through a solar source, all active student learning, during which the students were engaged, emphasized replicating models which required attention to the assembly of components, reducing light to a solar panel through the use of transparencies, and the reduction of friction in wheels. The following points reflect this sequence:

- 1) What was articulated to the students explicitly by Mr. Stephens was that they would learn about solar power by building a solar car.
- 2) The handout that introduced the unit and guided the building of the solar propeller, Project: Effects of Amount and Wavelength of Light on a Solar Cell, described the concepts of energy transformation from solar to electrical power through atom decomposition.
- 3) Activities emphasized listening and assembly of the propeller.
- 4) The second half of the unit focused on putting together the solar car and required that the students connect the components accurately and reduce any visible friction.
- 5) During his lectures, Mr. Stephens referred back to prior classroom activities of radiant heat, color wheels, gears, wheels and axles and he asked the students generally about experiences they may have had at home or in the community about seeing solar panels.
- 6) Mr. Stephens summed up the unit with several sentences about homes and cars that make use of solar panels to collect radiant heat, embedded within a seven minute oral lecture that emphasized the importance of listening to his directions.

Of all this, I believe that the key conceptual learning the students gained from this unit was: *they were told that light could make enough energy in a solar cell to enable a motor to make an object move. They, then, observed this fact when their solar models ran via a light source.* Knowledge was delivered to the students through a one-way, transmission-oriented perspective of univocal lectures driven by a commercial handout. Isolated activities were completed through observation and imitation, and value was placed upon exact copying and the completion of the models. Student groupings supported efficiency for the activities and routines and, ultimately, encouraged a competitive atmosphere. A significant result of this one-size-fits-all program was a class of students who, ultimately, struggled to make conceptual connections to personal prior schema, as was revealed through their inability to describe the involved processes, concepts and events.

All of the components including the materials, the space, the small number of students, the skill and scientific knowledge of the teacher, the enthusiasm on the part of teacher and students, their curiosity, the collaborative groups and the necessary time, were present within the classroom to establish a rich unit of shared discovery. There seemed to be so much potential to involve the students in inquiring, discovering and developing conceptual knowledge in addition to building the model; to situate these activities within some broader understandings by connecting them more closely to past learning as well as to their lives. Had they been learning about solar energy as a concept, they might have considered many sources of energy and then studied solar energy as one source, gathering data about its viability as a renewable resource, which is one of the

required science units for the Grade Five curriculum. Because the students were not generating their own ideas or searching for answers, it was questionable if they were actually listening to the lengthy, univocal lectures or engaging with the printed handouts. This lack of internal drive also impacted upon the group interactions which were characterized by comments and utterances about the components but not by queries to deepen the understanding of concepts.

### How We See the World:

#### Language Builds Internal Schema

Throughout my observations, and underlying all of the data collected on the students, the significance and power of language as foundational to how they saw the world and how they shared those experiences, was highlighted. When teachers make explicit the language and relationships that define scientific concepts, students are able to use developing cognitive skills such as attending to, analyzing, synthesizing and classifying, not only scientific concepts, but also ideas and relationships found in their everyday lives. That is the significance and importance of conceptual development in classrooms, and that is what was absent from Mr. Stephens' lessons.

As was expected, the data collected during the sorting of everyday concepts showed Tanya, Emily and Jason classifying labels according to their own unique perspectives with various connections and relationships, due to past cultural and linguistic experiences, indicating very individualized ways of conceptualizing and seeing the

world. This speaks to the uniqueness of schema systems with implications for teachers to move beyond their personalized view of the world to understand their students' perceptions. While Tanya could sort the cards according to broad logical relationships that she established, Emily and Jason both had numerous categories, and even so, had difficulty speaking to the relationships of the items within the groupings.

Concepts are abstract ideas that refer to a particular category of objects, grouped together based upon their similarities, phenomena or the relationships between them. While everyday concepts are learned "upward" from sensory experiences to generalization, scientific concepts are learned "downward" through written symbols to examples. Making these relationships visible and explicit through specific instruction plays a critical role in the child's mental and linguistic development (Kozulin et al., 2003; Moll, 1990; Vygotsky, 1986; Wertsch, 1985). Because these empirical relationships are backed up with evidence, instruction within the conceptual framework of science encourages students to also make explicit the relationships they see in everyday concepts around them. Students develop an understanding of various connected concepts through instruction which is mediated by the tools of language, signs and symbols. These tools become acquired and internalized and then "function as mediators of the children's higher mental processes" (Karpov, 2003, p. 65). This develops students' ability to attend to various perceptions, analyze and synthesize information, all higher thinking skills, which support conceptual development. Students are then able to use these higher mental processes to categorize and connect ideas to everyday experiences.

Teachers must also recognize the language differences and needs of students, and consequentially, rethink activities with the goal of supporting linguistic growth and refinement as the basis of learning. When Mr. Stephens described teaching vocabulary and definitions to the students, at best this showed his recognition of the importance of highlighting new terminology. However, Mr. Stephens did not encourage student use of terminology, nor did he establish contexts for supporting, refining and extending the students' language base in spite of the fact that the hands-on activities provided many rich opportunities for context-based language development. The words that were highlighted in the handout under the heading Glossary included terms like *photovoltaic solar cells*, which he read to the class but did not elaborate upon, and which would probably have done little to advance students' understanding.

### The Role of Language and Literacy in the Science Classroom

Lemke (2004) describes the multiple literacies of science that are often used together to create and share meaning and which teachers often assume students have facility with. Charts, discussions, lectures, gestures, demonstrations, videos, websites, pamphlets, photos, overhead transparencies, textbooks, and documents all present information in unique ways that students must often integrate, sometimes simultaneously, within a single class. While this integration was also noted in Mr. Stephens' room, I shall continue to address the six strands of language as described by Saskatchewan Education (2002, 2004a, 2004b, 2006). From the context within which the literacy terms were discussed and observed it was easy to assume that a narrow definition of language and

literacy was used in which the strands were seen as tools to support activities on a superficial level rather than as linguistic and cognitive processes to support the construction of science concepts and competencies.

### Speaking and Listening as Acts of Literacy: Dialogic Discourse

Univocal utterances are often used by transmission-oriented teachers who see their function as providing information to students. This perspective concerns itself with how information is processed, coded, sorted, stored, retrieved and basically managed; with the assumption underlying this view that information is a formed and complete entity which can be passed from person to person (Bruner, 1966). Greene (1990) refers to Bakhtin's (1984) concept of monologism: a one-dimensionality that denies the possibility of another perspective, another someone with the same rights that is capable of responding. The univocal speaker only views the others present as objects, or receivers of their univocal utterances and, in doing, so denies any other perspective or reality, thus claiming the final word.

Instead of dialogic discourse to shape discussions and facilitate inquiry and meaning, the strands of speaking and listening were observed as separate tools with the students spending large portions of class time as an audience to Mr. Stephens' univocal lectures and accompanying closed questions. While the students were encouraged to talk to each other as well as ask questions, and Mr. Stephens asked some questions of them throughout his lectures, he maintained a firm hold on the knowledge and ideas to be

learned. Speaking and listening appeared to remain separated activities rather than joined as dialogism through the co-construction of ideas (Wells & Chang-Wells, 1992).

Only a small part of learning takes place through transmission or “on a one way street” in which the teacher explicitly provides information to unknowing students. Dialogic instruction such as open discussion, authentic teacher questioning, scaffolding and questions with uptake which extend a previously made comment, can support the development of knowledge concepts in conjunction with students’ linguistic ability (Nystrand, 2006). Univocal lectures not only attempt to transmit information to students, they create a norm of thinking and doing in classrooms by establishing and supporting the belief that an unquestionable authority presides within ideas. Interruptions to the lectures which could challenge ideas and create tensions, and which are needed to shape thinking (Bakhtin, 1986) require articulation and deeper understandings but are discouraged or ignored. What may appear to be open discussion connected with the lectures are often only comments and questions that further advance the perspective of the teacher and content of the talk. The rigidity that underlies these speeches shuts out any rich responsiveness that must exist within our diverse classrooms; and the multiple perspectives that are needed to understand the “coherent world” as suggested by Green, 1990 as well as Bakhtin, 1986 and Wells, 2000 are silenced through the transmission-oriented view which characterized Mr. Stephens’ class.

Along with lecture, Mr. Stephens' lessons relied heavily on the use of modeling or demonstrations. Bruner (1968) describes demonstrations as "vicarious learning through observation", one of the three types of experiences that support learning. The other two include direct mediated experiences and vicarious learning through symbols. Thus, demonstrations can be deemed a middle road between actual and symbolic learning. Bruner suggests that demonstrations (or *observational learning experiences*) can be effective if accompanied by in-depth discussions of alternative methods and solutions along with reasons. Rather than copying a demonstration or model, students must be encouraged to create their own meaning or personalized artifact to represent their understanding of the concepts being taught and to share this unique creation with others. This will require them to dig deeply as, with mediated support, they learn to analyze and then synthesize their ideas, connect with other concepts, sequence the steps they worked through, provide back up and rationale for their ideas and articulate their experiences through an ongoing expansion, as well as refinement, of their language. However, what was valued in Mr. Stephens' class was the imitation of a model following step-by-step univocal lectures which allowed little or no time or place for language mediation, inquiry, creativity or reflection.

#### Authentic Purposeful Dialogic Interactions

During several instances, observations revealed that the group of students had difficulty sharing the tasks required of them. Language seemed to be a contributing issue, particularly with Emily who did not seem able to express herself the way she needed to, in order to lend some authority to her understandings about the solar model. This was



no doubt compounded by the fact that there did not appear to be a consistent need or expectation in class for the students to express themselves either orally or in writing using specific vocabulary.

Authentic questions encourage wonder and exploration, not simply repeating an answer on the page. In fact, seldom in life is one required to provide responses to questions to which the interrogator already knows the answer. Situations that do come to mind speak of a power stance between the two participants in which the questioning, rather than providing information to the person with the questions, is seen as either a lack of trust or a challenge to the person being asked.

Social constructivism advocates that in order to support growth in expression of language and the development of conceptual understandings classrooms require authentic interactions such as group problem-solving activities in which groups actually create a model on their own, rather than copy one. Or they may inventing a concept map, attempt to understand a piece of text in a collaborative manner, or participate in group writing to either explore, connect or summarize concepts (Applebee, et al., 2003; Baker, 2004; Britton, 1993; Cairney, 1997; Dewey, 1938; Freire, 1970; Gee, 1999; Giroux, 1996; John-Steiner, 1985; McLaren 1987; Wells, 1999, 2000; Wells & Chang-Wells, 1992).

## Writing and Reading as Acts of Literacy

### In the Science Classroom

In spite of the value inherent within the literacy tools of reading and writing to advance conceptual and linguistic growth, only a narrow perspective of reading was observed in Mr. Stephens' class. There was no writing by the students, nor by the class as a whole under Mr. Stephens' guidance, nor did Mr. Stephens at any time model or engage in writing, although there were numerous times when it would have provided a visible means of focusing, brainstorming, sharing, reflecting, presenting and describing the concepts, ideas, processes and data within the unit.

#### Writing as a Tool For Learning

No writing was observed during in-class sessions other than the students recording numbers on a chart. However the students did mention writing they had done in science booklets for a previous unit on Heat. During whole class discussions, a chart stand or overhead to record the discovery process as it evolved could have provided a model of inquiry for the students and focused their thinking and understanding as it would make explicit the relationships within the categories, provide evidence for their findings, and reinforce a structure for the concepts being taught. Writing a summary of the lesson would have highlighted concepts, given language to the ideas that students may have been grappling with, and would provided a model, as well as a reflective summary, to bring closure to the lessons. It is interesting that these invaluable activities would have

taken little additional time during class for Mr. Stephens and would have demanded no additional cost to his program budget.

### Reading and the Discourse of Science

The two documents that guided the solar energy lessons encouraged the purpose of reading to perform a task, which Langer (1997) has suggested is more easily taught during math and science classes than during language arts. Many of the characteristics of typical of written science discourse were observed in the two pieces of text. Mr. Stephen's method of discussing and demonstrating the equipment and procedures referred to in the text as well as the inter-textual connections he made through references to past activities and personal experience, supported the students' understanding. However, in reality, the main difference between Mr. Stephens' univocal lectures and the reading he did to guide the demonstrations was that he and students had the text in front of them in the event they wished to refer to it. Each student had their own copy and there seemed to be an unspoken expectation that they follow along. Occasionally both Tanya and Emily looked at the steps in the first handout which described how to build the propeller, but, based on my observations of the reading and retelling I am not convinced that they could actually read the material. While Jason appeared to be following along with Mr. Stephens when he began reading the first document that directed the assembly of the propeller, he did not demonstrate interest in the text nor in the accompanying diagrams of either handout following that initial class beyond having the second document face him while assembling the solar vehicle. While both handouts appeared to be written beyond a level that the students would have been

able to understand on their own due to complexity of sentences and vocabulary, no mention was made that it would be difficult for them and intended more for the teacher's use. Rather, the complexity of the text for grade five students seemed to contribute to, and reinforce, the unstated but ever present underlying impression that, like the development of conceptual understanding, meaning and the interpretation of text were, at best incidental, rather than at the heart of learning. And reinforced their belief that learning science was "hard"!

In order for this read-aloud to be effective in contributing to the development of the science unit, as well as a model to teach students reading strategies in content area material, the text would have had to been written closer to their linguistic and conceptual level. With only a little additional effort and awareness, this opportunity to model use of text could have been made more explicit with references to the strategies the teacher was engaged in so that the "science teacher is not only helping students become *scientifically* literate, but she or he can be a true partner of the language teacher in helping students develop broader literacy skills" (Angelis 2001, p.1).

#### Valuing Student Understanding or Surface Features?

Probes into the students' use of reading strategies led me to believe that they were likely not able to gain much information independently from the handouts Mr. Stephens provided them with. I sensed that the three students considered reading to be an act of saying the sounds and the words, and placed importance on the surface features of text rather than on interpretation, making connections and developing strategies that would

support monitoring for understanding. This narrow view of reading will not support students as they move beyond picture books and into decontextualized material with its reliance on the symbolic representation of print, particularly in content area material with specific and unique discourses.

Emily and Jason demonstrated facility with decoding. This resulted in a masking of their struggle to understand and develop new concepts through text. Social constructivism would promote the use of text as a tool along with dialogic discussion of an individual's interpretation to build further knowledge as they work with others through authentic purposes, rather than programs that eschew a meaningless and fragmented, scripted and standardized program. When schools base their instructional theory on a narrow definition of literacy as reading and writing rather than recognizing that literacy is also a way of thinking and doing, the result is a curriculum-driven skills-based education which is easier to test than deeper understandings. Yet, educators are continually dismayed when assessments indicate that students are not being encouraged to think broadly and deeply about ideas and content (Langer, 1987).

Word choices by Emily and Jason during a cloze activity did not always contribute to meaningful ideas in sentences or within the whole passage, and indicate a view of reading as fragmentation rather than coherence of ideas and meaning. Inadequate vocabulary, the unfamiliar discourse of science, a view of reading as unpredictable and disjointed along with a collection of seemingly unrelated science activities can prevent students like Emily or Jason from making use of text as a tool to support a growing envisionment of science concepts.

This is aligned with Mr. Stephens' comments that the students often had difficulty with exams in spite of much in-class support, group studying, and test rewriting. Unless students understand how these activities are a vehicle to demonstrate and support understanding of larger and connected concepts, and unless these new concepts can connect with their prior experiences and resultant schema, the students will have difficulty, not just with understanding but also with their ability to articulate, store and retrieve information and knowledge.

When the reading activities observed during in-class sessions and the independent activities were analyzed and synthesized, it was clear that reading in its broadest sense broke down for the students on several levels including 1) lack of prior knowledge of concepts 2) inadequate vocabulary 3) provision of text that was written beyond what would be typical for grade five students 4) a view of reading as saying the words and 5) reading word-by-word as opposed to seeing sentences and passages as meaningful ideas which contribute to the development of a concept and to the building of an envisionment.

In addition to needing to recognize when their understanding of text breaks down enough to interfere with acquiring meaning, all students (including those like Tanya who appear on the surface to navigate science text with ease but who require support to retell basic ideas) need to develop strategies that 1) allow them to make connections at a deep level, 2) make explicit the relationship of the format and organization of text to conceptual understandings and 3) encourage a critical stance as they evaluate the

information they encounter, share perspectives and provide evidence of their interpretations from text.

### Viewing and Representing

Viewing and representing modes provide support for construing meaning of conceptual information and the restructuring and transformation of student schema. This is especially important for students like Emily who prefer this visual/symbolic mode of learning. There were many opportunities for Mr. Stephens to model and guide the students to develop understanding and facility within these strands. Unfortunately these opportunities went by unnoticed.

