Taking Action in Science Classrooms Through Collaborative Action Research

A Guide for Educators

Karen Goodnough

SensePublishers

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DEDICATION

I dedicate this book to the teachers I have worked with during my career and thank them for affording me the privilege of playing a role in their professional learning.

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INTRODUCTION

I have been a teacher and a teacher educator for 25 years, with 14 of those years as a classroom teacher. From the very early stages of my career as a K-12 teacher, I constantly sought out opportunities to engage in professional development. However, I had never been exposed to collaborative action research. My introduction to collaborative action research occurred during graduate studies and, since that time, I have become a facilitator of collaborative action research, as well as a researcher who examines the potential of collaborative action research to support and enhance teacher learning. Moreover, I have also become an action researcher myself. In the context of my university-based teaching, I have studied my beliefs and practices as they relate to teaching and learning in teacher preparation and graduate education. As a result of these experiences, I have seen first-hand the power of collaborative action research to effect change − in teacher beliefs about teaching and learning, in professional knowledge and practice, in learning environments, and in school and school district policies.

The purpose of this book is to help others develop an understanding of the nature of collaborative action research, when it is helpful or appropriate for teachers or practitioners to engage in collaborative action research, and how to engage in the collaborative action research process. In writing about collaborative action research, I adopt the metaphor of *learning spaces*. Typically, traditional notions of space focus on a particular time or place. While we all occupy physical spaces and sometimes virtual spaces, these are not the only spaces that exist. Spaces are created and exist as a result of individuals' experiences and interactions with others and the environment. Spaces may be formal or informal, and certainly have an impact on learning.

In this book, I examine how collaborative action research can be used to create different types of spaces: problem-posing spaces, problem-solving spaces, meaning-making spaces, and spaces for communicating and disseminating the outcomes of collaborative action research. Action researchers pose problems and examine issues that are relevant to their own practice; they create meaning as they adopt new pedagogies and reflect on how their actions are impacting students and themselves; and they simultaneously create new knowledge while sharing it both locally and publicly. The spaces created through collaborative action research are constantly shifting as teachers uncover, examine, and scrutinize their own beliefs, the beliefs of others, and the research of others. Collaborative action research provides a venue for establishing learning spaces that promote collaboration, reflection, and classroom- and school-based change. In addition, collaborative action research provides a means for teachers to integrate practical wisdom, theory, and experience (Korthagen, 2001). Luenberg and Korthagen (2009) describe practical wisdom as "the sensitivity for and awareness of the essentials of a particular practice that shapes our perception of the situation, and helps us find possible courses of action. Practical wisdom is not something that is stored in our heads, but is intrinsically connected to specific phenomena occurring in the here-and-now and it only functions well in relation to these phenomena" (p. 227). Perception and awareness are important elements of developing practical wisdom and result in new ways of seeing the world. In contrast, theory is considered to be known and written down, and "involves logical structuring, such as the formulation of definitions and logically derived propositions" (Lunenberg & Korthagen, p. 227). Unlike practical wisdom, theory is not context-bound and is usually generated by university researchers and used by practitioners. Experience, the third component of this triad, is gained by being in the real world, and involves both the environment in which one operates (e.g. classrooms) and one's inner reality as one connects with the environment. This inner reality includes beliefs, perceptions, know-how and one's sense of professional identity. In this three-pronged view of teacher learning, practical wisdom, theory, and experience need to interact for learning to occur and for teachers to enhance their practical wisdom.

I offer this book as a set of guidelines to science teachers, teachers of science, teacher educators, or any other educator who would like to develop a greater understanding of the nature of collaborative action research and how to engage in the collaborative action research process. The book is divided into two parts. Part One focuses on helping the reader develop an understanding of collaborative action research, while Part Two presents four cases studies of teachers who have engaged in the action research process.

PART ONE

This part of the book is about the nature of collaborative action research and how to "do" action research. I draw upon my own experiences and insights as a facilitator of action research and as an action researcher, as well as the experiences of numerous teachers who have engaged in the action research process. As a starting point, you may wish to read a case study from Part Two of the book before starting Part One. This will give you an immediate introduction to what action research looks like in a classroom. However, your approach to reading the book will depend on your own personal learning style. Embedded in each chapter in Part One are connections to the case studies, thus providing you with specific examples of how teachers navigated the action research process. As well, at the end of each chapter is a set of reflective questions to guide your thinking as you conceptualize and plan for an action research project.

Chapter 1 provides an introduction to the nature of collaborative action research (the relationship of action research to other types of research, definitions, theoretical underpinnings, the history of action research, and the action research cycle) and its potential to create different types of learning spaces. Chapter 2 explains how to identify an area of focus and develop research questions, as well as how to examine personal beliefs and values about teaching and learning. Chapter 3 outlines how to create a plan of action to guide implementation of an action research project. Ethical actions and issues of rigour in conducting research are also addressed. Chapter 4 introduces data collection methods and sources, and provides insight into how to organize, describe, analyze, and interpret data. Chapter 5 discusses considerations and decisions that need to be made prior to sharing action research outcomes, as well as formats that may be adopted for dissemination. Happy reading!

CHAPTER 1

CREATING LEARNING SPACES

The Nature of Action Research

Learning spaces may be bounded in some instances, such as the walls of a classroom, but they can also assume many other forms (e.g. creating time for individual reflection or establishing a community of learning for a specific purpose). Learning spaces are created as a result of individuals' experiences and interactions with others and the environment. This chapter provides an introduction to action research and its potential to create different types of learning spaces. It situates action research within the broader context of educational research; examines the nature of action research (definitions and theoretical underpinnings); provides a brief history of the development of action research; and describes the action research cycle.

ACTION RESEARCH IN THE CONTEXT OF EDUCATIONAL RESEARCH

As a long-term facilitator of action research, one of my roles is that of teacher. As teachers experience their first encounters with action research, they need to develop a sound understanding of the nature of action research and how to engage in the action research process prior to planning a classroom or school-based project. During early planning sessions with collaborative groups of action researchers, I often ask group members to brainstorm descriptors that reflect their understanding of educational research. Responses typically include words and phrases such as "publishing," "scientific," "generating knowledge," "gathering evidence," "collecting data," and "understanding things around us." Many of these descriptors reflect the essence of educational research. McMillan (2004) defines educational research as "systematic, disciplined inquiry applied to educational problems and settings" (p. 4). Blaxter, Hughes, and Tight (2001) state that all research should be "planned, cautious, systematic, and reliable ways of finding out or deepening understanding" (p. 5). Educational research moves beyond ways of knowing that are based solely on personal experience or sources of knowledge that are idiosyncratic; it involves finding answers to questions or exploring issues through a systematic process of collecting, analysing, and interpreting data or evidence and then drawing conclusions. It can inform decision-making about the educational policies and practices we adopt.

While many research traditions exist and each is informed by particular beliefs about the nature of the world and how we explore and understand it, two broad research traditions have been delineated. Ary, Jacobs and Razavieh (2002) describe quantitative research, one of these traditions, as "objective measurement and statistical analysis of numeric data to understand and explain phenomena," whereas qualitative research, the other broad tradition, "focuses on understanding social phenomena from the perspective of the human participants in the study" (p. 22). Quantitative research involves controlled settings, reflecting a philosophical perspective that the social world can be understood in the same way as the physical world. In other words, principles and laws can be discovered and then applied to predict or understand human behavior. In contrast, philosophic perspectives underpinning qualitative research approaches are informed by the notion that social reality is constructed and experienced by individuals in different ways, based on their interactions with others and events and the corresponding meanings that they attach to those events. Quantitative approaches to research in education were prevalent until the 1970s. Today, quantitative and qualitative approaches are well-represented in the research literature, and mixed methods (drawing from both traditions) are often adopted depending on the goals and purposes of a study.

Educational research may also be categorized based on its purposes and how research findings are used. For example, basic research is conducted mainly for the purpose of generating theory that attempts to understand, explain, or establish generalizations. Applied research, unlike basic research, seeks to apply theories and ideas to practical settings in an attempt to solve problems and issues, and to inform decision-making about real world events and phenomena. While most educational research is applied, some researchers do engage in basic research. Action research is considered a form of applied research that may be adopted to examine specific issues or address problems that are classroom-, school-, or society-based.