#### Viewing

Several examples of visual representations were noted during the science solar unit. The first handout the students received, Project: Effects of Amount and Wavelength of Light on a Solar Cell, had 5 visual images. Beyond the first illustration, which was representative of a fairly complex process of energy transference and as such seemed to contribute little to understanding at the Grade Five level, the other diagrams served to break up the text and enhance awareness of the steps to be followed while assembling the propeller. With the exception of the chart *What Did You See?* none of them were acknowledged by Mr. Stephens. Presenting material at too complex a level (such as the first diagram about the solar cell) but not referring to it as such, may contribute to students' notion that the handout is not expected to make sense. Although this may seem insignificant, when joined with the other science handouts that are too difficult to

understand, compounded by too much new terminology and very abstract processes, students are apt to receive the message that ‘doing’ (such as completing activities, or reading quickly and fluently) is the most important aspect of science, while making connections, understanding and learning are optional.

Viewing as a mode of comprehending and integrating visual data with other literacy knowledge is enhanced through the areas of multimedia, digital and technological literacy (Saskatchewan Education, 2002). While Mr. Stephens referred to computer-based research with his class he cited a lack of machines as an obstacle to incorporating it as a regular strategy. The students also had difficulty remembering any specific computer research activities, recalling however, that they had used the machines for story writing, Typing Pals and to visit different web sites which may have been for research. Whether computer research is viewed as a social and integrated constructivist activity which includes all six language strands with an emphasis on viewing or in the narrow sense as a task of searching for correct answers needs further study. However, Langer (1987) suggests that within the field of literacy and information technology “...there is growing evidence that two students working together on a machine create support for sophisticated activities...By working together and dividing the labor of the task, they can bring their separate strengths together...” (p. 204).

Representing:

The students were not involved with any activities requiring them to represent ideas through a combination of images and /or text during this particular unit. However when



asked to describe how the solar propeller worked Tanya excused herself from creating a diagram. Emily and Jason drew separate disconnected components in spite of having previously viewed (or at least having had available) the completed model in their handout.

### Student Profiles

Throughout this research project I built envisionments of the three students as I attempted to understand how they used the six strands of language to develop concepts in science. My theory was that the three students would have varying perspectives, schema and background knowledge, unique interests and motivations, personally preferred styles of learning, as well as varying skills and abilities within the language strands and would, thus, make different use of the support and opportunities provided through activities, discussion, reading, writing and viewing to create very unique and personal understandings.

The findings do, indeed, support this assumption. Tanya, Emily and Jason appeared to have their own conceptual schemas and varying skills, abilities and interests within the language strands to create personalized understandings about the science ideas presented. Limitations to this include, of course, the fact that I only observed them during the course of one unit. The subject domain of science does not necessarily lend itself to observations of all types of reading and writing purposes. As well, a single unit may not be representative of the entire course of study for the year as evidenced by the

fact that some of the routines typically included by Mr. Stephens during his lessons, such as the vocabulary study, lab sheets and written tests were not observed. However, the greatest obstacle to my understanding of how the students' ideas developed was that the concept described by the teacher (*light could make enough energy in a solar cell to run an object through a motor*) was not developed through the activities. Perhaps I was looking for too much. Or perhaps my understanding of the students' knowledge was hampered by their ability or willingness to describe what they understood.

Because there were few instances of the language strands to observe in an in-depth manner or at any great length (with the exception of listening and speaking), my envisionments are still full of many questions which will go unanswered. I have nonetheless, developed the following profiles filled with my own interpretations, assumptions, predictions of and insights into the students, their strengths and their needs.

Tanya:

Tanya presented herself as a model student. Rather than being focused on learning, her goal was to follow what the teacher said, as shown in the interview with me. Her excellent attendance and seven year stay at one school, an older brother in classes just down the hall from her, a mom who volunteered in the school's community centre most days, as well as her competence in school achievement no doubt all contributed to the stability, security and success Tanya demonstrated. Mr. Stephens also saw Tanya as a

competent student, directing me to her science binder when I asked to see one, assuring me it would be both complete and well organized.

Language did not appear to hamper Tanya's efforts to succeed as she was able to demonstrate and explain the connections and relationships she made among objects and concepts. She also attempted to listen to her teacher and followed his instructions for the most part. A keen reader of fiction, she explained that if she was came to something she didn't know while reading she would, "Try to sound it out." But if the ideas don't make sense she read the text over again. She believed that "sometimes" there was reading to do on a computer. She was able to read fluently with what appeared to be at least a surface understanding of the material presented during the science units. She followed along with the text as Mr. Stephens read it and, while she preferred to not draw diagrams, she occasionally referred to them while building the models.

Tanya was capable of writing as was necessary to complete assignments and test questions. She had used a computer to write a ten page mystery during her library class. Although she didn't see herself as a good writer, when asked if she had trouble writing she said only with spelling. Any changes she made to her story were to do with editing the spelling and the apostrophes. She had also written a fairytale at home several weeks ago. However, she showed insight into, and seemed to understand the value of, writing. She recognized that LA, Math and Science might require different types of writing but that all three subjects needed "writing down for information" because writing "gets out more information."

While Tanya was able to take an assertive role during the class projects which involved negotiating with the other students, she appeared, like many who are socialized to school behaviors, to be passive and unquestioning in her learning. An exception to this was noted when she was confronted with material that was difficult and she asked for help to find the correct answer. She was capable of finding answers to questions through reading, providing they were fairly obvious but she was unsure how to retell what she had read and it is unlikely that she had facility with strategies that would encourage her to interpret material while providing backing from the text to support her answers.

Tanya would benefit from the development of strategies and skills to read critically and interpret material at a deep and personal level, and allow her to question text (or the teacher's ideas for that matter). An inquiry approach with an emphasis on the Grade Five science concepts would require that Tanya learn to actively ask questions, search out answers, make connections and evaluate ideas, resulting in a student who can think critically and creatively while developing knowledge through process with the tools of language.

Emily:

Emily was curious, interested, willing to learn and willing to be part of a group, with the exception of the session that saw her largely ignored by her team members which seemed to cause her to withdraw. She showed facility with visual mode activities such

as viewing and representing information through drawings or diagrams, and she seemed to have a quick grasp of what was required to assemble both solar projects. She appreciated the attention she received from me and helped herself to my digital tape recorder without hesitation.

Emily enjoyed reading but was unsure if she was a good reader. Emily had written and illustrated several books at home from half to a full page in length by hand complete with illustrations. She didn't share them with anyone and, according to Emily; they were usually thrown away by her parents, which may have contributed to why she didn't view herself as an author. She also liked writing and illustrating birthday cards for friends. Emily thought writing made it easier to learn science, "So you can you remember stuff. Look on your pages."

Emily's struggle with language manifested itself as an issue throughout all observations, interviews and activities. In fact, the vague word "things" peppered her language as she attempted to communicate ideas without specific terms and labels. When asked to describe how her solar propeller worked she created a drawing about the various components and then pointed at each one as she described the process:

You have to connect these two wires onto this thing right here...there's little things sticking out...you connect these two things onto these two and make them connect these things right here onto this thing right here. **(pointing at the wires)**...And then they use these little sticky tak things... You have to use this **(pointing at the propeller)**. You have to put this on. Use one of these things right there and stick this thing right here **(indicating that the propeller needed to be tacked onto the cardboard)**.

Nevertheless, it is of interest to note that Emily did know many of the correct labels. She started her explanation by talking about the wires yet in the next sentence referred to them as “things.” As well, at one point, I indicated the colored transparencies and asked Emily if she knew their purpose. She replied, “You have to use these for the sunlight...to be able to see how fast they run.” When asked what they were called, she hesitated for a moment than said, “Transparencies.”

This seemed to be the paradox with Emily. On the one hand she relied heavily on non-descript words like “things” and “stuff” even though this created issues in her learning and possibly in her working relationships with her peers. She didn’t automatically use specific terms and labels that she was learning or even that she knew. On the other hand, Emily appeared either frustrated or annoyed such as when Tanya and Jason ignored her vague suggestions while working out problems with their solar car. Although Emily gave a clear indication that she understood the diagram and how the car was supposed to run, she shared that knowledge by pointing to gears in the drawing which was upside down to her view and saying, “It works... just that thing.” This information would not be valued by her partners who may not have had the facility Emily did to understand the diagram. During the incident when she attempted to retrieve the lamp stand from the back science room, she clearly did not focus specifically on the type of stand, and she appeared embarrassed by the other students’ reaction. Emily also suggested that science was “kinda hard” because the tests were hard. “You have to write stuff down.”

Yet, Emily seemed to enjoy the challenge of learning specific terminology as she demonstrated when I had blocked-out the labels on the solar cell model. She was keen to try to come up with the correct vocabulary and also to help the other students. She appeared proud of this learning, and commented, “Oh, that’s easy...I got it without having help,” and later repeatedly went over the terms. She also seemed to like certain words, for example “slither”. Emily used it as a heading when categorizing her science cards, exaggerating the pronunciation of the s-l blend and then she insisted her group include it as a heading during their group sort.

Even when she did know the terms, though, she did not use them consistently. It seemed as if she had made a distinction between: “This is learning and takes effort” with “This is how I’m used to talking and sharing my ideas.” In other words, it may have been partly habit as well as low classroom expectations that allowed Emily to continue to struggle with a vocabulary that appeared inadequate for the formal Discourse of academic learning. When she needed a term that she didn’t have, Emily managed to talk around it. She referred to the “washers” as “little, tiny, little circle things” and “appliances” as “plug ins”. “Baking ingredients” became “flavors” and tableware such as “plates” and “bowls” were over-generalized as “plates” rather than as “dishes”; which brings us back to how did Emily conceptualize the kitchen items?

Relying heavily on non-descript, vague and general terms, Emily’s language influenced how she experienced the world and the relationships she made among those objects and events. This, in turn, affected what Emily chose to attend to and focus on during new

experiences; how she perceived these new events; how she connected them to prior understandings; and finally, how she re-conceptualized what may have been shadowy experiences.

Emily's language may be characteristic of her home-based vernacular, a discourse which lacks the specific clarity valued in academic settings that require a socially accepted way "... of using language, of thinking and of acting that can be used to identify oneself as a member of a socially meaningful group..." (Gee, 1989, p.18). Emily's lack of facility with academic language also seemed to interfere with 1) her ability to read sentences and passages as coherent, meaningful ideas and 2) her capacity to communicate effectively with her group and be recognized as a valuable contributing member. A strong ability to decode words efficiently masked the fact that Emily had few other strategies to assist her in reading critically. When this was all compounded by a view of science as a collection of isolated activities, some school transiency and a passive attitude towards knowledge attainment, learning must have been frustrating at best. She claimed that science tests were hard because of the writing, yet, in spite of it all, Emily said she liked science best; after, of course, computers.

Initially when Emily was asked to describe how the solar propeller worked she said, "The light hits the battery and then goes in through the wires to the motor." When asked what would be in the motor she replied, "Batteries." The following week however, she suggested there might be tiny little gears in the motor. In response to the question: Why



is it important to learn about solar power? Emily had no idea, nor did she believe she has any solar items in her home.

Emily's eager attitude may eventually be overtaken by frustration as she struggles to feel like a contributing member of a learning community and as her ability to learn is impeded by her ability to express herself and conceptualize ideas. Without a program that addresses her language needs, it is questionable whether Emily will manage deeper content material in higher grades in spite of an ability to grasp ideas visually. Like Tanya, Emily would also benefit from the development of strategies and skills to read critically and understand at a deeper level, and allow her to question material such as is required with an inquiry approach to learning.

Jason:

Jason appeared to have an interest and an aptitude in science; taking ownership for, and becoming immersed in, the solar projects. Hands-on learning may have captured his preferred style. He also demonstrated an ability to decode well, although there is insufficient data to comment further on this. Jason seemed to understand how the solar cell made the motor run although his language lacked detail. "This gets hot...goes through the wires into the motor."

Jason was able to use many vocabulary terms connected with the solar unit correctly although he needed help with several such as "transparencies", "axles" and "washers."

While he indicated some deep reflective ideas about science he occasionally used general and unclear remarks as shown in this example of dialogue:

*Mr. Stephens shows us stuff.  
Demonstrations?”  
Yah.*

As well, many of his attempts at discussion consisted of single word utterances such as “Crooked” when examining the car axles. When asked if solar energy could help the environment, he gestured to the power lines outside the window and said, “Yah, the towers.” Jason seemed to have some difficulty at making himself understood clearly when trying to express himself at any length as noted in this exchange where he is trying to explain how writing can be used to help record important information:

*Is writing important for science?  
Usually we’re writing down on sheets.  
Why is it important?  
Tells...on the sheet it says...what is it used and how- is it working?  
A reminder?  
See if you understand.  
Like a test question?  
Yah, but we just read it.*

Like Emily, Jason grouped everyday and science items with little focus on the relationships they had to each other. Language seemed to lack the refinement that would allow these relationships to be noted and articulated.

Some school disruption to his Grade One year, many late arrivals registered for his attendance this school term, inadequate school language and a view of learning through disconnected activities all hampered Jason’s ability to recognize, develop and articulate relationships between concepts. This seemed to be compounded by the fact that Jason

either seemed to be short of time, in part due to his attendance, or chose to act in a very laid back, clowning manner. This attitude may have been a strategy to distract others from his seemingly inconsistent ability; perhaps not so evident with this open ended activity, but with his general inability to cope effectively with school in general. His science binder was missing many assignments and handouts, symbolic of the skills and understandings he appeared to be lacking.

Jason, like Emily, also shows potential to be at risk for academic difficulty as he moves through the middle years. As expectations for using the language strands to demonstrate his conceptual knowledge increase, teachers may have less patience for his seemingly laidback attitude toward school.

#### Collaboration or Competition

The two contrasting pedagogical philosophies laid out at the beginning of this chapter have very distinct and opposing results. A one-size-fits all program has an agenda of conforming and acculturating students into a uniform world view and promoting and valuing particular perspectives and beliefs (Street, 1995). Another consequence of this perspective that insists upon the same route for each person is the creation of a competitive rather than collaborative environment. When educators teach through an interpretation-oriented perspective, which values the active exploration of concepts through dialogic inquiry, learning becomes connected and transformative, and students' identities and voices become strengthened rather than ignored. The result is a building and celebrating of a dynamic classroom and school culture with a far reaching impact.

Prior to observing the students, I had anticipated dialogic conversations that supported knowledge building and transformative thinking among the students, so I was struck by the competitive atmosphere both among the groups and also within the groups themselves during the assembly of both solar items. While there were conversations that indicated encouragement and problem-solving dialogue, they were minimal. This trend was also noted when I watched the three students sort the science cards into categories as a group project. I assumed that, jointly, their categories would be more sophisticated with more thoughtful reflection than they had shown while working independently but again, this was not the case. They created six taxonomic categories, but not together. Rather, each student determined a category and then proceeded to find objects with a feature that would allow it to belong. Tanya created three groups while Emily put together 2 categories and Jason gathered items to fit within one grouping. The activity appeared to be more competitive (who could gather the most cards for their category) than collaborative.

Groups only become cooperative and supporting when there exists a common goal and purpose larger than each person's individual needs to provide motivation for shaping understandings and supporting transformative learning. Activities, then, need to be the means to an end, not the end. Their purpose is to examine and explore concepts. They need to be centered within a process of discovery which may or may not result in a product. What is important is the journey that is undertaken within the community of

the classroom. Assessment, then, also becomes an inquiry as the students and teacher alike use this tool to “examine” which concepts continue to require further exploration.

### Learning, Community and Culture

When teachers take the notion of literacy one step further and facilitate authentic literacy practices and events made up of context, practice and text (Bakhtin, 1981; Barton & Hamilton, 1998) which connect people to each other through broad social goals, students will gain insights and discover the value of literacy as they engage in the roles of both reader and writer. This could have been done if Mr. Stephens had connected the concept of solar energy to specific home-based and community or provincial facts and issues such as viable renewable energy resources, hours of sunlight in the province or city, cost of energy forms, cost of solar homes, solar uses during camping, the amount of power needed to run certain electronic devices, and, a seemingly endless list of opportunities as students and teacher could have brought their ideas and concerns to brainstorm sessions during inquiry units.

Gee (1989, 1999, 2001a, 2001b), Bruner (1996) and Britton (1993) suggest that in order for school learning to continue the growth and refinement of linguistic ability that begins in the home, instruction must extend and help transform children’s individualized schema and world view, rather than impose another cultural perspective. In addition to building upon children’s linguistic and conceptual knowledge, school learning must extend and support the transformation of that knowledge through a

continuous process of highlighting and emphasizing connections to the child's past learning as well as home and community experiences and reality.