THE NATURE OF ACTION RESEARCH

A review of the literature on action research finds numerous definitions. The following represent how several authors conceptualize action research. It is:

> a process by which practitioners attempt to study their problems scientifically in order to guide, correct, and evaluate their decisions and actions (Corey, 1962, p. 6).

> any systematic inquiry conducted by teacher researchers, principals, school counselors, or other stakeholders in the teaching/learning environment to gather information about how their particular schools operate, how they teach, and how well their students learn. This information is gathered with the goals of gaining insight, developing reflective practice, effecting positive changes in the school environment (and on educational practices in general), and improving student outcomes and the lives of those involved (Mills, 2003, p. 5).

> a form of self-reflective inquiry undertaken by participants (teachers, students, or principals, for example) in social (including educational)

> situations in order to improve the rationality and justice of (a) their own social or educational practices, (b) their understanding of these practices, and c) the situations (and institutions) in which these practices are carried out (Carr & Kemmis, 1986, p. 162).

> a substantive act with a research procedure; it is action disciplined by inquiry, a personal attempt at understanding while engaged in a process of improvement and reform (Hopkins, 2002, p. 42).

> used in almost any setting where a problem involving people, tasks and procedures cries out for a solution, or where some change of feature results in a more desirable outcome (Cohen, Manion & Morrison, 2007, p. 297).

These definitions share a number of commonalities. Action research is systematic, intentional research that is carried out by practitioners themselves and is not imposed by others. It is insider research in the sense that those directly involved in the situation take action to improve their own practice and their understanding of that practice, while resolving problems. It involves an "ethical commitment to improving society (to make it more just), improving ourselves (that we may become more conscious of our responsibility as members of a democratic society), and ultimately improving our lives together (building community)" (Holly, Arhar, & Kasten, 2005, p. 31).

As you read more and more about action research, you will find varying labels for action research (e.g. classroom-based action research, participatory action research, school-wide action research, individual-researcher action research). These reflect different purposes and theoretical foundations of action research. Because of the plethora of conceptions of action research, Rearick and Feldman (1998) developed a framework as a guide to understanding the multi-faceted nature of action research. In reviewing the many models and categories of action research, they proposed that action research be viewed as a space with three dimensions: theoretical orientation, purpose, and reflection. Building on the work of other authors (Carr & Kemmis, 1986; Grundy, 1987; Habermas, 1971), they describe three orientations: technical, practical, and emancipatory. The technical orientation involves control. External researchers or individuals with special expertise determine the research questions; and the focus is product-oriented and on determining effective practices. Because the research is directed by others, practitioners may not take ownership or "buy in" to the research. The practical orientation, on the other hand, is focused on understanding particular contexts, such as school and classroom events, through group reflection and consensual meaning-making. Critical orientations are concerned with issues of power, and finding ways and means through research to empower individuals and groups to effect societal change.

In terms of the purpose of action research, Rearick and Feldman, drawing upon the work of Noffke (1997), articulated three broad foci: a) personal growth (developing new insights into one's own professional knowledge and practice), b) professional understanding (teacher development and generation of new knowledge in the area of teaching and learning), and c) political empowerment (becoming aware of economic, social, gender, and racial inequities and directing social action to overcome these inequities).

The third dimension involves various forms of reflection (autobiographical, collaborative, and communal). Autographical reflection focuses on the researcher's personal introspection about beliefs, perspectives, and actions. As the reflection becomes more public, it becomes collaborative where groups of individuals pose questions that move beyond the self. In this form of reflection, there is a move towards understanding the actions of others and how the self is constructed in relation to the social context. Communal reflection then situates the self in relation to the broader society and issues such as social justice. Public meaning is achieved through public debate and dialogue.

In chapters 6 to 9, four cases studies of teachers engaging in action research are presented. I invite you to read and examine one or all cases from the perspective of the Rearick and Feldman framework. What orientation to action research is reflected? What are the primary goals of the research and what types of reflection are utilized by the teacher action researchers?

ACTION RESEARCH: A BRIEF HISTORY

Kurt Lewin is generally given credit for coining the term action research (Lewin, 1946). Lewin believed action research provided a means to solve practical social problems, to improve social conditions, and to "discover 'general laws of group life'" (Peters & Robinson, 1984, p. 115). Throughout the 1950s, action research in education continued to be championed through the work of Stephen Corey. According to Corey (1953), practitioners were pivotal to the improvement of curriculum through investigating their own problems and concerns. Near the end of the decade, action research moved into the background as the focus on rationalist approaches to curriculum development became entrenched. There was limited tolerance for a form of research (action research) that recognized the key role of educators in the development of curriculum and the creation of educational theory. Later, in the 1970s, action research gained momentum again through the work of Lawrence Stenhouse. For the betterment of schools, he believed "curriculum research and development ought to belong to the teacher … [and] is based on the study of classrooms. It thus rests on the work of teachers" (Stenhouse, 1975, pp. 142-143). His work was supported and developed through the efforts of John Elliott and Clem Adelman in the Ford Teaching Project (Elliott, 1976-1977).

In the past three decades, educational action research has grown in popularity and is being adopted and promoted by many educators, including K-12 teachers, school and school district administrators, and university researchers, as a means to effect change. Many action research resources are available, including:

– *The Ontario Action Researcher* at http://www.nipissingu.ca/oar/
  This is an electronic peer-reviewed journal that targets the work of elementary, secondary, and university teachers.
– *The Collaborative Action Research Network* (CARN) at http://www.did.stu.mmu.ac.uk/carnnew/
  This network supports action research through the publication of action research projects from many disciplines (education, health, etc.) and by providing a forum for engaging in critical dialogue about many aspects of action research.
– *Educational Action Research* at http://www.tandf.co.uk/journals/titles/09650792.asp
  This refereed international journal publishes reports of a variety of action research and related studies in education and across many professions.

A quick search of the Internet or your local library databases will reveal many other resources and materials related to action research.

THE ACTION RESEARCH CYCLE

Now that you have had an opportunity to situate action research within the context of educational research, and to consider the characteristics of action research, we will explore the action research cycle. We will ask, how do practitioners carry out action research, thus creating spaces for learning? The action research process is typically represented as a cycle or spiral involving a number of stages, although the number of stages may vary. For example, Lewin's approach to action research, as described by McKernan (1991), starts with

> a general idea or difficult problem requiring resolution. This is followed by further fact-finding … resulting in an overall plan of how to solve the problem. This planned action is implemented, and monitored in an attempt to evaluate the effectiveness of the first action step, to plan the next step and to modify the 'overall plan' … The researcher then spirals into developing a second and possibly further action steps (p. 18).

Others have described the action research cycle in a similar manner. Stringer (2004) presented the action research process as involving a) research design (defining, exploring, and framing the issue; conducting a review of the literature; checking the validity and ethics of the work), b) data gathering (using a variety of techniques and sources), c) data analysis (identifying key features of the experiences), d) communication (dissemination of the outcomes), and e) action (using the outcomes of a project to work towards a resolution to the issue).

In chapters 2 to 5, the steps in the action research cycle will be discussed in more detail (see Figure 1). The initial step involves identifying an issue or problem, thus linking an action with an idea. For example, teachers may wish to explore the reasons for students' lack of engagement in learning science. After identifying the problem, the researcher then explores the nature of the problem, generating ideas about how the problem or issue can be addressed. This step is referred to as *reconnaissance* (Elliott, 1991), describing and explaining the facts of the situation or context. Once the action research group has clarified the idea or problem, a "plan of action" is established − how will data be collected and how will the implementation of the plan be monitored. Next, the group analyzes the results of the implementation, and states conclusions. Data analysis should not only occur at the end of data collection, but also throughout the entire implementation process. If the plan has not resulted in positive change (e.g. students have not become more engaged in science class), then the plan may be revised and further implementation may occur. All stages of the action research cycle require the group to engage in monitoring, reflecting, and evaluating.

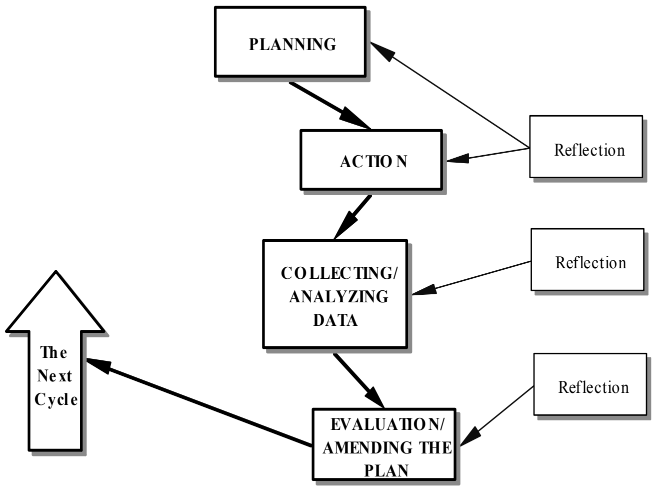


Figure 1. The action research cycle.

Chapter 6 describes the experiences of a colleague of mine, Katrina, as she completed an action research project. The following summarizes how she engaged in the action research process:

– Issue or Problem
Katrina wanted to shift her approach to teaching science from teacher-directed to being student-directed.

– Research Focus

Katrina adopted a webquest to create an inquiry-oriented learning environment for her grade one students.

– Research Questions
How does a webquest engage students in learning?
How does using a webquest influence the role of both the teacher and the student in the science classroom?

– Plan of Action
This involved collaboration with two other teacher researchers. Katrina engaged in web-based research and completed a literature review; adapted an existing webquest for use in her classroom; integrated the webquest into a unit on *Living Things*; developed and/or selected appropriate assessment tools and learning activities; considered ethical issues; sent a letter to parents about the action research project; developed a timeline for implementation; and selected data collection sources and methods.

– Implementation
Katrina implemented five lessons to engage students in inquiry through a webquest.

– Data Collection
Data collection methods and sources included classroom observational notes, a parent survey (baseline data collected prior to implementation), student-generated work, a student survey, and teacher reflective journal entries.

– Data Analysis
This was ongoing during implementation, but was more intensive at the end of implementation. Katrina looked for evidence of changes in student learning. She tabulated frequencies of responses from parent and student surveys, examined student work and compared observational notes and survey responses to look for common themes related to student behaviors, and analyzed her reflective journal entries to examine changes in her own classroom behaviors and beliefs about teaching.

– Revised Plan of Action
Katrina continues to use the webquest and is refining her teaching through inquiry. In addition, she recognizes the need to provide students with more consistent feedback and to elicit more response from them about how they are learning through webquests.

Engaging in the action research process provides a means for teachers to view themselves differently and to adopt an inquiry stance to their teaching (Cochran-Smith & Lytle, 2001). Approaches to action research that are teacher-centred, teacher-driven, and afford teachers opportunities to situate themselves as knowledge-creators and inquirers (Carson & Sumara, 1997) have the potential to positively impact teaching and learning and can greatly influence the teaching profession.

QUESTIONS FOR REFLECTION

- How is action research different from your current practice of reflection?
- Why would collaboration be an important element of action research?
- Identify an issue or concern you would like to explore in your own classroom. How would you use action research to explore this problem?

CHAPTER 2

PROBLEM-POSING SPACES

Identifying an Area of Focus

Before crafting a plan for engaging in action research, you need to identify an area of focus − a concern, issue, or problem. The area of focus will define the project and shape how it will be implemented. In this chapter, you will develop an understanding of how to: a) identify an area of focus, b) examine how it relates to your beliefs and values about teaching and learning, and c) craft specific research questions based on an identified area of focus. This initial stage in the action research process fosters the development of spaces for problem-posing where you can identify and pursue questions that are relevant and meaningful to you in the context of your classroom and school.

IDENTIFYING AN AREA OF FOCUS

One of the most critical aspects of the action research process is identifying an area of focus. Sometimes teachers start an action research project with a particular focus already identified. For example, a school-based group of three junior high teachers that I worked with two years ago formed an action research project with an established area of focus. For several years, these teachers had been using slide shows, which incorporated text, graphics, applets, animations, and interactive activities, and they wanted to demonstrate the positive impact this pedagogical approach was having on their students' learning. In other instances, it may be far more challenging to identify an area of focus.

Most of the teachers I have supported in action research projects have typically started the process without an area of focus. The teachers described in the case studies in chapters 6 to 9, for example, were all new to action research; thus they identified a research focus after they understood the nature of action research and how to engage in the process. So, while teachers have many interests, and certainly have numerous questions and concerns about their teaching and student learning, selecting a specific focus requires careful thought and consideration. When selecting a focus or topic, you should consider the following questions:

– Have you chosen a topic that focuses on teaching and learning?

– Does the topic focus on your own work?
– Are you passionate about your topic of choice?
– Does the identified topic focus on something you wish to change or improve?
– Have you chosen a topic that is manageable, considering your time, energy, and resources?

In Chapter 8, which describes the action research experiences of Arlene, Ernie, and Lisa, identifying an area of focus was one of the biggest challenges for this school-based group. They wanted to broaden their teaching repertoires and adopt a new approach that would challenge them, as well as engage students in a new way of learning. Moving from this very broad notion, and with the help of some other members of the larger action research group, we brainstormed a list of classroom approaches. A graphic organizer, concept maps, appealed to the three teachers as a possible option that would "breathe some life" into their approach to teaching science. They became passionate about the topic as they learned more about the nature of concept mapping and its possible pedagogical potential. The teachers felt it would be feasible to explore this topic and incorporate it into their science curriculum over a period of several months.

As a facilitator of action research, one of my cautions has always been that groups need to start small and create plans of action that are manageable. It has been my experience that many teachers often become very zealous about their new projects and, consequently, have a tendency to plan a project that is far too large in scope. While it may be challenging to identify an area of focus, there are a number of reflective exercises that can be used to facilitate the process. For example, Holly, Arhar, and Kasten (2005) describe five lenses that may be used to assist in selecting an area of focus:

– Examining the needs of an individual student (Why is Sara so quiet in science class?)
– Focusing on a small group of students in a classroom (Why are these students performing so poorly in science? How can I help these students develop a better understanding of the relationship among voltage, current, and resistance?)
– Studying an area in the curriculum that affects an entire class or a number of classes (How can we engage students in more student-directed inquiry in our biology classes?)
– Addressing larger issues (Why are so few students enrolling in physics courses in high school?)
– Examining social issues (How can we address the issue of bullying in our school?).

The authors suggest that action researchers use these different perspectives simultaneously, viewing events and phenomena from both a broad and a more focused perspective when indentifying an area of focus.

In my own work with action researchers, many of whom have focused on classroom teaching and learning, I have found the work of Fichtman-Dana and Yendol-Silva (2003) to be very helpful. After analyzing over 100 teacher inquiry projects, these authors identified eight distinct passions or areas of foci that were represented in teachers' research. These are described in Table 1.

Table 1. Areas of focus in action research and ways to identify them.

Passion or Area of Focus	Examples	Activity to explore this passion
Helping an Individual Child	How can I help a student understand a particular topic in science? How can I encourage this child to participate more in classroom activities?	Generate a list of the students in your class. Note next to the name of each child how each child is unique and/or note whether each child is experiencing a challenge in your classroom.
Improving or Enriching the Curriculum	How can I make the unit on *Living Things* more inquiry-based? How can I design a science unit that integrates language arts and social studies?	Meet with a program specialist to discuss changes that will be introduced in the curriculum in the near future. Craft a research project that connects to one of the suggested changes. Generate a list of topics or units that you would like to change. Why were you dissatisfied with them in previous implementations?
Developing Content Knowledge	I am uncomfortable with teaching the upcoming unit on electricity. How can I increase my understanding of the key concepts and principles in this unit?	Generate a list of topics of which you feel you would like to enhance your understanding. Prioritize the list, noting the topics and areas in which you feel you need to augment

		or enhance your subject matter knowledge.
Improving or Experimenting with Routines or New Teaching Strategies or Techniques	While I incorporate questioning into my lessons, I would like to ensure I ask higher level thinking questions. How can I do this? This approach (problem-based learning) seems to have the potential to enhance student problem-solving skills, while promoting collaborative learning. How can I use this approach to promote both of these goals?	Draft a list of teaching strategies you would like to try and state a reason for your desire to try each. Now, write a question that connects the strategy and your reason.
Examining the Relationship between Beliefs and Classroom Practice	It is important to me that students not only understand scientific concepts and principles, but that they also develop an appreciation for how scientific knowledge is generated. Unfortunately, I devote very little time to this in the curriculum. How can I change my classroom planning and practice such that I have a more focused emphasis on promoting and understanding of the nature of science?	Keep an ongoing reflective journal of classroom events. Identify ways you might respond differently to these events. What beliefs underpin how you reacted and what beliefs underpin how you might act differently in a particular situation?
Examining the Intersection between Personal and Professional Identities	I am very passionate about music and perform on the weekends on a regular basis. How can I use this passion to make	Develop a timeline of your growth as a person and as a teacher. Connect a personal

	my science classes more engaging for students?	passion to your classroom practice.
Advocating Social Justice (exploring questions of race, class, gender, or disability)	How can I incorporate examples and analogies into my science classroom that are more gender inclusive? Analyze existing resources to determine the perspectives reflected as they relate to diversity.	Keep a journal that focuses on a particular subset of your students (e.g. race, gender, etc.). Based on your observations, how do these students experience schooling? If inequities exist, how can you make learning opportunities more accessible to these students?
Understanding the Teaching and Learning Context	My school district has adopted standardized testing in science courses. How can I prepare students for these examinations while promoting student-centred teaching practices?	Brainstorm a list of contextual issues (e.g. large class size) that may impact your classroom practice or school functioning. How can each be addressed or changed?