During the interviews with the students there was no talk of science in years past, and only slight connection to science concepts in the everyday world around them. Tanya mentioned that science was helpful and she would need to know about it for future grades. She thought she had seen science on TV but couldn't provide any details. Emily also said that she sometimes learned science when she wasn't at school but couldn't specify what it was she had learned or seen. Jason thought it was important to learn science for college. When asked if solar energy could help the environment he gestured to the power line poles outside the window and replied, "*Yah..., the towers*" Sometimes he saw science outside of school "*Kind of at my grandpa's farm. He has a well with gears...motors and gears and all that,*" but Jason wasn't too sure he would see any evidence of science, particularly solar, during the class's bike trip to a forested picnic area: "*Maybe some gears.*"

According to Aikenhead (1996) most students view science content as having little or no relevance to their lives. He quotes Medvitz (1985) who claims that "science learned in school is learned as science in school" unrelated to other content or contexts within the child's experiences. Aikenhead refers to this notion of segregated school science as "cognitive apartheid," a term coined by Cobern (1994). Cajete (1986) claims that much research has explored the "cultural mismatch between home and school" (p. 195). "In some cases, the disparity between home and school environments is so great that some

native American students experience a kind of culture shock which significantly affects their attitudes toward school" (p. 201). Students lack of cultural capital (Nickels & Piquemal, 2005; Moll, 2000; Tharp and Yamauchi, 1994; Aronowitz & Giroux, 1993) may have a significant negative effect upon school experiences and can lead to school failure.

#### Implications: The Need for Inquiry Programs

*If, then, we come to see knowledge and competence as products of the individual's conceptual organization of the individual's experience, the teacher's role will no longer be to dispense "truth", but rather to help and guide the student in the conceptual organization of certain areas of experience. Two things are required for the teacher to do this: on the one hand, an adequate idea of where the student is and, on the other, an adequate idea of the destination. Neither is accessible to direct observation. ...good teachers have always found ways and means of [supporting this learning] because, consciously or unconsciously, they realized that, while one can point the way with words and symbols, it is the student who has to do the conceptualizing and the operating (von Glasersfeld, 1983, p.16).*

Science-as-Discovery or Science -As-Activity. Doing or Learning? ...or Both?

Science-as-activity is the theme that winds through the data of in-class observations as well as the student and teacher interviews. Science-as-discovery, on the other hand, is necessary if one hopes to authentically engage students in the transformative process of learning. An inquiry program allows teachers to investigate both the individual and collective knowledge of their students and direct a course of action that, through the tools of language and literacy, will support learners' conceptual development. At the same time, an inquiry program relies upon and validates each individual and their personal perspective, culture, interests, preferred styles and discourses. Finally, an inquiry program provides a means of addressing the cultural, economical, social and

political issues in society that impact on students' lives when teachers view curriculum, resources, assessment and classroom interactions through critical pedagogy.

Knowing that students categorize concepts individually through their personal world view can assist teachers as they scaffold students through inquiry and discovery to negotiate, organize and reorganize new concepts and relationships as they are presented. Understanding that different cultural world views also influence the classification of various objects can be a starting point to recognizing the underlying Western view of science upon which are curriculums are built, and for encouraging discussion of perspectives within a framework that validates students' worldviews and supports conceptual growth as new knowledge builds upon and transforms prior schema. Certain taxonomic concepts along with the vocabulary that signifies particular processes of scientific learning, may appear unquestionable and straightforward in Western Science, but may be viewed within a very different system of embedded relationships in other cultures. For example, the classification of plants or animals may be related to purpose or season rather than the western view of categorical attributes seen in school science. "A system of classification and the conceptual reason for that system as well as behavior in reference to this system forms the essence of 'science' in every culture" (Cajete 1986, p. 15).

This highlights the significance of science instruction in schools as well as presents implications for how we teach science to encourage students to cross these cultural borders. These include 1) creating a variety of opportunities to develop the concepts which will trigger the students' own thinking, 2) presenting the concepts being dealt



with and demonstrating relationships to other concepts in the context of the students' culture (a cultural approach to science education), 3) understanding the everyday conceptual development that students have already attained through personal and culturally unique experiences, 4) encouraging dialogical meaning making so that learning is a process of coming to know and becomes personally transformative, 5) building learning upon the cultural framework familiar to students, 6) using the new scientific learning to make explicit those concepts in students' everyday world, 7) working to scaffold the learning of small groups of students to support the meaning-making of both words and concepts, and 7) utilizing a spiral curriculum. As von Glasersfeld points out, concepts do not exist as packaged objects that can be handed over to students but rather they are understandings or perceptions of ideas that need to be developed.

The fundamental fact that concepts can be formed only in the experiential world of an individual remains buried under the general notion that everything conceptual is but a representation of an independent reality and can therefore be transferred to students ready-made. But this kind of realism is a poor basis for teaching (2000, p.8).

Rather than completing activities through a one-size-fits-all transmission model, students engage in a model for learning that allows them to search for answers to authentic questions as they explore concepts within a broad framework of relationships.

When teachers model the process and provide instruction in the language tools students are scaffolded into gaining conceptual knowledge as well as facility with the language strands including the formal discourse of science. They become competent with the inquiry process and learn to challenge the worldview associated with the dominant

discourse of academic language. Students need to know how to critically interpret a variety of visual and auditory resources in all subject areas. Metacognitive strategies and think-alouds must be modeled to encourage independent learning; and the art of reflection valued to support the transformations that new learning brings. However, perhaps the most difficult element for teachers to relinquish their grasp on is the knowledge they wish students to learn and the questions they want them to be able to answer. Authentic inquiry requires educators to plant seeds of interest, to whet students' curiosity and then to become inquirers along with them, searching for evidence to support their notions and creating new questions and answers as they journey together. Authentic learning holds within it a tension as learners negotiate familiar and unfamiliar ideas through individual and collaborative interrogation. It is at times messy, non-sequential, confusing, yet always inspiring and lasting, for the transformations that occur are deep and personal.

Authentic dialogical inquiry projects that begin with the community's environment and resources, particularly local knowledge and ways of knowing and doing science, can contribute to a broadening of understandings as teachers help students cross cultural borders. Only as the culture of a classroom continually evolves to encourage the multiple discourses and various perspectives and realities that reflect the diverse backgrounds within our communities can teachers begin to challenge power inequities and prepare students for a more democratic, global and technological society. The greatest learning can be the strengthening and ultimately transforming of students' and teachers' identities as together they search for answers to create a new world no one has before envisioned.

## Lessons Learned

During my study a number of issues presented themselves as barriers to the students' conceptual learning. However, while they appeared as barriers, they were also the greatest lessons I learned.

### The Absence of Both the Language Strands and Conceptual Knowledge

Although the focus in Mr. Stephens' transmission-oriented class was on doing, the students were no doubt engaged in learning, and enjoying the lessons. However, observations of the students and comments by the teacher indicate that minimal conceptual knowledge about solar energy was actually constructed due to lessons and that the three students appeared to have difficulty 1) describing or explaining the solar models, 2) using the science terminology in the unit, 3) monitoring their reading and 4) understanding and retaining concepts.

Language is pivotal to learning and to understanding the relationships of concepts. In order for the students to construct conceptual knowledge they needed to understand what the concept was and how it related to other concepts. This was not made explicit in the unit of study. Language was needed to support conceptual development such as the growing ability to describe the relationships inherent within the conceptual framework, distinguishing features, similarities and differences, connections, and the related terminology connected to the discourse of science. Language was also needed to support an inquiry process. However, language for illuminating ideas through

learning, explaining, sharing describing, reflecting and remembering was not modeled, encouraged, practiced or even expected.

I have not gone into depth regarding which science concepts are covered within the curriculum guides available through Saskatchewan Education nor how these required concepts were (or might have been) addressed during my classroom observations. At present, the elementary and middle years curriculum documents in Saskatchewan do **not** outline a conceptual framework for learning science. Rather there are lists of topics to be covered and the Seven Dimensions of Scientific Literacy describe twenty-five Key Science Concepts such as *change, interaction, model, theory, and scale* (see Appendix P). Saskatchewan Education (2005) has, however, announced that all renewed science curricula will align with the Pan Canadian framework which supports an emphasis on the inquiry process and divides 'Knowledge' into three main conceptual areas: *life science, physical science, and earth and space science*. The Pan Canadian Protocol for Collaboration on School Curriculum (Council of Ministers of Education, Canada [CMEC], 1997) states "Unifying concepts are meant to integrate big ideas as a way of providing a context for explaining, organizing and connecting knowledge...[they] link the theoretical structures of the various scientific disciplines and show how they are parallel and cohesive." The protocol also claims, "The knowledge foundation is intended to reduce the volume of material traditionally covered in science curricula, and to ensure that students are not learning isolated bits of information, but rather are developing a greater understanding of science through the appropriate contexts" A united conceptual framework of knowledge in the science guides would, I believe, emphasize

the importance of conceptual teaching as opposed to completing activities. It could also allow for educators to establish a spiral curriculum within their schools and systems.

### Fragmentations and Disconnections

The theme of fragmentations and disconnections or isolated bits and pieces, unrelated to a holistic meaningful unit of learning, ran throughout the course of this study at various levels. The concept of solar energy was not supported through the provincial elementary science curriculum. Nor was it nested within a conceptual framework by Mr. Stephens. The reading demonstrated by Mr. Stephens was also fragmented as he omitted and substituted words, skipped over diagrams and charts, and added his own inter-textual comments and demonstrations without explanation. Two of the three students, Emily and Jason, demonstrated a fragmented sense of reading as they focused on sounds and words rather than meaning-making strategies that connected ideas with their prior knowledge.

In spite of Mr. Stephens' attempts to relate prior terms and past topics to the unit, his emphasis on activities without a conceptual framework, holistic perspective or reflective practice through dialogic or writing resulted in another disconnected and isolated entity. Not only disconnected from past units and activities, it was seemingly unrelated to other subject areas, to the three students' personal schema, or to life outside of school. These fragmentations and disconnections were perpetuated by the science curriculum, the commercial documents, the strategies presented, and the activities the students were involved with. They were consequentially visible in the strategies they

used and, as a result, were often seen, according to Mr. Stephens, in their pencil and paper end-of-the-unit assessments. Because of the lack of explicit connections made between the concept and the hands-on learning, and the absence of both whole class and individualized reflection through discussion, writing or drawing about their learning, I am assuming that those activities stood alone in the students' minds, and became viewed as isolated or completed activities. The students' vague and nondescript language would have resulted in, at best, shadowy perceptions of thoughts and ideas. This is in keeping with data provided by the teacher's interview, which emphasized numerous activities rather than the concepts being learned, and student difficulty retaining information; as well as the students' descriptions of the learning they had done in science.

### Masks and Illusions

There is an illusion that completing activities correctly results in learning. This is not unlike the illusion that reading a passage fluently and accurately equates with understanding and comprehension. The hands-on collaborative activities I observed, much like the fluency and accuracy of the students' reading, masked the lack of in-depth learning that one might have anticipated. On the surface, it would appear that students were engaged, constructing knowledge and internalizing concepts. However, upon closer examination, the hands-on activities merely resulted in the students taking turns copying a model, with most dialogue limited to what should go where rather than exploration, discovery and scaffolding of transformative ideas. Similarly, while the students may have been capable of reciting back what they had read, Emily and Jason

were unable to paraphrase, retell or explain their ideas. Furthermore, the modeling and demonstrations presented by Mr. Stephens, while designed to bring clarity to the lesson, were not unlike his univocal lectures which transmitted information to the students in order for them to reproduce and recall what had been said and done, rather than an invitation to dialogue, wonder and explore.

These illusions, which included hands-on collaborative learning groups that encouraged talk, accurately completed activities, accuracy and fluency in reading and teacher demonstrations, masked the lack of in-depth experiences the students needed to interpret ideas and to create personalized concepts in science.

#### The Fourth Grade Slump

As learning becomes more decontextualized through the grades these fragmentations and disconnections, masks and illusions as well as the absence of both a conceptual framework and language in units of study can hamper students' learning, particularly those whose discourse and prior experiences differ from the mainstream. This can be seen in the Fourth Grade slump.

#### Final Reflections and Further Wonderings

Since I relied upon a single site, and observed the students for only a brief period of time, the ideas I reported here reflect my perspective of one teacher's classes and three students' learning as I understood it. I have little doubt that there are many assumptions

that I as an educator had regarding Mr. Stephens' beliefs and practice, as well as the students' understandings, and that I used these assumptions in my translation, analysis and interpretations to create my envisionments.

As well, the focus for this study was on conceptual learning in science through language and literacy. Saskatchewan Education describes seven dimensions of scientific literacy of which conceptual knowledge is only a portion of one of the dimensions: "Science will enable a student [to]...understand and accurately apply appropriate science **concepts**, principles, laws and theories in interacting with society and the environment" (1990, p. 2). Quality programs must also address the other dimensions of which I have touched only briefly upon. Additionally, an Aboriginal perspective is an important consideration in Saskatchewan schools. Aikenhead (2000b) suggests that while the seven dimensions of science outlined by Saskatchewan Education (1990) create a balanced approach for cultures influenced by Western science, the nature of science, values, and STSE relationships are three dimensions that can be taught by comparing western and Aboriginal science as we teach students to cross cultural borders.

In our cross-cultural approach...Aboriginal knowledge and languages are treated as an *asset* in the science classroom. Rather than adopting a deficit model (i.e. an Aboriginal back-ground puts a student at a disadvantage in school science), we recognize the advantages that accrue to Aboriginal students who can see the world from two different perspectives (Aboriginal and Western), and who can choose the one that better fulfills their goals at any given moment. The flexibility to move back and forth between cultures is a definite asset in Canadian society today. Some educators call this flexibility "empowerment," others call it walking along two different paths (Aikenhead, 2000b, p. 7-8).

This study was limited to three students within a Grade Five science classroom. However in spite of these limitations, I feel a number of my observations and interpretations



are not untypical of many elementary schools within our province and perhaps even our nation. This is supported by the highlights of the *Science 1-5 Curriculum Evaluation Report* (Government of Saskatchewan, 1994) which collated responses by teachers and assessed students at the grade five level. These include: 1) students perform at a high level in activities related to scientific and technical skills however, 2) generally their performance in written communication was lower than expected and of most importance, 3) many grade 5 students had difficulty with science processes such as hypothesizing, inferring and explaining, all components of a quality Inquiry program. These highlights were generalized across the elementary grades. In other words, as my study suggested, a focus on activities and ‘doing’ within elementary classrooms in our province has outweighed an emphasis on constructing knowledge and learning through inquiry.

The rich literature base that supports both a social constructivist view of learning, as well as the tool of critical pedagogy which brings a structure for social praxis to address societal injustices that are perpetuated through our education institutions, crosses grades, disciplines, neighborhoods and geographical borders. As a result, I truly believe, that inquiry programs can support the construing of conceptual knowledge in schools across our nation. More research in this area with different grades and in various subject domains would be needed to challenge this belief.

## CONCLUSION

The language strands have a significant role in the construction of concepts in science. This finding can be generalized beyond science to the construction and reconstruction

of all conceptual knowledge. While various subjects and disciplines have a unique structure and discourse, learning as viewed through a social constructivist perspective, is process of socialization and internalization. In particular, dialogic discourse supports students as they impose shape and form on the shadows of their growing ideas, consolidating thoughts that are on the cusp of consciousness. In this same manner, writing requires that students search within their inner well spring and untangle the web of ideas that lies therein. Talk and writing, when used in combination, are powerful means for illuminating students' developing concepts.

Teachers that recognize and value the linguistic and cultural diversity within their classrooms and attempt to understand the educational and societal issues that perpetuate inequities feel compelled to set aside commercial programs and become decision makers. A collaborative inquiry model of learning along with a negotiated but visible conceptual framework and a willingness to delve into matters that touch students' lives result in transformative and lasting experiences for all involved as knowledge is interpreted by participants' individual and collective prior experiences. Together they can scaffold each others' linguistic and cognitive growth through authentic activities that hone meaning-oriented skills and strategies, and that reach across disciplines and beyond the classroom walls, with an energy that comes from seeking to know and to be.

## REFERENCES

- Aikenhead, G. (2000). Integrating western and aboriginal sciences: cross-cultural *science teaching*. Paper presented at American Education Research Association, New Orleans, Louisiana.
- Aikenhead, G. (1996). Science Education: Border Crossing Into the Subculture of Science. *Studies in science education* 27, 1-52.
- Angelis, J. (2001). *Let us not abandon our older readers*. CELA Newsletter fall 2001 retrieved from <http://cela.albany.edu/emailus.htm#Angelis>.
- Applebee, A., Langer, J., Nystrand, M. & Gormoran, A. (2003) Discussion-based approaches to developing understanding: classroom instruction and student performance in middle and high school students. *American Educational Research Journal*, 40(3), 685- 730.
- Applebee, A. (1981). *Writing in the secondary school*. Urbana, Illinois: National Council of Teachers of English.
- Aronowitz, S. & Giroux, H. (1993). *Education still under siege*. Toronto, Ontario: Ontario Institute for Studies in Education.
- Audet, R. & Jordan, L. (2005). *Integrating inquiry across the curriculum*. California: Corwin Press.

- Auerbach, E. (1996). *Teacher, Tell Me What To Do*. In I. Shor & C. Pari, C. (Eds.). (1999) *Critical literacy in action: writing words, changing worlds*(pp.31-52). Portsmouth, New Hampshire: Heinemann Books.
- Baker, L (2004). *Reading Comprehension and Science Inquiry: Meta-cognitive Connections*. In W. Saul (Ed). *Crossing borders in literacy and science instruction*(pp.239- 257). Newark, Delaware; International Reading Association.
- Bakhtin, M.M. (1981). *The dialogic imagination*. Austin, Texas: University of Texas Press.
- Bakhtin, M.M. (1986). *Speech genres & other late essays*. Ausin, Texas: University of Texas Press.
- Banks, J & McGee Banks, C. (2001). *Multicultural education: issues and perspectives*. (4th Ed). New York, New York: John Wiley and Sons.
- Barber. Catz, K., Arya, D. (2006.) *Improving Science Content Acquisition through a Combined Science/Literacy Approach: A Quasi-Experimental Study*. University of California: Berkeley, CA A paper presented at the American Educational Research Association April 2006 Retrieved June 3, 2006 from: [http://seedsofscience.org/PDFs/Barber\\_NagyCatz\\_A2314BB.pdf](http://seedsofscience.org/PDFs/Barber_NagyCatz_A2314BB.pdf).
- Barnes, D. R., Britton, J. N., & Torbe, M. (1990). *Language, the learner, and the school*. (4th Ed.). Portsmouth, New Hampshire: Boynton/Cook.
- Barton, D & Hamilton, M. (1998). *Local literacies: reading and writing in one community*. London, England: Routledge.
- Beach, R. (1993). *A Teacher's Introduction to Reader Response Theories*. Urbana, Illinois: National Council of Teachers of English.

- Berger, P. & Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledge*. Garden City, New York: Anchor Books retrieved December 2005 from: <http://www.brainwashed.com/h3o/Dislocation/reality.html>
- Berlin, J. (1996). Students (Re) Writing Culture. In I. Shor, & C. Pari, (Eds.), (1990) *Critical literacy in action: writing words, changing worlds.*(pp. 280-307). Portsmouth, New Hampshire: Heinemann Books.
- Best, R.M., Floyd, R.G., & McNamra, D.S. (2004). *Understanding the fourth-grade slump: Comprehension difficulties as a function of reader aptitudes and text genre*. Paper presented at the 85th Annual Meeting of the American Educational Research Association. Retrieved June 10, 2006 from: <http://csep.psyc.memphis.edu/mcnamara/pdf/bestetel.pdf>.
- Bogdan and Biklen, S. (2003). *Qualitative research for education. an introduction to theories and methods*. Boston: Massachusetts, Pearson Educational Group.
- Bracey, G. (2005). *No child left behind: where does the money go? Policy brief*. Retrieved February 14, 2006 from <http://www.asu.edu/educ/eps1/EPRU/documents/EP1SL-0506-114-EPRU.pdf>
- Bracey, G. (2004). *The seven deadly absurdities of no child left behind*. NoChildLeft, Volume 11, Number 8, October 2004. Retrieved February 12, 2006 from <http://nochildleft.com/2004/oct04absurd.html>.
- Britton, J. N. (1993). *Language and learning* (2nd Ed.). Portsmouth, New Hampshire: Boynton/Cook Publishers: Heinemann.

- Britton, J.N. (1990). Talking to Learn. In D. Barnes, J. Britton & M. Torbe, M. (Ed.), *Language, the learner, and the school* (pp. 90-130). Portsmouth, New Hampshire: Boynton/Cook.
- Britton, J. N. (1987). *Writing and reading in the classroom*. Berkeley, California: Center for the Study of Writing.
- Britton, J. N. (1984). *English teaching, an international exchange*. Portsmouth, New Hampshire: Heinemann Educational Books.
- Britton, J. N., Lightfoot, M., & Martin, N.,(1988). *The word for teaching is learning: language and learning today: essays for James Britton*. Portsmouth, New Hampshire: Heinemann Education Books.
- Britton, J. (1972). Writing to Learn and Learning to Write. In G. Pradl (Ed) 1982 *Prospect and retrospect: selected essays of James Britton*. (p.94- 111) Montclair, New Jersey: Boynton/Cook Publishers, Inc.
- Brown, AA. & Ferrara, R. (1985). Diagnosing Zones of Proximal Development. In J. Wertsch (Ed.). *Vygotsky and the social formation of mind*.(pp. 273-304). Cambridge, Massachusetts: Harvard University Press.
- Bruner, J. (1996). *The culture of education*. Cambridge, Massachusetts: Harvard University Press.
- Bruner, J. S. (1990). *Acts of meaning*. Cambridge, Massachusetts: Harvard University Press.
- Bruner, J. S. (1986). *Actual minds, possible worlds*. Cambridge, Massachusetts: Harvard University Press .
- Bruner, J. S. (1968). *Toward a theory of instruction*. New York, New York: Norton.

- Bruner, J.S. (1966). *Towards a theory of instruction*. Cambridge, Massachusetts: Belkap Press.
- Bruner, J., Oliver, R., & Greenfield, P. (1966). *Studies in cognitive growth*. New York: New York: John Wiley & Sons.
- .Bruner, J. S., & Weinreich-Haste, H. (1987). *Making sense: The child's construction of the world*. New York, New York: Methuen.
- Bybee, R.(2002). Scientific Inquiry, Student Learning and the Science Curriculum. In R. Bybee, (Ed.), *Learning science and the science of learning*. Arlington, Virginia: National Science Teachers Association.
- Bybee, R. (Ed.). (2002) *Learning science and the science of learning*. Arlington, Virginia: National Science Teachers Association.
- Bybee, R. (2000). Teaching Science As Inquiry. In J. Minstrell & E. van Zee (Ed.), *Inquiring into inquiry learning and teaching in science*(pp.20-46). Washington, D.C.: American Association for the Advancement of Science.
- Cajete, G.A. (1986). *Science: a Native American perspective: A culturally based science education curriculum*. Unpublished doctoral dissertation, International College, Los Angeles. Retrieved July 10, 2006 from:  
[http://www.usask.ca/education/ccstu/guiding\\_documents/cajete\\_thesis.html](http://www.usask.ca/education/ccstu/guiding_documents/cajete_thesis.html).
- Cairney, T. (1997). New avenues to literacy. *Educational Leadership*, 54 (6), 76- 77.
- Cairney, T. & Langbein, S. (1989). Building communities of readers and writers. *The Reading Teacher*,42 (8), 560-567.
- Calkins, Lucy McCormick. (1991). *Living between the lines*. Concorde, Ontario: Irwin Publishers.

- Calkins, Lucy McCormick. (1984). *The art of teaching writing*. Portsmouth, New Hampshire: Heinemann.
- Calkins, Lucy McCormick. (1983). *Lessons from a child*. Portsmouth, New Hampshire: Heinemann.
- Chall, J. & Jacob, V. (2003). *Poor children's fourth-grade slump*. American Educator [Electronic version] American Federation of Teachers, Retrieved June 11, 2006 from: [http://www.aft.org/pubsreports/american\\_educator/spring2003/chall.html](http://www.aft.org/pubsreports/american_educator/spring2003/chall.html)
- Chall, J.S., Jacobs, V.A., & Baldwin, L.E. (1990). *The Reading Crisis: Why Poor Children Fall Behind*. Cambridge, Massachusetts: Harvard University Press.
- Chall, J.S. (1983). *Stages of reading development*. New York. New York: McGraw-Hill.
- Chall, J.S., & Jacobs, V.A. (1983). Writing and reading in the elementary grades: Developmental trends among low-SES children. *Language Arts*, vol. 60, no. 5, pp. 617-626.
- Cole, M. & Griffen, P. (1986). A Sociohistorical Approach to Remediation. In S. De Castell, A. Luke & K. Egan, (Eds.), *Literacy, society and schooling* (pp. 87-109). Cambridge, New York: Cambridge University Press.
- Cole, S. and Lindemann, J. (1990). *Reading and responding to literature*. Orlando, Florida: Harcourt, Brace, Janovitch.
- Corson, D. (1991). *Language, power and minority schooling*. Toronto, Ontario: Ontario Institute for Studies in Education Press.
- Council of Ministers of Education, Canada. (1996). *Science assessment: framework and criteria*. School Achievement Educators Program SAIP, Toronto: Ontario.



- Retrieved July 16, 2006 from  
<http://www.cmec.ca/pcap/science3/public/02Framework.en.pdf>.
- Council of Ministers of Education, Canada. (1997). *Common framework of science learning outcomes, K to 12*. Retrieved July 16, 2006 from  
<http://www.cmec.ca/science/framework/pages/english/cmec%20eng.html>
- Cummins, J. & Sayers, D. (1995). *Brave new schools: challenging cultural literacy through global learning networks*. Toronto, Ontario: Ontario Institute for Studies in Education Press.
- Cummins, J. (1981a). *Bilingualism and minority-language children*. Toronto, Ontario: Ontario Institute for Studies in Education Press.
- De Castell, S., Luke, A., & Egan, K. (Eds.) *Literacy, society and schooling*. Cambridge, New York: Cambridge University Press.
- DeLeon, A. (2002). *The rand report*. Retrieved March 16, 2006 from  
[http://www.rand.org/pubs/technical\\_reports/2002/RAND\\_TR180-1.pdf](http://www.rand.org/pubs/technical_reports/2002/RAND_TR180-1.pdf).
- DeVillar, R. A., Faltis, C., & Cummins, J. (1994). *Cultural diversity in schools: from rhetoric to practice*. Albany, New York: State University of New York Press.
- Dewey, J. (1963) *Experience and education*. Toronto, Ontario: Collier Macmillan.
- Flood, J. (Ed.). (2003). *Handbook of research on teaching the english language arts* (2nd ed.). Mahwah, New Jersey: L. Erlbaum Associates.
- Feuerstein, R. (1980). *Instrumental enrichment: an intervention program*. Baltimore, Maryland: University Park Press.
- Fish, S.E. (1980). *Is there a text in this class? The authority of interpretive communities*. Cambridge, MA: Harvard University Press.

- Ford, D. (2004). Highly Recommended Trade Books: Can They Be Used in Science Inquiry? In W. Saul (Ed.) *Crossing borders in literacy and science instruction* (pp.277-290). Newark, Delaware; International Reading Association.
- Freebody, P., Muspratt, S. & Dwyer, B. (Eds.), (2001) *Difference, silence, and textual practice: studies in critical education*. Cresskill, New Jersey: Hampton Press.
- Freire, P. (1998). *Teachers as cultural workers*. Boulder, Colorado: Westview Press.
- Freire, P. (1970). *Pedagogy of the oppressed*. New York, New York: Seabury.
- Garan, E. (2001). *Beyond the smoke and mirrors: a critique of the national reading panel report on phonics*. Phi delta Kappa V.82 No.7 Pages 500-506 March2001.  
Retrieved February 2006 from <http://www.pdkintl.org/kappan/k0103gar.htm>.
- Gee, J. (2001a). Reading, Language Abilities and Semiotic Resources: Beyond Limited Perspectives on Reading. In J. Larson (Ed.), *Literacy as snake oil. Beyond the quick fix* (pp. 7-26). New York, New York: Peter Lang Publishing.
- Gee, J. (2001b). A Sociocultural Perspective on Early Literacy Development. In S. Neuman & D. Dickenson (Eds.), *Handbook of early literacy research* (pp. 30-42). New York, New York: The Guilford Press.
- Gee, J. (2000). Teenagers in New Times: A New Literacy Studies Perspective. [Electronic version]. *Journal of Adolescent & Adult Literacy*, 43(5) 412-420.
- Gee, J. (1999). Critical Issues: Reading and the New Literacy Studies: Reframing the National Academy of Science's Report on Reading. [Electronic version]. *Journal of Literacy Research*, 31(3) 355-374.
- Gee, J. (1990). *Social linguistics and literacies: Ideology in discourses*. Bristol, Pennsylvania: The Falmer Press.

- Gee, J. (1989). What is Literacy? [Electronic version]. *Journal of Education*. 171(1) 18-25.
- Giroux, H. (2001). *Theory and resistance in education: towards a pedagogy for the opposition*. Westport, Connecticut: Greenwood Publishing Group, Inc.
- Giroux, H. (2000). *Stealing innocence: youth, corporate power, and politics of culture*, New York, New York: St. Martin's Press.
- Giroux, H. (1997). *Pedagogy and the politics of hope: theory, culture and schooling*. Boulder, Colorado: Westview Press.
- Giroux, H. (1996). *Fugitive cultures: race, violence and youth*. New York, New York: Routledge.
- Giroux, H. (1994). *Between borders: pedagogy and politics in cultural studies*, New York, New York: Routledge.
- Giroux, H. (1992). *Border crossings: cultural workers and the politics of education*. New York, New York: Routledge.
- Giroux, H. & McLaren, P. (1987). *Critical pedagogy, the state and cultural struggle*. Albany, New York: State University of New York Press.
- Goodman, K., Smith, E. Brooks, Meredith, R. & Goodman, Y. (1987). *Language and thinking in schools: a whole language curriculum*. New York, New York: Richard C. Owen Publishers.
- Goodman, Y. (1990). *How children construct literacy: piagetian perspectives*. Newark, Delaware: International Reading Association.
- Government of Saskatchewan (2001). *Special committee to prevent the abuse and exploitation of children*. Retrieved February 14, 2006 from

- <http://www.legassembly.sk.ca/committees/Archive/aecc/Docs/000320Children.htm>.
- Graves, D. (1983). *Writing: teachers & children at work*. Portsmouth, New Hampshire: Heinemann. Educational Publishers.
- Greene, M. (1995). *Releasing the imagination*. San Francisco, California: Jossey-Bass Inc.
- Greene, M. (1990). Relationality in the Humanities: A Perspective on Leadership. *Language Arts* 67(4) 370-378.
- Halliday, M.A.K. (1993). Towards a Language-Based Theory of Learning. *Linguistics and Education* (5) 93-116.
- Halliday, M.A.K. (1978). *Language as social semiotic. The social interpretation of language and meaning*. Baltimore, Maryland: University Park Press.
- Halliday, M.A.K. & Mathiessen,(1999) *Construing experience through meaning: a language -based approach to cognition*. New York, New York: Cassell.
- Hiebert, E. (Ed.). (1991). *Literacy for a diverse society: perspectives, practices and policies*. New York, New York: Teachers College Press.
- Holliday, W.G. (2001). Taking A Look At Science Visuals. [Electronic Version]. *Science Scope* 24(4 ) 62- 65.
- Huffman, T. (2001). Resistance theory and the transculturation hypothesis as explanations of college attrition and persistence among culturally traditional american indian students. *Journal of American Indian Education* ,40(3) 1-23.
- Jacobs, E. & Jordan, C. (1993). *Minority education: anthropological perspectives*. Norwood, NJ: Ablex Publishing Corporation.

- Jingzi, H. (2003). Activities as a vehicle for linguistic and sociocultural knowledge at the elementary level. *Language Teaching Research* 7(1) 3–33.
- Johnson, A. (2005). *Making connections in elementary and middle school social studies*. Thousand Oaks, California: Sage Publications.
- Johnson, R. S., Britton, J. N., & Purves, A. C. (1973). *Responding: basic sequence*. (Teacher's annotated ed.) Lexington, Massachusetts: Ginn.Publishing.
- Journeys In Science (5), 1988. New York, New York: Macmillan/McGraw Hill Publishers.
- Kamil, M. L., Langer, J. A., & Shanahan, T. (1985). *Understanding reading and writing research*. Boston, Massachussttes: Allyn and Bacon.
- Karpov, Y.V. (2003). Vygotsky's Doctrine of Scientific Concepts. In A. Kozulin, B. Gindis, V. Ageyev, & S. Miller (Eds.). *Vygotsky's educational theory in cultural context* (pp. 65- 82). New York, New York: Cambridge University Press.
- Kozilin, Kimberley, K., Meak, M. & Miller, J. (Ed). (1992) *New readings: contributions to an understanding of literacy*. London, England: A & C Black Publishers.
- Kohn, A. (2004). In M. Moll (Ed.), *Passing the test: the false promise of standardized testing* (pp.55). Ottawa: Ontario. Canadian Centre for Policy Alternatives.
- Kozulin, A., Gindis, B., Ageyev, V. & Miller, S. (Ed.) (2003). *Vygotsky's educational theory in cultural context*. New York, New York: Cambridge University Press.
- Langer, J. A. (1995). *Envisioning literature: Literary understanding and literature instruction*. New York, New York: Teachers College Press.