In identifying an area of focus, it is always important to talk about your interests and possible topics with colleagues. If you are part of a school-based group that is exploring a common topic, then you have an immediate forum for sharing ideas and reflection. Furthermore, this discussion and collaboration can be extended to other school-based colleagues or those from other schools, as well as critical friends such as university researchers or other experienced facilitators of action research. Costa and Kallick (1993) describe a critical friend as "a trusted person who asks provocative questions, provides data to be examined through another lens, and offers critique of a person's work as a friend" (p. 50). Critical friends can play a valuable role at many stages in the action research process, from assisting with identification of a focus area, providing feedback on the design of the action research plan, to offering advice on data collection and analysis.

INTERROGATING THE AREA OF FOCUS (RECONNAISSANCE)

Once an area of focus has been identified, it is important to find out more about the topic, and to develop an understanding of the area of focus in connection to your own beliefs, values, and teaching practices. This step in the action research process is referred to as *reconnaissance* and involves reflecting on what you already know about the area (self-understanding and the context), as well as reviewing what others know about the area (literature and research). Issues and questions that should be considered include:

- Self-Understanding
  As a starting point, you need to examine your own beliefs and values about teaching and learning in relation to the area of focus. Why have you chosen this topic? How does it fit with your current classroom practices? How does it fit with the context of your classroom and school? For example, in Chapter 9, the teacher action research group, consisting of five primary and elementary teachers, pursued a shared inquiry focused on adopting problem-based learning (PBL). Initially, the teachers wished to examine how PBL affects student achievement in their classrooms. After reflection about the science program and the lack of student excitement and/or lack of interest in science classes, they shifted their focus to examine how the adoption of PBL could foster student engagement and interest in learning science.

- The Context
  With any area of focus, you need to be aware of your starting point. You need to determine if you can act on the issue and if you can realistically effect change and make improvements. Mills (2003) suggests that action researchers describe the situation by addressing the "who, what, when, where, and how" as it relates to the area of focus. During reconnaissance, the teachers described in Chapter 9 posed these questions: Which students are not engaged in learning science? Are some groups engaged while others are not? What is our evidence that a lack of engagement in science is an issue? How often do we have science class? Where is science class held? Do we utilize different learning settings in science (classroom-based, informal learning environments, virtual environments)? How do we structure science inquiry in our classrooms? Is it mainly teacher-directed? How do we encourage students to take responsibility for their own learning?

- What Others Know about the Area of Focus
  Ascertaining what others know about the area is a crucial part of reconnaissance. Consulting with teachers, university researchers, community-based professionals, or other educators who have completed work on your proposed topic can be extremely informative. A wealth of information can be garnered through reviewing the literature (internet sites, practitioner and professional journals, and professional books). If you know very little about the area of focus, you may need to tackle general readings first and then move on to more specific literature. During this stage, you are not only learning about your

topic, but you are also interrogating the literature! You are examining ideas and research from a critical perspective, and connecting theories and empirical research to your own experiences and emerging understandings.

DEVELOPING RESEARCH QUESTIONS

Once you have engaged in reconnaissance, you are ready to draft a research question or set of research questions to which you wish to find answers. You should start by drafting an open-ended question(s) that reflects the purpose of your study. The following are examples of research questions generated by the teachers described in chapters 6 to 9 of this book.

– Katrina (Grade one teacher)
Broad Questions: How does a webquest engage students in learning? How does using a webquest influence the role of both the teacher and the student in the science classroom?

– Arlene, Ernie, Lisa (Primary/elementary teachers)
Broad Question: How do we use the concept mapping tool to improve teaching and learning in the elementary science classroom?
Specific questions: What is concept mapping? How do we teach concept mapping to children? How do we assess concept maps? How do teachers view concept maps? What are students' perceptions of concept mapping? Do they like it? What are some advantages/disadvantages of concept mapping?

– Lana (Junior high science teacher) and Sonja (Junior high art teacher)
Broad question: How will the integration of art and science affect student learning in a simple machines science unit?
Specific questions: What are the most feasible approaches for incorporating art into the science curriculum? How will participation in a student-centred unit, with a focus on integrating art and science, affect student engagement in learning science? How will participation in a student-centred unit, with a focus on integrating art and science, impact student understanding of concepts and principles in a unit on simple machines?

– Deidre, Lois, Judi, Nancy, and Samantha (Primary/elementary teachers)
Broad Questions: How does the adoption of PBL engage all students in my classroom? What are the roles of teachers and students in PBL environments?

Questions may be open-ended and include both broad and specific questions. When phrasing the questions, identify the expected outcomes of your research.

Moreover, drafting a set of clear questions will help you to determine if you have a feasible path for moving forward with your plan of action.

QUESTIONS FOR REFLECTION

– Use one of the lenses or several in Table 1 to explore a possible idea (focus area) for an action research project.
– Develop a broad research question, based on the outcomes of the previous exercise.
– Write responses to the questions posed in the self-understanding stage of "Interrogating the Area of Focus" in relation to the focus you identified.
– Write responses to the questions posed in the context stage of "Interrogating the Area of Focus" in relation to the focus you identified.

CHAPTER 3

PROBLEM-SOLVING SPACES

Developing a Plan of Action and Quality and Ethics in Action Research

In the previous chapter, we discussed how to identify an area of focus and develop research questions to guide your project. After identifying an area of focus, it was suggested that you engage in the process of reconnaissance; that is, exploring the topic in relation to your own beliefs and values, and interrogating the literature to find out what others know about your topic. After these initial steps in the action research process are completed, you are ready to create a plan of action to guide implementation. By developing a plan, you are more likely to move forward with your research in a systematic manner.

In this chapter, you will develop an understanding of how to create a plan of action to guide implementation. This allows you to engage in the process of problem-solving as it relates to your area of focus and research questions. Ethical actions that need to be taken by the researcher to ensure participants will not experience any harm as a result of participating in your research, and the processes that need to be followed to ensure that your action research project is systematic and high in quality will also be addressed. These actions and processes need to be given the utmost attention as you generate your plan of action.

THE PLAN OF ACTION

Several factors need to be considered when developing a plan of action. While the action research process is cyclical in nature (refer to Figure 1, Chapter 1), clearly describing each step in the process separately will help you to view the process more holistically and keep you focused. The list below will be helpful in considering the various points in the action research process.

– Identifying an area of focus
– Engaging in reconnaissance
– Formulating research questions
– Describing the intervention
– Describing the action research group
– Developing a timeline
– Considering the scope and resources
– Describing data collection and analysis
– Reflecting on outcomes and dissemination

Table 2 is an example of an action plan developed by two teachers, Lana and Sonja (see Chapter 8). You may wish to refer to this table as each stage in the process is described subsequently.

Table 2. An Example of an Action Plan.