- Langer, J. A. (1989). *The process of understanding literature*. (Report No. 2.1). Albany, New York: Center for the Learning and Teaching of Literature.
- Langer, J. A. (1987). *Language, literacy, and culture: Issues of society and schooling*. Norwood, New Jersey: Ablex Publishing Corp.
- Langer, J. A., & Applebee, A. N. (1987). *How writing shapes thinking: A study of teaching and learning*. Urbana, Illinois: National Council of Teachers of English.
- Langer, J. A., & Educational Resources Information, C. (1999). *Beating the odds: Teaching middle and high school students to read and write well*. Albany, New York: National Research Center on English Learning & Achievement University at Albany State University of New York.
- Langer, J. A., & Smith-Burke, M. T. (1982). *Reader meets author/bridging the gap: A psycholinguistic and sociolinguistic perspective*. Newark, Delaware: International Reading Association.
- Lee, C. D., & Smagorinsky, P. (Ed.). (2000). *Vygotskian perspectives on literacy research: Constructing meaning through collaborative inquiry*. Cambridge, England: Cambridge University Press.
- Lemke, J. (2004). The Literacies of Science. In W. Saul (Ed.). *Crossing borders in literacy and science instruction*. (pp. 33-47). Newark, Delaware; International Reading Association.
- Lightfoot, M. & Martin, N. (1988). *The word for teaching is learning*. Portsmouth, New Hampshire: Boynton/Cook Publishers.
- McLaren, P. (1998). *Life in schools: an introduction to critical pedagogy in the foundations of education*. New York, New York: Addison Wesley Longman, Inc.

- McLeod, B. (Ed.). (1994). *Language and learning: educating linguistically diverse students*. Albany, NY: State University of New York Press
- Meaghan, D. & Casas, F. (2004). Bias in Standardized Testing and the Misuse of Test Scores- Exposing the Achilles Heel of Educational Reform. In M. Moll (Ed.), *Passing the test: the false promise of standardized testing*(pp. 35-50). Ottawa, Ontario: Canadian Centre for Policy Alternatives.
- Minstrell, J. & van Zee, E. (Ed.). (2000). *Inquiring into inquiry learning and teaching in science*. Washington, D.C.: American Association for the Advancement of Science.
- Miller, A.I. (1996). *Insights of genius: imagery and creativity in science and art*. New York, New York: Springer.
- Miller, A. I. (1986). *Imagery in scientific thought*. Boston, Massachusetts: The MIT Press.
- Mishler, E.G. (1991). *Research interviewing: context and narrative*. Cambridge, Massachusetts, Harvard University Press.
- Moffett, J. (1989). Introduction to Chapter 2. In A. Dyson (Ed.), *Collaboration through writing and reading: exploring possibilities* (pp. 21-24). Urbana, Illinois: National Council of Teachers of English.
- Moffett, J. (1985). Liberating inner speech. *College Composition and Communication*. 36(3), 304-08. National Council of Teachers of English. Retrieved April 12, 2006 from:  
<http://www.jstor.org.cyber.usask.ca/cgi-bin/jstor/printpage/0010096x/ap020155/02>

a00040/0.pdf?backcontext=page&dowhat=Acrobat&config=jstor&userID=80e95514@usask.ca/01cce4403100509f0d9&0.pdf

Moffett, J. (1982). Writing, inner speech and meditation. *College English*. 44(3),231-246.

Moll, L.C. (2000). Inspired by Vygotsky: Ethnographic Experiments in Education. In C.

Lee & P. Smagorinsky (Ed.), *Vygotskian perspectives on literacy research: Constructing meaning through collaborative inquiry*(pp. 256-268). Cambridge, England: Cambridge University Press.

Moll, L. C. (Ed.). (1990). *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*. Cambridge, Massachusetts: Cambridge University Press.

Moll, M. (Ed.). (2004). *Passing the test: the false promise of standardized testing*. Ottawa, Ontario: Canadian Centre for Policy Alternatives.

Morrow, R & Torres, C. (2002) *Reading Freire and Habermas*. New York, New York: Teachers College Press.

Neuman, S. & Dickenson , D. (Eds.), (2001) *Handbook of early literacy research*. New York, New York: The Guilford Press.

Nickels, B. & Piquemal, N. (2005). Cultural congruence in the education of and research with young aboriginal students. *Alberta Journal of Educational Research*, 51 (2) 118- 127.

Nystrand, M., Gamoran, A., Kachur, R. & Prendergast, C. (1997). *Opening dialogue: Understanding the dynamics of language and Learning in the English classroom*. New York, New York: Teachers College Press.



- Nystrand, M. (2006). Research on the Role of Classroom Discourse as it Affects Reading Comprehension. *Research in the teaching of English*. 40(4) 392-412.
- Nystrand, M. (1986). *The structure of written communication*. Orlando, Florida: Academic Press.
- Nystrand, M. (1977). *Language as a way of knowing*. Toronto, Ontario: Ontario Institute for Studies in Education. Press.
- Panofsky, C., John-Steiner, V. & Blackwell, P. (1990). The Development of Scientific Concepts and Discourse. In L.C. Moll, (Ed.). *Vygotsky and education: Instructional implications and applications of sociohistorical psychology*(pp. 251-267). Cambridge, Massachusettes: Cambridge University Press.
- Pradl, G. (Ed). (1982) *Prospect and retrospect: selected essays of James Britton*. Montclair, New Jersey: Boynton/Cook Publishers, Inc.
- Probst, R.E. (1987). *Transactional theory in the teaching of literature*. ERIC Clearinghouse on Reading and Communication Skills Urbana IL. Retrieved July 21, 2006 from: <http://www.ericfacility.net/databases>.
- Rosen, H. (1992). The Politics of Writing. In K. Kimberley, K., M. Meak, and J. Miller (Ed). *New readings: contributions to an understanding of literacy* (pp. 119-130). London, England: A & C Black Publishers.
- Rosenblatt, L. (1995). *Literature as exploration*. New York, New York: The Modern Language Association of America.
- Rosenblatt, L. (1938). *Literature as Exploration*. New York: Appleton-Century.

- Roth, K. (1991). Reading Science Texts for Conceptual Change. In C. Santa and D. Alvermann (Eds.), *Science learning: processes and applications*(pp. 48-63). Newark, Delaware: International Reading Association.
- Santa, C. & Alvermann, D. (Eds.) (1991). *Science learning: processes and applications*. Newark, Delaware: International Reading Association.
- Saskatchewan Education. (2006). *English language arts: a curriculum guide for the middle level*. Retrieved June 11, 2006 from <http://www.sasked.gov.sk.ca/docs/mla>
- Saskatchewan Education. (2005). *On curriculum*. Regina, Saskatchewan: Saskatchewan Education. Retrieved November 20, 2006 from:  
<http://www.learning.gov.sk.ca/branches/curr/pdf/OnCurriculum2005.pdf>.
- Saskatchewan Education. (2004a). *Assessment for learning project: 2005 reading assessment. Information for school divisions*. Regina, Saskatchewan:  
Saskatchewan Education.
- Saskatchewan Education. (2004b). *Building communities of hope: best practices for meeting the learning needs of at risk and Indian and Metis students..* Retrieved June 16, 2006 from:  
[http://www.sasked.gov.sk.ca/branches/pol\\_eval/community\\_ed/docs/bchope2004.pdf](http://www.sasked.gov.sk.ca/branches/pol_eval/community_ed/docs/bchope2004.pdf).
- Saskatchewan Education. (2002). *English language arts - a curriculum guide for the elementary level*. Retrieved June 11, 2006 from:  
<http://www.sasked.gov.sk.ca/docs/ela/learnobj/g4-03.html>
- Saskatchewan Education.(2001). *Task force and public dialogue on the role of the school: school plus: a vision for children and youth*. Regina, Saskatchewan:

- Saskatchewan Education. Retrieved September 12, 2006 from:  
[http://www.sasked.gov.sk.ca/branches/pol\\_eval/spip/docs/roleofsch/roleofsch.pdf](http://www.sasked.gov.sk.ca/branches/pol_eval/spip/docs/roleofsch/roleofsch.pdf).
- Saskatchewan Education. (1994). *Science 1-5 curriculum evaluation project report*.  
Retrieved December 10, 2006 from:  
<http://www.learning.gov.sk.ca/branches/aar/afl/docs/curriculum/sci/1994.pdf>.
- Saskatchewan Education. (1990). *Science: a curriculum guide for the elementary level*.  
Regina, Saskatchewan: Saskatchewan Education.
- Saskatchewan Education.(1988). *Understanding the common essential learnings: a framework for teachers*. Retrieved June 14, 2006 from:  
<http://www.sasked.gov.sk.ca/docs/policy/cels/index.html>.
- Saskatchewan Education. (n.d.) Retrieved August 4, 2006 from:  
<http://www.learning.gov.sk.ca/branches/fn-me/-> 10.6KB - Department Information.
- Saul, W. (Ed.). (2004). *Crossing borders in literacy and science instruction*. Newark, Delaware; International Reading Association.
- Shor, I & Pari, C. (Eds.). (1999). *Critical literacy in action: writing words, changing worlds*. Portsmouth, New Hampshire: Heinemann Books.
- Short, K. G., Schroeder, J., Laird, J. Kauffman, G, Ferguson, M.J. & Crawford, K. M. (1996). *Learning together through inquiry*. York, Maine: Stenhouse.
- Skutnabb-Kangas, T., & Cummins, J. (1988). *Minority education: From shame to struggle* (1st ed.). Clevedon, United Kingdom: Multilingual Matters.

- Smith, M.K. (2002) 'Jerome S. Bruner and the process of education', *the encyclopedia of informal education*. Last updated: January 28, 2005. Retrieved March 2005 from: <http://www.infed.org/thinkers/bruner.htm>.
- Smolken, L. & Donovan, C. (2004). Improving Science Instruction with Informational Books: Understanding Multimodal Presentations. In W. Saul (Ed). *Crossing borders in literacy and science instruction*(pp.190-208). Newark, Delaware; International Reading Association.
- Spencer, K. (1991). *The psychology of educational technology and instructional media*. Liverpool, England. Manutius Press [electronic version] Retrieved February 5, 2006 from: <http://www.hull.ac.uk/php/edskas/edtech/c7.pdf>.
- Spindler, G. (1982). *Doing the ethnography of schooling*. New York, New York: CBC College Publishing.
- Stock, P. L. (1995). *The dialogic curriculum: Teaching and learning in a multicultural society*. Portsmouth, New Hampshire: Boynton/Cook Publishers.
- Street, B. (2005). Recent applications of new literacy studies in educational contexts. *Research in the Teaching of English*. 39 (4) 417- 423.
- Street, B. (1995). *Social literacies: critical approaches to literacy in development, ethnography, and education*. London, United Kingdom: Longman.
- Street, B. (1984). *Literacy in theory and practice*. London, United Kingdom: Cambridge University Press.
- Steffe, L. D., Cobb, P., & von Glasersfeld, E. (1988). *Construction of Arithmetical Meanings and Strategies*. New York, New York: Springer Verlag.

- Taylor, D. (1998). *Beginning to read and the spin doctors of science*. Urbana, Illinois: National Council of Teachers of English.
- Thier, M. (2002). *The new science literacy: using language skills to help students learn science*. Portsmouth, New Hampshire: Heinemann.
- Tynjala, P., Mason, L., & Lonka, K. (Ed.). (2001). *Writing as a learning tool: integrating theory and practice*. Norwell, Massachusetts: Kluwer Academic Publishers.
- United States Department of Education. (2001). *No child left behind: public law 107-110*. Washington, District of Columbia: Department of Education. Retrieved December 20, 2005 from <http://www.ed.gov/policy/elsec/leg/esea02/index.html>
- United States Department of Energy (1995). *Project: effects of amount and wavelength of light on a solar cell*. Washington, district of Columbia: Author. Retrieved June 14, 2006 from:  
[http://www.energyquest.ca.gov/library/documents/NREL\\_Solar\\_Projects.pdf](http://www.energyquest.ca.gov/library/documents/NREL_Solar_Projects.pdf).
- Unsworth, Len (Ed.). (2000). *Researching languages in schools and communities: functional linguistic perspectives*. London: Cassell Academic.
- von Glasersfeld, E. (2000). *Radical constructivism and teaching*. Geneva, Switzerland. Retrieved November 2005 from:  
<http://srri.nsm.umass.edu/vonGlaserfeld/onlinePapers/html/geneva/>
- von Glasersfeld, E. (1989). *Cognition, construction of knowledge, and teaching*. retrieved December 2005  
from <http://srri.nsm.umass.edu/vonGlaserfeld/onlinePapers/html/117.html>.

- von Glasersfeld, E. (1983). *Learning as constructed activity*. retrieved November 2005 from [http://srri.nsm.umass.edu/vonGlasersfeld/onlinePapers/pdf/von Glasersfeld\\_080.pdf](http://srri.nsm.umass.edu/vonGlasersfeld/onlinePapers/pdf/von%20Glasersfeld_080.pdf).
- Vygotsky, L. (1987). *Thinking and speech*. In R.W. Rieber and A.S. Carton (Eds.), *The collected works of L.S. Vygotsky, Volume 1: Problems of general psychology*, (Trans. N. Minick). New York, New York: Plenum.
- Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, Massachusetts: Harvard University Press.
- Vygotsky, L. (1962). *Thought and language*. Cambridge, Massachusetts: The MIT Press.
- Wells, G. (2001). *Action, talk, and text: Learning and teaching through inquiry*. New York, New York: Teachers College Press.
- Wells, G. (2000). Dialogic Inquiry in Science: Building on the Legacy of Vygotsky. In C. Lee & P. Smagorinsky (Ed.), *Vygotskian perspectives on literacy research: Constructing meaning through collaborative inquiry(pp.51-85)*. Cambridge, England: Cambridge University Press.
- Wells, G. (1999). *Dialogic inquiry: Towards a sociocultural practice and theory of education*. New York, New York: Cambridge University Press.
- Wells, G. (1994). *Learning and teaching "scientific concepts": vygotsky's ideas revisited*. Paper presented at the Conference, "Vygotsky and the Human Sciences", Moscow, Sept.1994. Retrieved March 6, 2006 from: [http://education.ucsc.edu/faculty/gwells/Files/Papers\\_Folder/ScientificConcepts.pdf](http://education.ucsc.edu/faculty/gwells/Files/Papers_Folder/ScientificConcepts.pdf).

Wells, G. & Chang-Wells, G. (1992). *Constructing knowledge together: classrooms as centres of inquiry and literacy*. Portsmouth, New Hampshire: Heinemann Educational Books.

Wertsch, J. V. (Ed.). (1985). *Vygotsky and the social formation of mind*. Cambridge, Massachusetts: Harvard University Press.

## APPENDIX A

### Sample Questions for Students

\*Note: Sample Questions will be framed in language that is clear to participants.

1. Do you like science? Why or why not. Are there certain parts of your science lessons that you like more than others?
2. What are your favorite topics you've studied? Why do you like them?
3. Tell me what you are studying in science now? Is this like other ideas you've learned about in science, maybe in other grades?
4. What kinds of activities make it easy to learn science?
5. What is hard/ difficult about learning science?
6. What do you do when something is science too hard to understand?
7. When you are reading and you come to something you don't know, what do you do?
8. Do you think you're a good reader? Why or why not?
9. Tell me how writing is important in science.
10. Do you learn science ideas when you're not at school? Tell me more.



## **APPENDIX B**

### **Sample Questions for Parents/ Caregivers**

1. How is school the same today as it was when you went to school?
2. How is it different?
3. Did you like school? Tell me about it.
4. Does your child like school? Tell me more.
5. Is this the same school your child has always attended? Please explain.
6. Does your child have homework? Is there a certain time when it gets done? Does your child need help with it?
7. What do you know about the science your child is taking?
8. What do you remember about learning science in school?

## APPENDIX C:

### Letter of Consent for Parents/ Caregivers

**Title: How does literacy support three Grade Five students' conceptual growth in science?**

**Supervisor: Dr. Linda Wason-Ellam, Professor, Department of Curriculum Studies, 306-966-7578 or e-mail: [wasonell@duke.usask.ca](mailto:wasonell@duke.usask.ca)**

**Researcher: Valerie Horner, Graduate Student, Department of Curriculum Studies, 306-763-3124 or e-mail: [valeriehorner@yahoo.ca](mailto:valeriehorner@yahoo.ca)**

You and your child are invited to participate in the research study: **How does literacy support three Grade Five students' conceptual growth in science?** This study will give insights to both you and to others about the way children use literacy to learn science concepts. I will adhere to the following guidelines which are designed to protect the interests of everyone taking part in the study.

**Purpose and Procedure :** I would like to observe your child as he/she participates in regular science class activities over a period of three to four weeks. I will be observing the activity and not evaluating your child. I will observe the task talk during class lessons which will include discussions and question and answer periods as structured by the teacher, as well as spontaneous talk that arises during activities either between the students and their teacher or amongst the three students as they work in groups exploring science. I will also observe your child during reading and writing activities so that I might gain understanding of the learning that is being developed through these processes. Likewise, activities of viewing and representing will be observed and described as your child study charts and diagrams, work on computers and create projects, posters and other activities. Secondly, I will interview you once for fifteen minutes to discuss ways your views of science learning when you were a student and how your child now is learning science. Also, I would like to interview your child, X \_\_\_\_\_.

**Potential Risks** There are no risks in this study. Each interview will be audio-taped. Interviewing is completely voluntary. There are no risks or stress in responding to the questions, but you may turn off the tape recorder at any time during the interview if you so wish. After your interview, the audiotape will be transcribed and analyzed to discover the major themes which were discussed. You and your child will be able to check the transcriptions to clarify and add information in your own words so as to construct the meanings that become “data” for later interpretation by the researcher. You will be asked to sign a data release form. Later, in discussing the data with me, you may delete anything you do not wish to be quoted in the study. You will be able to see a copy of your contributions to the study before the final draft and you will receive a copy of the study.

**Potential Benefits:** This study will look at how students learn to make meaning through talk, listening, reading, writing, viewing and representing in science projects. The findings of the study will extend educators’ understandings of how students are learning through literacy in science classrooms.

**Storage of Data:** The tape recordings and transcriptions made during the study will be kept in a secure place and will be held with Dr. Wason-Ellam, College of Education, at the University of Saskatchewan for five years according to the University of Saskatchewan guidelines before being destroyed.

**Confidentiality:** Your and your child’s participation will be anonymous and contributions will remain confidential. To assure confidentiality, pseudonyms will be used for your name, your child, and all identifying information will be excluded. The results of the study will be used for my Master Thesis and may be disseminated at scholarly conferences, in journal articles, and community newsletters etc.

**Right to Withdraw:** Participation in the study is voluntary, and you may withdraw at any time without penalty or loss of grades at school. If you withdraw, the tape recordings and interview data will be destroyed.

**Questions:** If you have any questions concerning the study, please feel free to ask at any point; you are also free to contact the researchers at the numbers provided above if you have questions at a later time. This study has been approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board on (insert date). Any questions regarding your rights as a participant may be addressed to that committee through the Ethics Office (966-2084). Out of town participants may call collect. At the end of the study, I will provide you with a copy of the written results.

**Consent to Participate:** I have read and understood the description provided above; I have been provided with an opportunity to ask questions and my questions have been answered satisfactorily.

In addition, I have been provided with a list of questions that you will ask my child. I consent and consent for my child \_\_\_X\_\_\_ to participate in the study described above, understanding that I or my child may withdraw this consent at any time. A copy of this consent form has been given to me for my records.

\_\_\_\_\_  
(Name of Participant) (Date)

\_\_\_\_\_  
(Signature of Participant) (Signature of Researcher)

## APPENDIX D

### Letter of Assent for Child

**(This letter will be read aloud to the child, age 10 to 12)**

**TITLE: How does literacy support three Grade Five students' conceptual growth in science?**

Let me introduce myself to you. My name is Ms. Horner and I am a student at the University of Saskatchewan. I am learning about how kids just like you learn about science ideas. I learn a lot about how kids learn from talking to them about what they do. I appreciate listening and talking to you because you can help teach me about how kids learn. It will take about 10 minutes.

Sometimes I will want to tape record some of the things you say so I can remember your ideas. I will ask you questions about what you like about science and some of the things you are learning in science. After our talks, you can listen to the tape recorder so you can make sure what you said is what you want to share. Later, I will talk to your parents so I can hear about how you learn science when you are out-of-school.

When I finish the study, I will write about how you and other children are learning science so that others will understand the wonderful work you are doing. What you say will be private and will not be shared with your parents or friends. I will not use your real name in the study unless you want me to and you can help me make up a pretend name for you. When the study is finished, the audiotapes will be safely stored with me at the University of Saskatchewan for five years before it is erased. Talking to me in the study is your choice and it is not a part of your regular classroom activities. If you choose, you can withdraw from the study at any time and no one will be angry with you nor will you lose grades. If that is the case, then I will not use any information that you told me and I will give back your tapes.

If you are willing to talk to me in the study, would you please sign your name and date the attached form. A copy will be provided for you to keep in a safe place. I will also give you a copy of what I wrote about you.

---

I agree to participate in the above study as explained to me. I understand the steps read to me [outlined] above. I have received a copy of the consent form for my records.

Parent's signature: \_\_\_\_\_ Date \_\_\_\_\_

Child's signature: \_\_\_\_\_ Date \_\_\_\_\_

Researcher's signature \_\_\_\_\_ Date \_\_\_\_\_

The proposed research project was reviewed and approved on ethical grounds by the University of Saskatchewan Behavioural Research Board on \_\_\_\_\_ . If at any time you have any questions about this study or your rights as a participant, you can contact me, Valerie Horner at 306-763-3124 or my supervisor, Dr. Linda Wason-Ellam, Department of Curriculum Studies, College of Education at the University of Saskatchewan by telephone:306-966-7578; or e-mail: [wasonell@duke.usask.ca](mailto:wasonell@duke.usask.ca). You may reach the Research Ethics Office, University of Saskatchewan at 306-966-2084 or by calling collect if you are out of town.

**APPENDIX E**

**Transcript/ Data Release Form**

**Title: How does literacy support three Grade Five students' conceptual growth in science?**

I, \_\_\_\_\_ have read my transcripts and agree to release them. I have had the opportunity to read the transcripts to clarify, add or delete information so it will accurately represent my words. The procedure and its possible risks have been explained to me by Valerie Horner and I understand them. I understand that my participation is completely voluntary that I may withdraw from this study at any time without a penalty. I also understand that although the data from this study may be published, and/or presented at seminars and/or conferences, my identity will be kept completely confidential in the writing.

-----  
Participant Signature Date

-----  
Researcher Signature Date

I have retained a copy of this form for my records.

## **APPENDIX F**

### **Letter of Consent for Teacher**

I appreciate your participation in the research study: How do three Grade Five students use the strands of literacy to construct knowledge of scientific concepts? The study will give insights to about the way children use literacy, to learn science concepts. I will adhere to the following guidelines which are designed to protect the interests of everyone taking part in the study.

1. As the researcher I will interview you once to discuss your perceptions of literacy and student learning of concepts found in your Grade Five science class.
2. The tape recordings and transcriptions made during the study will be kept in a secure place and will be held with Dr. Wason-Ellam, College of Education, at the University of Saskatchewan for five years according to the University of Saskatchewan guidelines before being destroyed.
3. Participation in the study is voluntary, and you may withdraw at any time without penalty. If this happens, the tape recordings and interview data will be destroyed.
4. Your participation will be anonymous and your contributions will remain confidential. The results of the study may be disseminated at scholarly conferences, in journal articles, and community newsletters etc. To assure confidentiality, pseudonyms will be used for your name, school and all identifying information will be excluded.



The proposed research project was reviewed and approved on ethical grounds by the University of Saskatchewan Behavioural Research Ethics Board on\_\_\_\_\_. If at any time you have any questions about this study or your rights as a participant, you can contact me, Dr. Linda Wason-Ellam, Department of Curriculum Studies, College of Education; telephone: 306-966-7578 (home 306- 653-5844); or e-mail: wasonell@duke.usask.ca or the Office of Research Services, University of Saskatchewan at 306-966-2084 and by calling collect if you are out of town

I, \_\_\_\_\_, agree to participate in the above study as explained to me. I understand the guidelines outlined above. I have received a copy of the consent form for my records.

Date: \_\_\_\_\_ Participant's signature: \_\_\_\_\_

Date: \_\_\_\_\_ Researcher's signature: \_\_\_\_\_

## APPENDIX G

### Open-Ended Questions for Semi-Structured Interview with the Teacher

1. Can you give me some background about your experience(s) in teaching science at the Grade 5 level?
2. How is teaching science different than teaching some of the other subjects you teach? How is it the same?
3. Can you share some of the more effective instructional strategies and/or activities that you have found support students and their understanding of concepts?
4. Do you follow any routines during your science classes?
5. Which resources have been the most helpful in your classroom?
6. Do you find that there is an integration of concepts and ideas through other subjects? Please explain.
7. What are some frustrations or obstacles you encounter as you teach science?
8. Have you ever adapted or modified your lessons/ program to meet the specific needs of students? Can you tell me more?
9. Tell me about how you assess science learning.
10. How does the curriculum support student learning?
11. What other kinds of supports would be helpful in your science classes?
12. Has your teaching changed since you began in the profession? If yes, in what ways.

## APPENDIX H

### Reading and Writing Interview

1. When you are reading and you come to something you don't know, what do you do?
2. Do you like to read? Why or why not?
3. Do you think you're a good reader? Why or why not?
4. Name your favorite books. Where did you read each one of them?
5. What is your favorite KIND of book?
6. Do you have a favorite author?
7. Tell me about reading and computers.

- 
1. When you are writing what kinds of troubles or problems do you have?  
What do you do about them?
  2. Do you ever make changes when you're writing?  
If so, what things get changed?
  3. Do you like to write? Why or why not?
  4. Do you think you're a good writer?  
Why or why not?
  5. What kind of writing do you do at school?
  6. What kinds of writing do you do at home?
  7. Tell me about writing and the computer.

## APPENDIX I

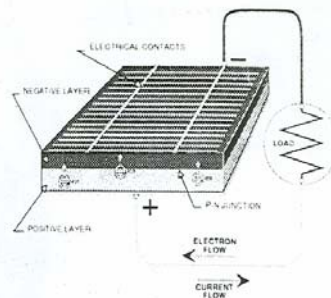
### PROJECT: EFFECTS OF AMOUNT AND WAVELENGTH OF LIGHT ON A SOLAR CELL

You've probably seen calculators that have solar cells - calculators that never need batteries, and in some cases don't even have an off button. As long as you have enough light, they seem to work forever. You may have seen larger solar panels - on emergency road signs or call boxes, on buoys, even in parking lots to power lights. Although these larger panels aren't as common as solar powered calculators, they're out there, and not that hard to spot if you know where to look. You have also seen solar cell arrays on satellites, where they are used to power the electrical systems.

You have probably also been hearing about the "solar revolution" for the last 20 years -the idea that one day we will all use free electricity from the sun. On a bright, sunny day the sun shines approximately 1,000 watts of energy per square meter of the planet's surface, and if we could collect all of that energy we could easily power our homes and offices for free.

#### HOW SOLAR CELLS WORK

Solar cells, also called photovoltaic or PV cells, change sunlight directly to electricity. When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back. When a connector, like a wire, joins the two surfaces a current of electricity travels between the negative and positive sides. Solar cells are used to power calculators and watches as well as lights, refrigerators, and even cars.



### GLOSSARY

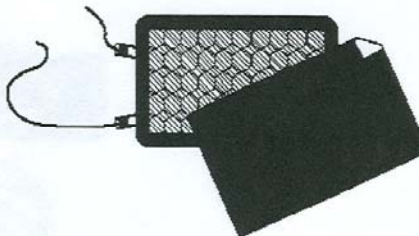
**Photovoltaic solar cells** - which directly convert sunlight into electricity, are made of semi-conducting materials. The simplest photovoltaic cells power watches and calculators and the like, while more complex systems can light houses and provide power to the electrical grid.

**Solar energy** - Energy from the sun. The heat that builds up in your car when it is parked in the sun is an example of solar energy.

### HOW THE *AMOUNT* OF LIGHT AFFECTS A SOLAR CELL

1 Shade one area of the solar cell with the black construction paper. Record your observations on the chart.

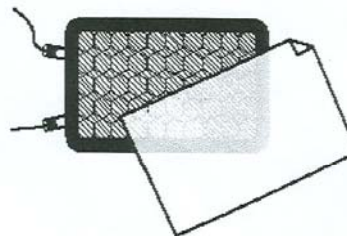
2 Repeat the experiment shading different areas and amounts of the solar cell. i.e.  $\frac{1}{2}$  and fully covered.



### HOW THE *WAVELENGTH* OF LIGHT AFFECTS A SOLAR CELL

1 Cover the solar cell with a piece of colored transparency film. Count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate in a chart similar to the one below.

2 Repeat the experiment with the other colors of transparency film.



### WHAT DID YOU SEE?

How did the spinning motion change when you covered part of the solar cell? The entire cell?  
 Which colors slowed the spinning the most?  
 Which colors slowed the spinning the least?

Colors	Number of Spins per Minute
Sunlight	
Red	
Yellow	
Blue	
Green	
Black	$\frac{1}{2}$ covered=      fully covered=

**Direct radiation** - Light that has traveled in a straight path from the sun (also referred to as beam radiation). An object in the path of direct radiation casts a shadow on a clear day.

*You will demonstrate how the amount and wavelength of light affects a solar cell.*

### MATERIALS AND EQUIPMENT

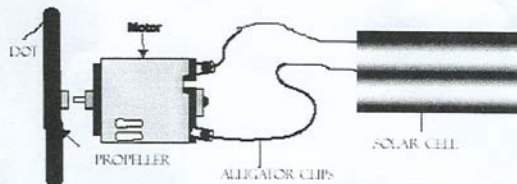
- Solar cell
- 2 alligator clips
- Electric motor
- Electric motor stand
- Propeller
- Double sided stick tape (2 Pieces)
- Black marker
- Watch
- 1 sheet of black construction paper
- 4 sheets of colored transparency film in a variety of colors (red, blue, green, yellow)
- Pencil or pen
- Piece of cardboard



### PROCESS

#### *Setting Up the Experiment*

1. Attach the motor to the motor case.
2. Attach one piece of double-sided sticky tape to the bottom of the motor case and stick onto the cardboard so the end with the shaft hangs over.
3. Attach the plastic propeller to the motor by gently pushing the propeller onto the shaft of the motor.
4. Mark a small dot on the edge of the propeller. This dot will be used as a frame of reference to measure the speed that the wheel is spinning.
5. Apply the other piece of sticky tape to the solar panel and stick it onto the cardboard.
6. Attach alligator clips from solar cell to motor.



#### *Doing the Experiment*

- 1 Place the solar cell, motor, and wheel in normal light. Observe the spinning motion. (If the motor does not spin the wheel, check the wire connections.)
- 2 Using the watch and watching the dot, count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate on a piece of paper.

## Energy Quest

# PROJECT 4: EFFECTS OF AMOUNT AND WAVELENGTH OF LIGHT ON A SOLAR CELL

## PROJECT

You will demonstrate how the amount and wavelength of light affects a solar cell.

## MATERIALS AND EQUIPMENT

- Solar cell
- 2 pieces enameled or plastic coated wire (8–10 inches [20–25 centimeters] each)
- Electric motor
- Soldering gun
- Solder (rosin core)
- Sandpaper
- Knife or wire stripper (optional)
- 6-inch (15-centimeter) diameter cardboard circle
- Utility knife
- Glue (hot or white)
- Plastic wheel with axle hole in center
- Black marking pen
- Stopwatch
- 1 sheet of black construction paper
- Several sheets of colored transparency film in a variety of colors
- Paper and pencil or pen

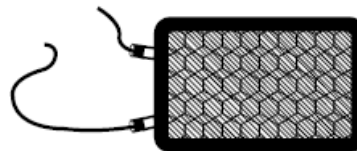
## RESOURCES

Solar cells, wheels, and motors are available from science supply stores and hobby shops. Soldering guns and solder are available at hardware stores. Transparency film is available at hobby shops and office supply stores.

## PROCESS

### Setting Up the Experiment

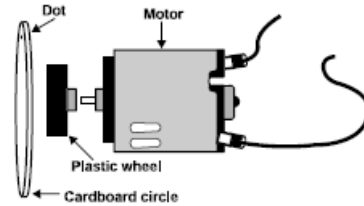
- 1 Strip the ends of each coated wire exposing about 1 inch (2.5 centimeters) of the metal. If the wire is plastic coated, use a knife or wire stripper to remove the plastic. If the wire is enameled, sand the ends to expose the wire ends.
- 2 Plug in the soldering gun to heat it up.
- 3 Melt a drop of solder onto one of the leads on the solar cell. Quickly place the end of one of the stripped wires in the drop of molten solder. Add a tiny drop of solder on top of the wire, making sure the wire is completely surrounded by the solder.
- 4 Repeat the process with the other wire.
- 5 Let the solder cool completely for 10 minutes. Gently pull on the wires to make sure that both are securely attached.
- 6 Melt a drop of solder onto one of the leads on the motor. Quickly place the end of one of the wires attached to the solar cell in the drop of molten solder. Add a tiny drop of solder on top of the wire, making sure the wire is completely surrounded by the solder.
- 7 Repeat the process with the other wire.



**8** Let the solder cool completely for 10 minutes. Gently pull on the wires to make sure that both are securely attached.