Area of Focus	Integrating art into science (interdisciplinary teaching and learning)
Reconnaissance	Visit the library Check internet sites Talk to program specialist at the school district office Order books Self-reflection (Why are we interested in this topic? What do I already know about this topic? How does this align with my beliefs about how students learn best?)
Research questions	What are the most feasible approaches for incorporating art into the science curriculum? How will participation in a student-centred unit, with a focus on integrating art and science, affect student engagement in learning science? How will participation in a student-centred unit, with a focus on integrating art and science, impact student understanding of concepts and principles in a unit on simple machines?
Intervention	Simple Machines Unit Curriculum mapping to determine the art and science outcomes that will be targeted Introduction to the Unit: Who was Leonardo da Vinci? Guided inquiry-based learning centres that target outcomes (e.g. to determine the efficiency of several sports balls) The approach will incorporate team-teaching, cooperative learning strategies, and multiple intelligences theory principles
Action research group	Lana, Sonya, Sarah (learning resources

	teacher); Karen (university researcher), and larger district action research group
Timeline	October to December: Write letters for parent and student informed consent forms Obtain administrative approval for changing the teaching schedule Reconnaissance (Lana, Sonya, and university researcher) December to February: Create learning materials Design assessment and learning activities Determine data collection methods and sources March and April: Implementation, data collection and analysis (Lana, Sonya, and graduate students) Reflection ongoing
Scope/resources	Determine the funding available for resources Consider the amount of time that can be devoted to planning and data analysis
Data collection methods and sources/analysis	Pre-and post-unit survey, student interviews, teacher observation checklists, student journal reflections, student artifacts, teacher reflections
Reflection/dissemination	Record notes in an online journal and meet regularly to share ideas and to debrief Present outcomes to the staff Share outcomes with teachers from other schools in the district

The teachers adhered to most aspects of their plan, but some elements were modified during implementation (e.g. timeline). While action research needs to be approached systematically, the process can be messy and requires changes as implementation is occurring.

The first three steps in the action research were described in detail in the previous chapter; thus, I will continue with “Describing the intervention.” This step occurs after you have identified a focus, engaged in reconnaissance, and formulated research questions.

DESCRIBING THE INTERVENTION

In this step of the process, you need to describe what you will do in the context of your classroom or school to find answers to your research questions. What units or topics in the curriculum will serve as the basis for addressing the questions? What types of learning and assessment activities will be adopted? What experiences will you create for students to allow you to collect data and determine if or how the intervention(s) is working? For example, in Chapter 8, Lana and Sonya implemented their intervention in the context of a grade eight unit on simple machines. The work of Leonardo da Vinci was used as the hub to integrate art and science learning outcomes. Based on previous experience in teaching this topic, Lana felt the students lacked interest in the topic and often had difficulty understanding the concepts. Hence, by adopting an innovative approach to teaching the content through inquiry-based learning centres, the teachers wanted to ascertain how the approach would impact student engagement with and student understanding of key scientific concepts and principles.

DESCRIBING THE ACTION RESEARCH GROUP

At this point, you need to describe who will be involved in your project and the possible roles they will play. How will they support the work of the group? How will school-based personnel be involved? Will educators from outside the school become part of the group? For example, Lana and Sonya were part of a larger action research group, which I facilitated, that met on a regular basis. As such, they were offered help from graduate students who were experienced teachers with strong content knowledge in science. Lana and Sonya were also assisted by a learning resources teacher who attended all action research meetings. The school principal also supported the project, but was not directly involved in the daily activities.

DEVELOPING A TIMELINE

Next, it is important to develop a realistic timeline for the project. This will help you in organizing your project and adhering to a planned schedule. This timeline should outline the tasks that action research group members will assume and dates when particular actions will be taken. For example, when will letters be sent home to parents? When will particular learning activities be implemented?

CONSIDERING SCOPE AND RESOURCES

The nature of the action research project will determine what resources are needed to support implementation. Revisit your goals and outcomes and consider your time and resources. Is teacher release time needed? Do you have funding to purchase materials? Generate a list of things you will need to support classroom implementation, to collect and analyze data, and to engage in dissemination. For example, as part of a larger action research group, and through external grant funding which I secured, Lana and Sonya were allocated several teacher release days to work at their school site, as well as to meet at the university for whole group action research planning and debriefing meetings.

DESCRIBING DATA COLLECTION

The nature of your research project and research questions will determine the types of data sources and methods used. Furthermore, "the researcher should determine the most practical, efficient, feasible, and ethical methods for collecting data" (Marshall & Rossman, 2006). There are a variety of data collection methods that may be selected; however, always keep in mind that you need to choose the most appropriate methods to answer your research questions. These methods and sources are discussed in detail in the next chapter, and may include classroom observation, focus groups, interviews, classroom events, artifacts, reflective journals, and questionnaires and surveys. For example, in addressing their research questions, Lana and Sonya used several data collection methods, thus enabling them to develop a comprehensive picture of what their students were learning and to what degree their intervention was impacting student engagement in learning. They collected data through student interviews and surveys; examined the work their students generated (their outputs as well as their reflections on what and how they were learning, and how they felt about the learning process); observed student behavior during unit activities and recorded notes; and recorded their own insights and reflections in their journal as events unfolded.

REFLECTING ON OUTCOMES AND DISSEMINATION

As implementation occurs and you collect data, you will be examining the data and making sense of what it means. The processes of data description, analysis, and interpretation are covered in the next chapter. Your personal and collaborative interpretations will allow you to determine how your interventions are effecting change in your classroom and to identify the evidence that supports your research claims. The learning that occurs as a result of your efforts will include new insights about the area of focus, and self-knowledge about your own teaching and practice. As well, consideration should be given to how the findings will be shared with others. Will the outcomes be shared with other teachers at a conference? Are you required to generate a report for an external funding agency? While one of the primary goals of action research is to improve your own practice and your understanding of that practice, and thereby improve the experience of all involved in the action, sharing the outcomes of the research with other educators can enhance their work as well.

CONSIDERING ETHICS

All forms of educational research require researchers to consider the ethical implications of their work. Ethics involves "well-founded standards of right and wrong that prescribe what humans ought to do, usually in terms of rights, obligations, benefits to society, fairness, or specific virtues" (Velasquez, Andre, Shanks, & Meyer, 2010). At all stages in the research process, from initial planning to data collection and analysis, researchers need to consider the potential impact of the research on participants and others with whom they interact. In the case of school-based action research, you need to be concerned with the students from whom data is collected, as well as others who may be involved in and/or supporting the research, such as parents, school principals, and other teachers. In many forms of educational research, the researcher is an outsider, documenting or describing the classroom practice of others. Action research, however, involves insiders documenting their own practice, and raises unique issues for the teacher researcher. Fundamentally, as an action researcher, you need to ask yourself two key questions (Zeni, 1998, p. 17): "What are the likely consequences of this research? If I were a participant, would I want this research to be done?"

Many professional associations, agencies, and universities have established policies and standards as they relate to those who engage in research. For example, *The Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* (2010) describes the ethical policies and principles of the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council of Canada, and the Social Sciences and Humanities Research Council of Canada. The framework is intended to "guide and evoke thoughtful actions based on principles" and "should be applied in the context of the nature of the research and of the ethical norms and practices of the relevant research discipline." The Tri-Council Policy is based on three core principles, available on the Government of Canada website (www.pre.ethics.gc.ca): Respect for persons, Concern for welfare, and Justice.

Table 3. Ethical Guidelines of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans.

Respect for Persons	Respect for Persons recognizes the intrinsic value of human beings and the respect and consideration that they are due. It encompasses the treatment of persons involved in research directly as participants and those who are participants because their data or human biological materials, which for

	the purposes of this Policy include materials related to human reproduction, are used in research. Respect for Persons incorporates the dual moral obligations to respect autonomy and to protect those with developing, impaired or diminished autonomy. Autonomy includes the ability to deliberate about a decision and to act based on that deliberation. Respecting autonomy means giving due deference to a person's judgment and ensuring that the person is free to choose without interference. Autonomy is not exercised in isolation but is influenced by a person's various connections to family, to community, and to cultural, social, linguistic, religious and other groups. Likewise, a person's decisions can have an impact on any of these connections. An important mechanism for respecting participants' autonomy in research is the requirement to seek their free, informed and ongoing consent. This requirement reflects the commitment that participation in research, including participation through the use of one's data or biological materials, should be a matter of choice and that, to be meaningful, the choice must be informed. An informed choice is one that is based on as complete an understanding as is reasonably possible of the purpose of the research, what it entails, and its foreseeable risks and potential benefits, both to the participant and to others. Respect for Persons also includes a commitment to accountability and transparency in the ethical conduct of research. Certain factors may diminish a person's ability to exercise their autonomy, such as inadequate information or understanding for deliberation, or a lack of freedom to act due to controlling influences or coercion. Such constraints may include the fear of alienating those in positions of authority, such as professional or personal caregivers, researchers, leaders, larger groups, or a community to which one belongs. Other constraints may consist of barriers to accessing resources or knowledge outside the research context. These factors and constraints should be addressed prior to any research being carried out, so as to ensure participants are sufficiently protected.