**9** Attach the plastic wheel to the motor by gently pushing the wheel onto the shaft of the motor. Be careful not to chip the solder or break the wires.

**10** Glue a 6-inch (15-centimeter) diameter cardboard circle on the face of the wheel.



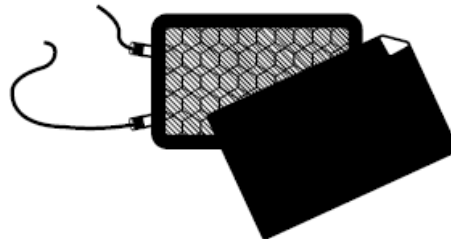
**11** Mark a small dot on the edge of the cardboard wheel. This dot will be used as a frame of reference to measure the speed that the wheel is spinning.

### Doing the Experiment

- 1** Place the solar cell, motor, and wheel in bright sunlight. Observe the spinning motion. (If the motor does not spin the wheel, check the wire connections. It may be necessary to resolder the connections.)
- 2** Using the stopwatch and watching the dot, count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate on a piece of paper.

### HOW THE AMOUNT OF LIGHT AFFECTS A SOLAR CELL

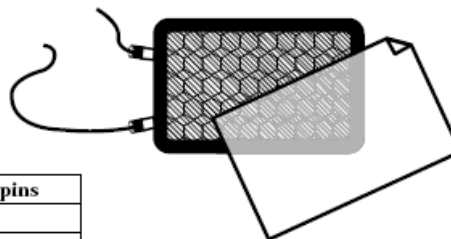
- 1** Shade one area of the solar cell with the black construction paper. Diagram the portion of the cell shaded and record observations on a piece of paper.
- 2** Repeat the experiment shading different areas and amounts of the solar cell.





## HOW THE WAVELENGTH OF LIGHT AFFECTS A SOLAR CELL

- 1** Cover the solar cell with a piece of colored transparency film. Count the number of spins in 15 seconds. Multiply this number by 4 to obtain the number of spins per minute. Record the spinning rate in a chart similar to the one below.



Colors	Number of Spins
Sunlight	
Red	
Yellow	
Blue	
Green	
Black	

- 2** Repeat the experiment with the other colors of transparency film.

### WHAT DID YOU SEE?

How did the spinning motion change when you covered part of the solar cell? All of the cell?

Which colors slowed the spinning the most?

Which colors slowed the spinning the least?

### HOW SOLAR CELLS WORK

Solar cells, also called photovoltaic or PV cells, change sunlight directly to electricity. When sunlight strikes the solar cell, electrons are knocked loose. They move toward the treated front surface. An electron imbalance is created between the front and back. When the two surfaces are joined by a connector, like a wire, a current of electricity travels between the negative and positive sides.

Solar cells are used to power calculators and watches as well as lights, refrigerators, and even cars.

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# GLOSSARY

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**Parabolic collector** - A U-shaped mirrored trough that focuses sunlight onto a tube running down the center of the trough.

**Photovoltaic cell** - A means of converting sunlight into electricity (see solar cell).

**Solar heater** - A water or space heating system that uses the sun's energy to heat homes and water.

**Solar cell** - A means of converting sunlight into electricity (see photovoltaic cell).

**Solar collector** - A box, frame, or room that traps the sun's rays to produce heat. A parabolic trough is a type of solar collector.

**Solar electric energy** - Energy from the sun used for electricity.

**Solar energy** - Energy from the sun. The heat that builds up in your car when it is parked in the sun is an example of solar energy.

**Solar thermal energy** - Energy from the sun used for heat.

**Thermosiphoning** - An event where heated water in a solar collector becomes lighter and rises to the top and cooler water becomes heavier and sinks to the bottom.

## APPENDIX K

### Reading Aloud To Students

(Children follow along, listen, respond to S → R)

#### *PROJECT: EFFECTS OF AMOUNT AND WAVELENGTH OF LIGHT ON A SOLAR CELL*

*You've probably see calculators that have solar cells. They look something like this. Here's one from a calculator...you've probably seen some in calculators even some in watches look like a little piece of glass*

*Calculators that never need batteries and in some cases don't even have an off button. As long as they have enough light, they seem to work forever. What happens when you cover them up? Cover up the*

*You may have seen larger solar panels – o emergency road signs or call boxes, on buoys, even in parking lots to power lights. You may have seen them ...Canadian tire big solar panels you can put up*

*Although these larger panels aren't as common as solar powered calculators, they're out there, and not that hard to spot if you now where to look. You have also seen solar cell arrays on satellites, You see any James Bond movie...or any movie where it has outer space you can see solar panels on there ...where they are used to power electrical systems.*

*You have probably also been hearing about the "solar revolution" for the past 20 years- the idea that one day we will all use free electricity from the sun. On a bright sunny day the sun shines approximately 1,000 watts of energy per square meter of the planet's surface, and if we could collect all of that energy we could easily power our homes and offices for free.*

#### *How Solar Cells Work*

*Solar cells, also called photovoltaic or PV cells, change sunlight directly to ~~electricity~~ (ENERGY).*

*So when the sun goes in, change sit into an energy source we can use...called electricity...*

*When sunlight strikes the solar cell, electrons are knocked loose.*

*Remember when we took atoms at the start of the year, for those people that were here? And we talked about things like electrons and protons?*

*They move toward the treated front surface. An electron balance is created between the front and the back. When a connector, like a wire joins the two surfaces a current of electricity travels between the negative and positive sides. Solar cells are used to power calculators and watches as well as lights, refrigerators and even cars.*

*All it does is creates the flow of electricity. Electrons start a flow, and the current starts to flows in the opposite direction and makes electricity.*

**GLOSSARY:**

*Photovoltaic solar cells – which directly convert sunlight into electricity, are made of semi-conducting materials. The simplest photovoltaic cells power watches and calculators and the like, while more complex systems can light houses and provide power to the electrical grid.*

How many people have seen those big solar panels on houses? What it does that collect pwer all day and stores it in a battery and a night it can turn your lights on...very cool.

*Solar energy- Energy from the sun. The heat that builds up in your car when it is parked outside in the sun is an example of solar energy.*

*Direct radiation:*

We kind talked about this remember when we did our light experiment, our heat experiment at the start of the year. We talked about how heat travels?...what was one of them? ...that had something to do with the sun? Remember?Conduction, convection and....?

Radiation. That's light directly from the sun that light is traveling.

*Light that has traveled in a straight path from the sun (also referred to as beam radiation). An object in the path of direct radiation casts a shadow on a clear day.*

So that direct radiation is the radiant energy from the sun.

*We're gonna demonstrate how the amount and wavelength of light affects a solar cell.*

## APPENDIX L

### Oral Reading

Studying Matter: How do Scientists See the World around Them?

*(Journeys in Science, 1988, McGraw MacMillan Publishers.)*

Studying Matter: How do scientists study the world around them?

Look around you. Almost everything you see is **matter**. You are matter and so is the world around you. Your pencil, your chair and the walls of your classroom are all made up of matter. Matter is anything that has **mass** and takes up space. You know that mass is a measure of the amount of matter in an object.

How do scientists study matter? Scientists begin by asking questions. Suppose a scientist asks the question, "How is food made in a leaf?" The scientist then gathers information to answer the question.

Scientists try to observe matter directly. To do this they use their senses of sight, smell, hearing, taste and touch.

**APPENDIX M**  
**Cloze Activity**

Studying Matter How Do Scientists Study the World Around Them?  
(*Journeys in Science*, 1988, p. 112, McGraw MacMillan Publishers.)

Cloze Activity: This is an activity in which selected words are deleted from a reading passage. Students complete the passage using context cues to supply the most meaningful words. When used as both a teaching or an assessment tool, a cloze activity can indicate student practice of, or use of, reading strategies such as the ability to predict and confirm specific text as well as their use of precise and correct grammar.

The original (Tanya's/ Emily's /Jason's )

**Studying Matter: How do scientists study the world around them?**

Look around you. Almost everything you see is **matter**. You are <sup>matter (matter/cool/ talking)</sup> \_\_\_\_\_ and so is the <sup>world(world/world/people)</sup> \_\_\_\_\_

around you. Your pencil, your chair and the <sup>walls(door/desk/ desk)</sup> \_\_\_\_\_ of your classroom are all made up of matter. Matter is

anything that has **mass** and takes up <sup>space(space/ space/space)</sup> \_\_\_\_\_. You know that mass <sup>is(is/is/is)</sup> \_\_\_\_\_ a measure of the

amount of matter in an object.

How do <sup>scientists(scientists/Sinicetists/you)</sup> \_\_\_\_\_ study matter? Scientists begin by asking <sup>questions(questions/you/questeungs)</sup> \_\_\_\_\_. Suppose a

<sup>Asks(asks/Ask/study)</sup> scientist \_\_\_\_\_ the question, "How is food made in a leaf?" The scientist then gathers <sup>information(information/food/up)</sup> \_\_\_\_\_

to answer the question.

Scientists try to observe matter directly. To do this they use their <sup>senses(senses/eyes/singhs)</sup> \_\_\_\_\_ of sight, smell, hearing,

<sup>Touch(touch/seeing/feel)</sup> taste and \_\_\_\_\_.

## APPENDIX N

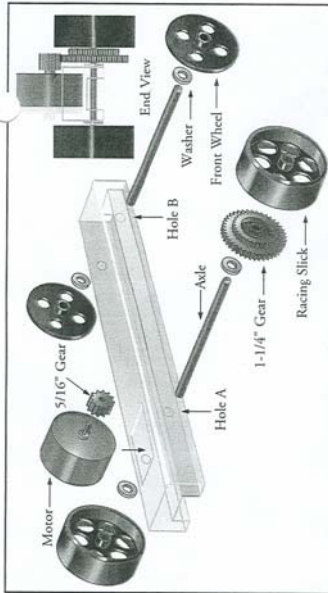
### Pitsco Solar Kit

**PITSCO'S SOLAR DESIGNER'S KIT**  
Welcome to the world of solar energy. With this kit, you will be able to build a solar-powered car (all parts included) and other solar energy projects using the supplied parts and instructions. Follow the instructions below to build a solar car. Then be inventive and design your own project.

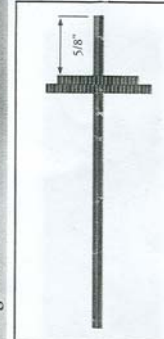
**Building Your Solar Car**  
Tools required: 9/64" drill bit, drill or drill press, utility or X-ACTO™ knife.

- Use a drill (or drill press) with a 9/64" bit to drill the two holes in the plastic body as indicated. Hole A (Figure 1) should be drilled 1-3/4" from the back end of the body (under the motor slot), and 1/2" from the top of the body. Drill through all four plastic surfaces, keeping the drill bit parallel to the top of the body and perpendicular to the side of the body.
- Hole B should be drilled in the same manner, with the center of the hole 1-3/4" from the front of the body, and 1/2" from the top of the body (Figure 1).
- Remove the 5/16" and 1-1/4" diameter gears from the gear pack and use a knife to remove any burrs. Push the small gear onto the shaft of the motor.
- Insert one axle through the 1-1/4" gear and position the gear 5/8" from one end of the axle (Figure 2). Slide one of the brass washers onto the long end of the axle, and insert the shorter end into one of the racing slick wheels (Figure 1).
- Insert the free end of the axle through Hole A in the plastic body. Slide a brass washer on the end of the axle, and push the other racing slick wheel onto the axle. Make sure the wheels turn freely (Figure 1).
- Insert the other axle into a front wheel. Slide a brass washer onto the free end of the axle and insert the axle through Hole B in the plastic body. Slide the remaining brass washer onto the end of the axle, and push the other front wheel onto the axle. Make sure the wheels turn freely (Figure 1).
- Connect the wires from the solar panel to the motor (Figure 3). If a soldering iron is available, solder the connections using 60/40 resin core solder. Otherwise, use plastic electrical tape to secure the wires to the terminals on the motor.
- Lay the motor in the slot in the top of the body, so that the gears from the motor and the wheels mesh. If necessary, use a knife to remove one of the plastic tabs on the back of the motor to allow it to drop fully into the slot. The force of gravity will keep the gears together. If necessary, use two drops of hot glue to keep the motor in place (Figure 4).
- Peel the paper from the adhesive tape on the back of the solar panel, and press the panel into place on top of the body (Figure 4).
- Your solar car is now complete. If your car runs backwards, switch the black and white wires on the motor.

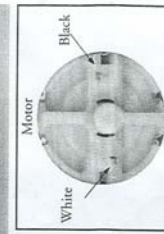
Note: The car will run on a smooth surface in full sunlight or under an incandescent 100-watt light bulb. Fluorescent light will not produce enough energy to move the car.



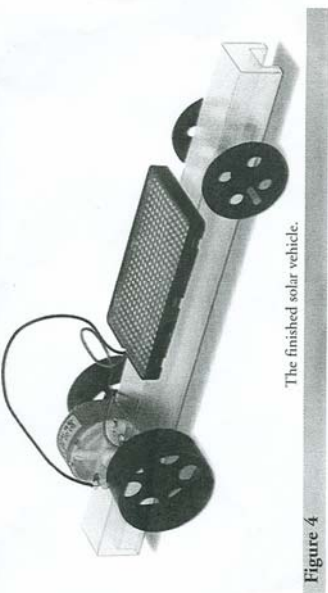
**Figure 1**



**Figure 2**



**Figure 3**



**Figure 4**  
The finished solar vehicle.

## APPENDIX O

### Assessment for Learning Sample Paragraph (Saskatchewan Education, 2005)

Something to think about before, during  
and after reading...

What's the difference between an  
"invention" and a "discovery"?

#### What is an Invention?

An invention is a new product, device or process that did not exist before. Before Armand Bombardier dreamed up the snowmobile or Alexander Graham Bell thought of the telephone, these inventions did not exist. Inventions usually happen when someone works to make our lives healthier, safer or easier.

Be careful, however, that you do not confuse inventions with discoveries!

A discovery is a product or process that already exists, but no one knows about it. For example, rubber comes from a rubber tree; rubber already existed in nature even before someone "discovered" it. A tire, however, is an invention. Charles Goodyear used rubber, a discovery, to make the tire, an invention.

Some inventions happen by accident. But most are the result of lots of hard work. Usually the first attempt at an invention is not successful. That's why someone once said that inventing is "99% perspiration and 1% inspiration."





*While the previous passage says that most inventions are "the result of lots of hard work," the following selection tells about an invention that happened by accident. Or was it a discovery?*

Read the passage to yourself, then wait quietly until your teacher instructs you to go on. Feel free to read the passage more than once. Your teacher will not be able to help you with any words in the reading; use all of your strategies to figure them out as well as you can.

## It Was an Accident!

**Not all great ideas take a long time to create. Some of our best inventions have happened purely by accident!**

One day in 1905, 11-year-old Frank Epperson was thirsty. So he added some powdered soda mix to water to make a drink. But he accidentally left the jar on the porch overnight. The temperature dropped and in the morning Frank found that his drink mixture had frozen. And it still had the stir stick in it.

Frank forgot all about his accident for 18 years. By then his own children were looking for treats. He created a recipe using fruit flavours instead of the powdered mix. He poured the mixture into a mould, added a wooden stick and froze the whole thing. Epperson's Icicles, called "Epsicles," were born! Later the Epperson children began calling them "Pop's Icicles"—and so today we have "Popsicles."



- Larry Verstraete

Something to think about....

Do you think the popsicle was an invention or a discovery?



**STOP! Wait until your teacher tells you to go on.**

### MULTIPLE-CHOICE QUESTIONS FOR "IT WAS AN ACCIDENT"

Some of the questions on the reading assessment will be multiple-choice. They require you to select the best answer from four choices. You will mark your answer on the separate answer sheet, according to your teacher's directions. Sometimes more than one answer may seem correct; you will have to think about which one is best. Feel free to go back and reread the passage.

1. **What does the author mean when he says, "Not all great ideas take a long time to create"?**

- a. Some inventions can be created quickly.
- b. Bad inventions take a short time to create.
- c. All inventions take a long time to create.
- d. Good inventions do not require work forever.

2. **What is the main purpose of the first two sentences in bold print?**

- a. They explain why the author wrote the article.
- b. They give an overview of what the article is about.
- c. They are the most important sentences in the article.
- d. They are supposed to make the reader want to read on.

3. **Why did the name "Epsicles" change to "Popsicles"?**

- a. The treats looked like icicles.
- b. The treats tasted like frozen pop.
- c. "Epsicles" was too difficult to spell.
- d. The kids named the treat after their dad.