	Some people may be incapable of exercising autonomy because of youth, cognitive impairment, other mental health issues or illness. While autonomy may be considered a necessary condition for participation in research, involving those who lack capacity to make their own decisions to participate can be valuable, just and even necessary. For those prospective participants, additional measures are needed to protect their interests and to ensure that their wishes (to the extent that these are known) are respected. These measures will generally include seeking consent from an authorized third party who is entrusted to make decisions on behalf of the prospective participant, based on knowledge of that person and that person's wishes or, if such wishes are unknown, on consideration of that person's welfare. Even when the requirements of free, informed and ongoing consent cannot be met, Respect for Persons requires involving individuals in circumstances of vulnerability in decision making where possible. This may include asking about their feelings regarding participation and/or for their assent. Where it is foreseeable that a participant may lose capacity during a research project, for example in studies of cognitive impairment, it may be appropriate to ask participants to express their preferences and ensure that they have authorized a trusted person to make decisions on their behalf should they lose the capacity to provide ongoing consent (see Article 3.11 for guidance on research directives for individuals who lack capacity).
Concern for Welfare	The welfare of a person is the quality of that person's experience of life in all its aspects. Welfare consists of the impact on individuals of factors such as their physical, mental and spiritual health, as well as their physical, economic and social circumstances. Thus, determinants of welfare can include housing, employment, security, family life, community membership, and social participation, among other aspects of life. Other contributing factors to welfare are privacy and the control of information about the person, and the treatment of human biological materials according to the free, informed and ongoing consent of the person who was the source of the information or materials. A person's or

	group's welfare is also affected by the welfare of those who are important to them. Harm includes any negative effects on welfare, broadly construed (for the relationship between risk and harm, see Chapter 2, Section B). Note that, for the purposes of this Policy, "group" and "community" are used in their ordinary sense. More detailed types of community as defined in Chapter 9 are specific to Aboriginal contexts. Concern for Welfare means that researchers and REBs should aim to protect the welfare of participants, and, in some circumstances, to promote that welfare in view of any foreseeable risks associated with the research. They are to provide participants with enough information to be able to adequately assess risks and potential benefits associated with their participation in the research. To do so, researchers and REBs must ensure that participants are not exposed to unnecessary risks. Researchers and REBs must attempt to minimize the risks associated with answering any given research question. They should attempt to achieve the most favourable balance of risks and potential benefits in a research proposal. Then, in keeping with the principle of Respect for Persons, participants or authorized third parties, make the final judgment about the acceptability of this balance to them. The welfare of groups can also be affected by research. Groups may benefit from the knowledge gained from the research, but they may also suffer from stigmatization, discrimination or damage to reputation. Engagement during the design process with groups whose welfare may be affected by the research can help to clarify the potential impact of the research and indicate where any negative impact on welfare can be minimized. Researchers must also consider the risks and potential benefits of their research and the knowledge it might generate for the welfare of society as a whole. Where research on individuals may affect the welfare of a group(s), the weight given to the group's welfare will depend on the nature of the research being undertaken, and the individuals or group in question. This consideration does not imply, however, that the welfare of a group should be given priority over the welfare of individuals.

Justice	Justice refers to the obligation to treat people fairly and equitably. Fairness entails treating all people with equal respect and concern. Equity requires distributing the benefits and burdens of research participation in such a way that no segment of the population is unduly burdened by the harms of research or denied the benefits of the knowledge generated from it. Treating people fairly and equitably does not always mean treating people in the same way. Differences in treatment or distribution are justified when failures to take differences into account may result in the creation or reinforcement of inequities. One important difference that must be considered for fairness and equity is vulnerability. Vulnerability is often caused by limited capacity, or limited access to social goods, such as rights, opportunities and power. Individuals or groups in vulnerable circumstances have historically included children, the elderly, women, prisoners, those with mental health issues and those with diminished capacity for self-determination. Ethnocultural minorities and those who are institutionalized are other examples of groups who have, at times, been treated unfairly and inequitably in research, or have been excluded from research opportunities. People or groups whose circumstances cause them to be vulnerable or marginalized may need to be afforded special attention in order to be treated justly in research. The recruitment process, both of participants who may become directly involved in research and those who participate as the source of information or biological materials to be used in research, is an important component of the fair and equitable conduct of research. Participation should be based on inclusion criteria that are justified by the research question. Inequity is created when particular groups fail to receive fair benefits of research or when groups, or their data or their biological materials, are excluded from research arbitrarily or for reasons unrelated to the research question. An important threat to Justice is the imbalance of power that may exist in the relationship between researcher and participant. Participants will generally not understand the

	research in the same way and in the same depth as does the researcher. Historically, there have been instances in which this power imbalance has been abused, with resulting harm to participants.

As an action researcher, you have a responsibility to be aware of and understand these ethical principles as they relate to informed consent, deception, privacy and confidentiality, and accuracy (Christians, 2005). Each of these and the issues they raise in relation to action research are described below.

INFORMED CONSENT

Informed consent requires researchers to disclose full details of the research to potential participants, and dictates that they have the right to know about the nature of the research that is being proposed and the possible consequences of their involvement. They need to know the purposes of the research and the expectations of them if they become involved. Participants must voluntarily agree to participate, be informed that they are free to withdraw from the study at any time without penalty, and be assured that their confidentiality will be protected. Written informed consent needs to be given by students and their parents and/or legal guardians, indicating that data being collected, such as student artifacts, interview transcripts, and photographs, may be used to answer the research questions and may be publicly shared with others at conferences, while ensuring that confidentiality and anonymity are protected. The school leadership team and school district personnel will also need to know that you are engaging in classroom-based research and will need to provide their support for doing the research.

DECEPTION

Action researchers need to be open and honest when interacting with those involved in their research. Everyone involved must be fully apprised of the nature of the research, and have opportunities to ask clarifying questions about the research. Students need to be aware of your reasons for conducting the research, and it is wise to make them partners in the research. There have been times in my own research projects when participants have shared their insights and thoughts with me during data collection and they have requested that their comments remain "confidential" or not be used as part of the dataset. As an ethical action researcher who may find herself in a similar situation, it is imperative that these types of requests be respected. Action researchers need to be always cognizant of the fears and concerns of their research participants, ensuring they are protected from harm.

PRIVACY AND CONFIDENTIALITY

Zeni (1998) raised the question "when does good teaching become research?" Many teachers collect data and other information from their students, as well as engage in reflective teaching and take into account the risks to their students of any actions, whether in the realm of normal practice or within the context of an action research project. In terms of privacy and confidentiality, you need to consider how individuals' identities and research locations will be protected. You should use pseudonyms for the names of students, colleagues, parents, schools, and communities. Data should not be left unattended and should always be stored in a secure location. However, as Christians (2000) suggests, "watertight" confidentiality may be challenging, especially in the context of action research. For example, because the outcomes of action research are often shared with school-based personnel and in the community, teacher action researchers may be identified by virtue of being associated with a particular school or class; thus, issues of reporting in relation to privacy and confidentiality arise.

ACCURACY

Christians (2000) notes that "fabrications, fraudulent materials, omissions, and contrivances are both unscientific and unethical" (p. 145). At all stages in the action research process (e.g. designing research instruments, implementing learning activities with students, collecting and interpreting data), your actions need to be ethical. Because action research is emergent and we cannot know the outcomes of the research in advance, we need to be prepared for things not to go as planned, or for the outcomes of the research to be different than anticipated. For example, in Chapter 8, Lana and Sonya had expected that after participating in an inquiry-based unit that integrated art and science, their students would perform very well. After administering an end-of-unit paper-and-pencil test, they were disappointed by the results; many students did not perform as well as students from previous years who had experienced a more teacher-directed approach. This was an opportunity for the teachers to reflect on the situation and offer possible hypotheses for this outcome. After considerable reflection, they concluded that there was a mismatch between the traditional assessment tools used and the learning experiences, which focused on performance-based, authentic forms of learning.