Answers:

1 – a

2 – b

3 – d



**STOP! Wait until your teacher tells you to go on.**

# APPENDIX P

## Factors of Scientific Literacy

(Saskatchewan Education, 1990, Science, A Curriculum Guide for the Elementary Level, Regina, Saskatchewan)

Dimensions; Factors	Levels												
	Elementary					Middle				Secondary			
	K	1	2	3	4	5	6	7	8	9	10	11	12
<b>1 Nature of Science</b>													
1. public/private.....													
2. historic.....													
3. holistic.....													
4. replicable.....													
5. empirical.....													
6. probabilistic.....													
7. unique.....													
8. tentative.....													
9. human/cultural related.....													
<b>2 Key Science Concepts</b>													
1. change.....													
2. interaction.....													
3. orderliness.....													
4. organism.....													
5. perception.....													
6. symmetry.....													
7. force.....													
8. quantification.....													
9. reproducibility of results.....													
10. cause-effect.....													
11. predictability.....													
12. conservation.....													
13. energy-matter.....													
14. cycle.....													
15. model.....													
16. system.....													
17. field.....													
18. population.....													
19. probability.....													
20. theory.....													
21. accuracy.....													
22. fundamental entities.....													
23. invariance.....													
24. scale.....													
25. time-space.....													
26. evolution.....													
27. amplification.....													
28. equilibrium.....													
29. gradient.....													
30. resonance.....													
31. significance.....													
32. validation.....													
33. entropy.....													
<b>3 Processes of Science</b>													
1. classifying.....													
2. communicating.....													
3. observing and describing.....													
4. working cooperatively.....													
5. measuring.....													
6. questioning.....													

from: Hart, E.P. (1987). Science for Saskatchewan Schools: Proposed Directions. Field Study, Part B. A Framework for Curriculum Development Instructional Development Research Unit project funded by Saskatchewan Education, Training and Employment.

Prepared or developed beyond Grade 6 are neither defined nor explained in this document.

KEY:      - - - - - Preparation.  
             □ Development.

## Dimensions; Factors

	Elementary					Middle				Secondary			
	K	1	2	3	4	5	6	7	8	9	10	11	12
<b>Processes of Science (cont)</b>													
7. using numbers.....													
6. hypothesizing.....		..											
9. inferring.....		..											
10. predicting.....		..											
11. controlling variables.....		..											
12. interpreting data.....		..											
13. formulating models.....		..											
14. problem solving.....													
15. analyzing.....													
16. designing experiments.....													
17. using mathematics.....													
18. using time-space relationships.....													
19. consensus making.....													
20. defining operationally.....													
21. synthesizing.....													
<b>D Science-Technology Society-Environment Interrelationships</b>													
1. science and technology.....													
2. scientists and technologists are human.....		..											
3. impact of science and technology.....		..											
4. science, technology, and the environment.....													
5. public understanding gap.....													
6. resources for science and technology.....													
7. variable positions.....													
8. limitations of science and technology.....													
9. social influence on science and technology.....													
10. technology controlled by society.....													
11. science, technology, and other realms.....													
<b>E Scientific and Technical Skills</b>													
1. using magnifying instruments.....													
2. using natural environments.....													
3. using equipment safely.....													
4. using audio-visual aids.....													
5. computer interaction.....													
6. measuring distance.....													
7. manipulative ability.....													
8. measuring time.....													
9. measuring volume.....													
10. measuring temperature.....													
11. measuring mass.....													
12. using electronic instruments.....													
13. using quantitative relationships.....													
<b>F Values That Underlie Science</b>													
1. longing to know and understand.....													
2. questioning.....													
3. search for data and their meaning.....													
4. valuing natural environments.....													
5. respect for logic.....													
6. consideration of consequence.....		..											
7. demand for verification.....		..											
8. consideration of premises.....													
<b>G Science-Related Interests and Attitudes</b>													
1. interest.....													
2. confidence.....													
3. continuous learner.....													
4. media preference.....													
5. avocation.....		..											
6. response preference.....													
7. vocation.....													
8. explanation preference.....													
9. valuing contributors.....													

Saskatchewan Education (1990). *Science: A Curriculum Guide for the Elementary Level*. Regina: Saskatchewan Education, p. 503

## APPENDIX Q

### Proposal

#### UNIVERSITY OF SASKATCHEWAN BEHAVIORAL ETHICS RESEARCH BOARD

BEH# 06-64

#### Application for Approval of Research Protocol

**SUPERVISOR:**

Dr. Linda Wason-Ellam, Department of Curriculum Studies, College of Education

**RESEARCHER:**

Valerie Horner, Masters' Candidate, Department of Curriculum Studies, College of Education

**1. ANTICIPATED START DATE:** April 10, 2006

**COMPLETION DATE:** April 2007

**2. TITLE OF THE STUDY:**

How does literacy support three Grade Five students' conceptual growth in science?

**3. ABSTRACT:**

The purpose of this study is to highlight how language can mediate the development of science concepts. Urban classrooms within Saskatchewan today reflect the rich cultural and linguistic diversity of our province and country and the need for pedagogy that is embedded in a social constructivist theory which recognizes the influence of language in the development of thought.

The study will be framed by two related constructs 1) social constructivism in which learners construct their own knowledge socially through interaction with others and as a function of their background and purposes and 2) social constructionist learning theory which views language as a

prime mediator (or intervening factor) in terms of what children will understand about a particular concept will support the development of the proposed thesis.

How learners hear language used and how they use language themselves will influence what they learn in any given content area. Saskatchewan Learning (2002) identifies six integrated, interrelated and interdependent language strands. These include listening, speaking, reading, writing, viewing and representing. Vygotsky's (1978) insights into human learning as a socially (and therefore culturally) mediated activity and Dewey's (1938) philosophy of an inquiry approach to learning are foundational to this study. The constructive nature of learning within subject disciplines, particularly those of science and mathematics has also been recognized by Bruner (1990) and von Glasersfeld (2000).

In the proposed study, I as researcher will observe how students use language to construct knowledge. The Research Question: The overarching research question framing this study is: How do three Grade Five students use the six strands of literacy to construct knowledge of scientific concepts? To do this, I will observe, interview and describe three students and the ways they use the six strands of literacy during a science unit. I plan to make explicit the links between the use of language and conceptual growth through a social constructivist framework.

**4. FUNDING:** None

**5. PARTICIPANTS:**

I am an experienced classroom teacher and administrator who has worked in both urban and Northern schools over the past twenty years. Presently I am a principal of an elementary-middle school in a mid-sized Western Canadian city. For this study, I have chosen a Grade Five Class in a Community School classroom within my urban school district to ensure that the classroom contains students from a variety of background experiences. In addition to being members of Saskatchewan Learning's Assessment for Learning program, the class has been selected in order to gain an understanding of the abstract and conceptual development that occurs as students leave behind the concrete world of picture books and move into chapter books and more formal

content area learning. In this study, the need for students to be able to rely on the symbolic representation of print to create their own visual images as they build knowledge and concepts is critical.

The participating classroom teacher is a member of my professional network and has already shared background information regarding the priorities and expectations of the science program. After the researcher has obtained ethics approval, the teacher will nominate students with varying backgrounds, interests and academic abilities who might become potential participants. As a researcher, I will not have had a previous relationship with any of these students so there will be no pressure or coercion for them to become a participant in the study.

## **6. INFORMED CONSENT:**

As the researcher, I will meet with the three participant families (parents/caregivers and children) individually to inform them about the research study and explain consent in detail and assent for children. Participants will be informed about the purpose and expectations for the study. They will be told that the study will occur within the stream of regular science activities. In addition, it will be explained to participants that their participation and their child's participation is completely voluntary and any information that they provide will remain anonymous. They are free to withdraw at any time without a penalty or loss of grades for their child. If they choose to withdraw, all their data sources from interviews and observations will be destroyed. Informed consent will be obtained from each participant who will be read the consent form aloud and be given opportunity for questions. The participants will sign the consent form to indicate their agreement to participate before the study proceeds. Assent will be done with the three children who may agree to talk about how they are learning in their science class. In the same manner, they will have the consent read to them step by step. (See Appendix B: Informed Consent Parents and Appendix C: Assent for Children).

## **7. RESEARCH METHODOLOGY:**

**OBSERVATION/DESCRIPTION:** During the course of the three to four week science unit, I will use observation/description, open-ended questioning, interviews and field notes to learn about

the literacy lives of these three students as related to the construction of science concepts. I will not observe the students who have not given consent. As a teacher with more than 20 years of experience in the classroom, I will observe/describe these students during their class lessons as they interact, dialogue [talk], problem solve, create alternative solutions, or modify, extend or realign their understandings while using literacy not only as a tool for learning about science topics, but also for sharing their understanding with others. Later, I will interview them individually and meet with them as a group to discuss their interactions, understandings, research, studying, assignments, projects and related artifacts so that I might better come to know the influence the literacy strands have on their learning process. The focus is on how the child is learning through literacy and not on the evaluation of the child's performance.

Specifically, the participants will be observed during class lessons for dialogue, which will include formal discussions and question and answer periods as structured by the teacher, as well as spontaneous talk that arises during activities either between the students and their teacher or amongst the three students. Data will also be collected during reading and writing activities so that I might gain understanding of the learning that is being developed through these literacy processes. Likewise, activities of viewing and representing will be observed and described as students study charts and diagrams, work on computers and create projects, posters and other artifacts.

**INTERVIEWING** In addition to observing the students as they learn about science, I intend to use a combination of a semi-structured and in-depth conversational interview (Mishler, 1989) as a data gathering tool to provide a more complete picture. Semi-structured interviews (*interviews in which the same general questions or topics are raised to each of the key informants*) give confidence of obtaining comparable data across participants using a list of general questions. In response to participants, I will also use open-ended questions along side the interview as a probe in order to gather a wide range of perspectives (*in depth interviewing is designed to elicit a rich understanding of the participant's way of thinking. These interviews are less structured than a typical interview and involve the researcher probing into topics that the participant may bring up*). The semi-structured interview is the mode of choice when a researcher *knows what he or*



*she doesn't know* and can therefore frame appropriate questions to find out while the conversational interview is used to elicit discussion about opinions or values that the participant deems relevant or meaningful to the topic. Such conversational questioning alerts a researcher to aspects of their topic that otherwise are overlooked. Questions will relate to the students' perspectives on learning science (see Appendix A: Sample Questions for Students).

The interviews (10 minutes per interview) will be audio-taped and transcribed. In keeping with respectful research, participants will have the opportunity to read the transcribed interviews for clarification and sign a Data Transcript Release (Appendix E). If quotes will be used, the participants will have the opportunity to read what is said about their participation but identifying information will be excluded.

The students' parents/caregivers may be interviewed if I am in need of more data to ensure a complete picture of the students' learning, and to understand student background such as attendance, attitude, and school history including transience, which may impact on students' background knowledge, language and related literacy skills, This would again take the form of a semi-structured and in depth conversational interview of approximately fifteen minutes in a face-to-face setting of each adult's choice such as the school, their home or a local coffee shop (see Appendix B: Sample Questions For Parents/ Caregivers).

Interviews would be audio-taped and transcribed. In keeping with respectful research, participants will have the opportunity to read the transcribed interviews for clarification and sign a Data Transcript Release (Appendix E). If quotes will be used, the participants will have the opportunity to read what is said about their participation but identifying information will be excluded.

**Analysis** will be ongoing as I sift through the data looking for patterns and connections using a constant comparative methodology. Through analytic induction, I will be able to infer that events or statements were instances of the same underlying theme all the while keeping the research question in focus. As a researcher, I will ask, "*Is this code similar to or different from other codes?*" A similar technique is used in looking for patterns between the codes and categories by

using the researchers' insights and knowledge of the subject area. The grounded theory that emerges is based on the interviewee's inside view and the original voice of the interviewee is never abandoned nor compromised. Using social constructivism as the frame, the intent is that the research will highlight the role literacy plays in the construction of science concepts.

**Interpretation:** More intensive than the summary of the patterns will be rendering the interpretation of the study which requires the researcher to think in new and dialogical ways. Interpretation involves redesigning old categories, formulating new relationships by combining elements in novel ways, projecting beyond what actually exists, and conjuring up probable connections. The interpretive practice of sense-making is both artful and political. In this project, the extended engagement in the field and the involvement of research will provide triangulated data for trustworthy and authentic interpretation. It is critical that the findings are integrated with those of related and relevant studies, to establish how these results relate to broader theoretical frameworks, to explicate what the study means outside of the one context, and to make recommendations and transfer of knowledge to the local schools and policy makers.

## **8. DATA STORAGE:**

Upon the completion of the study, all data (field notes, transcripts, and tapes) will be securely stored and retained by the researcher's supervisor, Dr. Linda Wason-Ellam, for a minimum of five years in the Department of Curriculum Studies, College of Education in accordance with the University of Saskatchewan guidelines before being destroyed.

## **9. DISSEMINATION OF RESULTS:**

The results of this research study are for the primary use of completing the researcher's thesis in fulfilling the requirements for an M. Ed degree. Participants will be informed that their contributions (which they agree to share in the Data/Transcript Release Form, Appendix D) may also be written in a scholarly journal article, in conference presentations, or community newsletters. The dissemination of results will be decided collaboratively among researcher, teacher, and family participants and may include the following: community meetings,

newsletters, board meetings, and workshop or conference presentations. This research model for partnerships should serve as a conduit for the transfer of theoretical and technical expertise from university to the community, and the concomitant transfer of equally valued practice-based knowledge and skills from the community back to the university.

In keeping with the collaborative nature of this research, the participants will have the opportunity to read their contributions to the draft of the study and make comments. At the end of the study, participants will be given the opportunity to have a copy of the manuscript and any and all publications.

#### **10. RISKS:**

There is no risk or deception in the study. Participants will be made aware of the purpose of the study and why they are participants. It is not anticipated that any of the questions will become uncomfortable. No questions will be asked that could cause embarrassment, humiliation, guilt, or any other emotional state. At no point should this research impinge on the rights of participants.

#### **11. CONFIDENTIALITY:**

The confidentiality and anonymity of each of the participants and the school will be protected. The study will take place in the classroom of the participants. Parent/ caregiver interviews that may take place will be held where the adult is most comfortable. Participants will be made aware what participation means. All participants will be assured that third party privacy (confidentiality) will be maintained throughout the gathering of information and the writing of the study. Pseudonyms will be used to identify participants and any identifying personal information about them or their attributes will not be used in publications and presentations.

#### **12. DATA TRANSCRIPT RELEASE: (See Appendix D)**

Since the interview records opinions, feelings, recollections, and descriptions the participants (parents/caregivers and children) will have the opportunity to read the transcripts to clarify, add or delete information so it will accurately represent them and their intellectual property. In keeping with respectful research, they will be told orally what the researcher would like to share

about what they said and later they can read/edit what is written in the draft of the report or journal article or community newsletter.

**13. DEBRIEFING and FEEDBACK:**

Since this study is collaborative, the participants will be involved throughout the study as they review their transcripts and their contribution to the draft of the study to feel reassured that the researcher is interpreting and representing their intellectual property, that is their thoughts, feelings, and knowledge about their professional practice.

**14. REQUIRED SIGNATURES:**

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Valerie Horner, Student Researcher  
Department of Curriculum Studies

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Date

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Dr. Barry Brown, Department Head  
Department of Curriculum Studies

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Date

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Dr. Linda Wason-Ellam, Professor  
Department of Curriculum Studies

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Date

# APPENDIX R

## Research Approval

	University of Saskatchewan Behavioural Research Ethics Board (Beh-REB)	13-Apr-2006
<b>Certificate of Approval</b>		
PRINCIPAL INVESTIGATOR Linda Wason-Ellam	DEPARTMENT Curriculum Studies	BEH# 06-64
STUDENT RESEARCHER(S) Valerie Homer		
INSTITUTION (S) WHERE RESEARCH WILL BE CARRIED OUT University of Saskatchewan Saskatoon SK		
SPONSORING AGENCIES UNFUNDED		
TITLE How Does Literacy Support Three Grade Five Students' Conceptual Growth In Science?		
CURRENT APPROVAL DATE 13-Apr-2006	CURRENT RENEWAL DATE 01-Apr-2007	
<b>CERTIFICATION</b> The University of Saskatchewan Behavioural Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol or consent process or documents.  Any significant changes to your proposed method, or your consent and recruitment procedures should be reported to the Chair for Research Ethics Board consideration in advance of its implementation.		
<b>ONGOING REVIEW REQUIREMENTS</b> The term of this approval is five years. However, the approval must be renewed on an annual basis. In order to receive annual renewal, a status report must be submitted to the REB Chair for Board consideration within one month of the current expiry date each year the study remains open, and upon study completion. Please refer to the following website for further instructions: <a href="http://www.usask.ca/research/ethical.shtml">http://www.usask.ca/research/ethical.shtml</a> APPROVED.		
 Valerie Thompson, Chair Behavioural Research Ethics Board University of Saskatchewan		
<hr/>		
Please send all correspondence to:	Ethics Office University of Saskatchewan Room 306, Kirk Hall, 117 Science Place Saskatoon, SK S7N 5C8 Phone: (306) 966-2084 Fax: (306) 966-2069	