Accuracy can also be safeguarded by sharing the outcomes of the research with colleagues who are also conducting action research or with other critical friends, such as a school principal, school district program specialist, or a university-researcher. The notion of a critical friend in action research, first suggested by Stenhouse in 1975, was envisioned as someone who would be a supporter and act as a sounding board at all stages in the research, rather than assuming the role of advisor or consultant. While critical friends can assume many roles, such as resource provider, writing consultant, and teaching consultant (see Kember et al., 1997 for a more extensive discussion of the possible roles critical friends may assume), they may also act as a mirror to help action researchers address dilemmas that may arise, and to assist with data analysis and interpretation.

ENSURING QUALITY IN ACTION RESEARCH

In any form of research, whether quantitative or qualitative, researchers need to establish criteria for ensuring the soundness of the research. In other words, they must ascertain the "veracity, truthfulness, or validity of the information and analyses that have emerged from the research process" (Stringer, 2007, p. 57). The criteria or standards used to judge qualitative research vary when compared to quantitative research. While both quantitative (e.g. surveys) and qualitative (e.g. interviews) methods may be used during data collection in an action research project, most classroom-based research conducted by practitioners relies heavily on qualitative methods. Within collaborative, teacher-driven action research paradigms, practitioners seek to understand phenomena within the particular contexts of their classrooms and do not attempt to establish causal links or to generalize their findings to all contexts, as in a quantitative paradigm. The terms validity and reliability are used in the context of quantitative research, although some scholars argue that these terms are not appropriate when referring to qualitative research (Stenbacka, 2001; Wolcott, 1990). Validity is used to refer to both the design and methods used in research. Tests and instruments are deemed valid if they actually measure what they purport to measure. In other words, on a survey that measures research participants' perceptions of the effectiveness of a particular school-based intervention program, the test would be valid if it actually measures current perceptions held by the participants. Validity also refers to whether the results of the research can be generalized to respondents who are not part of the study. Many studies will select a research sample from which to collect data and then generalize the results to the larger population. Reliability refers to the consistency of a survey, test, or other instruments. For example, if you weigh yourself to find you are 150 pounds and then weigh yourself 15 minutes later to find that the scales indicate you are 145 pounds, then you would conclude that the scales are not working well as they do not give you the same result with repeated measurements

When considering how you will ensure that your research study is sound, checks for trustworthiness can be adopted. Guba and Lincoln (1985) suggest that trustworthiness be established by assessing the following attributes of a study:

– *Credibility*: This refers to the results of the study being believable from the perspective of the participants, and that the complexities of the study are addressed and explained in a thorough manner. Various methods may be used to establish credibility, such as spending a prolonged period of time at the research site; observing participants over time in their natural setting; establishing a validation group or identifying a critical friend who will help you reflect on your developing ideas and thoughts as the research unfolds; using triangulation or multiple research informants, sources of data, or data-gathering methods, thus ensuring you can be more confident in your results if multiple data sources, methods, or observers are corroborating findings; providing opportunities for participants to engage in debriefing about the experiences; sharing researchers raw data and interpretations of the data with participants for verification purposes; ensuring all stakeholders' perspectives are incorporated into the study; and including the language and terminology of the participants to ensure their voices and perspectives are prominent.

– *Transferability*: This refers to the degree to which the study may be relevant or applicable to others who operate and function in similar contexts. The outcomes of an action research study apply to people and contexts (e.g. students and classrooms) in which the study is completed. Hence, in order for readers to determine the relevance of a study for their particular contexts, the researcher needs to provide descriptions of the context, events, and activities that were part of the study. Readers can then determine if they trust the research outcomes and their applicability to their classroom or school.
– *Dependability*: This refers to the need to account for the ever-changing context of the research. In quantitative research, views of reliability are based on the notion that if a study was replicated or the same measures were used a second time, the same results would be obtained. In action research, dependability can be established by using an audit trail or providing considerable detail about the procedures that were used in the study. Also, triangulation, mentioned above, or using multiple sources of data can be adopted to ensure themes and insights from one source of data are supported from another source. For example, data from classroom observations may be corroborated by examining the artifacts generated by students.

– *Confirmability*: This refers to establishing that particular procedures were actually used during a study and/or that the reported outcomes can be confirmed or corroborated by others. Strategies to foster confirmability include adopting triangulation (ensuring data is collected from multiple sources or by several different people), revealing underlying assumptions about the researcher's beliefs and values in relation to the research focus (reflexivity), and conducting an audit trail that carefully reveals data collection and analysis procedures.

Generally, criteria for establishing the soundness of action research should address key questions, as presented by Marshall and Rossman (2006):

- By what criteria can we judge the credibility of the study?
- How applicable are the findings to another context?
- How sure can we be that the same outcomes would be replicated if the study was done with the same participants in the same context?
- How can we be sure the study reflects the experiences and the inquiry itself rather than being a representation of the researchers' views and biases?

QUESTIONS FOR REFLECTION

Consider an action research study you may wish to pursue.

- What ethical issues or dilemmas may arise as you carry out your research?
- How will you address those issues or dilemmas?
- How will you ensure your action research inquiry is sound?

CHAPTER 4

MEANING-MAKING SPACES

Data Collection, Description, Analysis, and Interpretation

As part of your plan of action, you will need to select data collection methods that will allow you to answer your research questions. As you collect data, you will start the processes of data description, analysis, and interpretation. In other words, you will create spaces for attaching meaning to your data. This chapter will introduce you to different data collection methods and sources, and give you insight into how to organize, describe, analyze, and interpret your data.

GATHERING DATA

The use of data collection techniques allows for the systematic gathering of information about the participants and/or context of a study. While there are many ways to collect data, methods need to be chosen that are appropriate for answering your research questions. While research designs in action research may involve quantitative or experimental approaches, many projects utilize qualitative data collection methods. Qualitative approaches are appropriate for understanding the specific contexts of classrooms and capturing the natural life of a classroom. Data collection methods generally fall into one of three categories:

- Experiencing (Using our senses to observe)
- Enquiring (Asking others about their beliefs, ideas, thoughts, and experiences)
- Examining (Looking at documents and artifacts) (Wolcott, 1994).

The remainder of this section will highlight several of the most common data collection methods used by teacher action researchers.

Observation (Experiencing)

Observing is a natural process, and much can be learned from recording observations and making judgments about those observations. Observations may involve participant observation where the observer is part of the context, or it may involve nonparticipant observation where the observer watches actions and interactions in a classroom and is not involved in the activity. For example, a colleague sits at the back of classroom taking notes. Recording observations may take many forms, such as recording verbatim the conversations of students, diagramming the layout of a classroom, or describing the interactions of a small group of students who are the focus of your study. Observation may also involve the use of published or teacher-designed rating scales or checklists. For example, Figure 2 shows a checklist that was developed by a school-based group of action researchers (seven teachers of grades 1-3), that I worked with for two years, integrating curriculum using outcomes from social studies, language arts, mathematics, and science.

Skill	Student name	Date	Comment
Listens to others			
Asks questions during group activities			
Offers advice and suggestions to others			
Accepts advice and suggestions from others			
Participates in group decision-making			
Assumes various roles in groups			
Helps group meet goals			

Figure 2. Checklist of participation skills during science activities (Grades 1-3).

They used this checklist over a period of several weeks to observe students' participation skills as they engaged in science activities. Regardless of the form, observation needs to be structured carefully, and the format needs to be determined by the nature of the research question. During the planning stage of action research, the location, frequency, and duration of observations should be determined. If one colleague is observing the classroom of another colleague, then coordination will need to occur to plan for the observation and to determine a time when debriefing and reflection about the classroom observation can occur.

Recording observations as teaching occurs may be challenging for teachers, thus the use of video-recording devices may be a better-suited data gathering technique. Video recording allows one to observe the action of the classroom after the fact and to "zero in" on specific aspects of classroom activities. It should be noted that classroom observation can initially be inhibiting and distracting for students if this is new for them. This may dissipate with subsequent visits as students become accustomed to having a visitor in the classroom or having their behavior videotaped.

Interviewing (Enquiring)

Interviewing is a means to gain in-depth insight into the beliefs and perspectives of others. For example, you may want to ask a student to explain how she conducted her science fair project, or to ask a student why he classified particular items as living or nonliving. According to Patton (2002), interviews may be informal and conversational, semi-structured, or structured. The informal or conversational interview is the most open-ended of the three; the interviewer takes the opportunity to ask interviewees about particular topics without using predetermined questions. The interviewer aligns his/her questions with the responses being provided by the interviewee ("going with the flow"). In the semi-structured interview, the same topics are explored with all interviewees, thus there is more guidance provided by the interviewer. The structured interview involves the use of pre-planned questions to which interviewees respond. The latter approach is quicker and allows the responses of the interviewees to be compared more easily. Also, this type of data is amenable to statistical analysis using quantitative software. Responses to interviews may be written during the interview process, although audio-taping allows the interviewer to listen to what is said later and/or to have the conversation transcribed. The following is a set of open-ended questions which Katrina (Chapter 6) used at the end of her action research project to find out how her grade one students felt about learning about penguins and learning through webquests:

– What do penguins eat?
– Where do penguins live?
– How do penguins take care of their babies?
– Why couldn't PB the Polar Bear find any penguin friends?
– Did you like learning about penguins using the webquest?
– What did you like about the webquest?
– What didn't you like about the webquest?

When planning for interview questions, the nature of questions needs to be considered. Are you asking about behaviors? Are you probing what a person thinks or feels? In addition to these two areas, questions may focus on knowledge or facts about a topic, sensory experiences (what was seen, touched, etc.), or demographic information (e.g. age, education). The following list offers suggestions for planning for and conducting interviews:

– Check equipment before the start of the interview if audio-taping.
– Explain the purpose of the interview at the beginning and start the interview with simple questions.

- Ask questions that are neutral, avoiding wording that might influence responses.
- Ask one question at a time.
- Provide a transition between topics (e.g. Ok, now I want to ask you about how you feel about some things we did in the unit).

While interviews can provide powerful insights into what students are thinking and feeling, they can also be quite time-consuming to conduct and especially to transcribe.

Artifacts and Documents (Examining)

The third category of data collection involves a variety of artifacts and documents, many of which are naturally-occurring. Schools generate many types of documents that can provide insight into the culture of schools and classrooms. One example includes archival data sources, such as attendance rates, discipline referrals, standardized test scores, memos, and meeting minutes, to name a few. Student materials (written texts or passages, pictures, presentations, art work, graphic organizers, etc.) are also natural products that are generated in classrooms. As Fichtman-Dana and Yendol-Silva (2003) suggest, when "teaching and inquiry are intertwined with one another . . . papers become data and take on new meaning" (p. 71). As described in the later chapters of this book, the teacher action researchers used student artifacts as a key source of data. Katrina (Chapter 6) worked with very young children; thus, both their written responses to journal questions and their drawings revealed insight into their understanding of penguins and their habitats. Concept maps were one source of data for Arlene, Ernie, and Lisa (Chapter 7) as they used both individual and collaborative maps to track changes in students understanding of scientific concepts. Lana and Sonja (Chapter 8) utilized student journal entries, sketches of solutions to design challenges presented to students in learning centres, sculptures, and an end-of-unit written test. Student research notes became a source of data for Nancy as she implemented problem-based learning in her classroom (Chapter 9). Student journal reflections about their understanding of the problem (How can Ms. Bartlett keep her garden plants healthy and prevent caterpillars from eating the leaves?) and final presentations of their solutions were also sources of data. Other types of data that may be examined include:

- Artifacts
  These may also include audiotapes, videotapes, and photographs, allowing teachers to capture classroom happenings and interactions that may not be evident while they are engaged in teaching.

– Technology
  Newer forms of technology, such as web tools (e.g. blogs, e-mails, podcasts, text messages, wikis) that promote interactivity and collaboration, can provide rich sources of data.
– Literature as data
  During the action research process, action researchers typically review literature at two points − while they are formulating the research focus, and as new insights and developments emerge during the unfolding of a project. Gathering and understanding information about the area of focus are critical to project design and implementation, and later to inform data analysis and interpretation.

DATA ANALYSIS AND INTERPRETATION

Data Analysis

While there are several challenges associated with conducting action research (e.g. lack of time, finding a research focus), data analysis can also be challenging. Dana-Fichtman and Silva-Yendol (2003) identify three reasons why they believe data analysis may present hurdles. First, the technical jargon, such as analytic induction, axial coding, in vivo codes, to name a few terms, used to describe the many strategies and approaches to data analysis can be confusing. Furthermore, many of our own prior conceptions of what constitutes research may be associated with quantitative design and, hence, we may feel that data analysis is more about dealing with numbers than extracting meaning from qualitative data in the form of themes, metaphors, or vignettes. While quantitative methods may be used in action research, areas of focus and questions lend themselves more to qualitative sources and methods. Teachers usually focus on a single classroom and small groups of individuals; thus, context is of utmost importance. A third reason why perceptions of analysis are challenging is the nature of qualitative data analysis itself; it can be messy and uncertain as you mine the data in search of emergent themes and patterns. In my own experiences as a facilitator of action research, teachers have found this stage to be intimidating and time-consuming. Reflecting on the overall data collection process and data analysis, one of my teacher colleagues, Nancy (Chapter 8) posed several questions about data analysis during a planning meeting: "How should we approach this? How will we interpret the feedback, interviews and questionnaires? How can we make sense of all this data?" This stage in the action research process necessitates the adoption of a critical lens and the creation of a meaning-making space for answering the questions posed at the beginning of your action research project.

Data analysis should occur as soon as you start the implementation of the project. It is the process of ordering, organizing, and thinking about the raw data you have collected. Stringer (2007) refers to data analysis as the "process of distilling large quantities of information to uncover significant features and elements that are embedded in the data" (p. 95). As data analysis is ongoing, you will start to find meaning in the data, linking themes, patterns, and categories into a story that communicates the significance.

There are many ways to approach data analysis and interpretation. While a formula cannot be followed for this process, guides are available that can be helpful. Drawing upon the work of Marshall and Rossman (2006), Creswell (2009), Miles and Huberman (1994), and Wolcott (1994), I offer the following suggestions for how to engage in the data analysis/interpretation process.

Organizing the Data

While data organization will occur during implementation, at the end of implementation you will need to conduct a careful review of all the data. Creating a log of research activities and sources will provide an overview of the dataset. This should include the date and place of the data collection activities, the types of data collected, and how the data was collected. For example, you may have collected questionnaires from 25 students on October 30, in your classroom, to determine their views on learning in science class. It would also be useful at this point to review any memos you recorded about emerging themes and patterns as data was being collected during implementation. You may be considering whether you will use a qualitative software program to assist with data organization and analysis (Weitzman & Miles 1995; Weitzman, 2000). Consider the following in making your decision to use a software program: Do you have large amounts of data that might not be manageable without the assistance of a program? Do you have the technical background to use the program? Is it user-friendly? Do you have the resources to purchase a program?

Immersion in the Data

This phase should start by revisiting the area of focus and your research questions. Next, you need to read and reread the entire dataset. This allows you to view the data holistically and to get a sense of what data has been collected. Furthermore, insights into the data may start to emerge. You may wish to record some notes at this point or to discuss your initial impressions with someone in your action research group or a critical friend. For example, as a facilitator of action research, I have often assumed the role of critical friend, offering feedback to teacher colleagues as they begin to examine their data and what it means.

Coding

Another strategy that is used very frequently when analysing qualitative data is coding. This involves the process of assigning labels or descriptors to units of data (phrases, sentences, or paragraphs), breaking down the data into manageable units. For example, Ernie, one of the teachers described in Chapter 7, administered a post-study survey to his students to determine whether or not they liked learning through concept mapping. The survey included both closed questions and open-ended items. Students provided different reasons for liking or disliking concept mapping, and their responses became the basis for using concepts or labels (e.g. likes concept mapping; reasons − enhances organization, seeing connections, etc.). Coding is one of several analytic strategies that helps in "relating our data to our ideas about the data. Because codes are thus links between locations in the data and sets of ideas or concepts, they are in that sense heuristic devices" (Coffey & Atkinson, 1996, p. 27). Often, the process of generating themes and categories relies on the coding of the data first.

Identifying Themes and Categories

One starting point for data analysis involves identifying themes and categories. This entails identifying recurring ideas or patterns in the data. This may be approached in an inductive manner where patterns and themes (e.g. understands habitats; enjoys concept mapping) emerge from what the research participants say and do. Conversely, a deductive approach may be adopted by returning to the literature that informs your study and applying pre-existing frameworks and typologies. During this process, you may physically cut and paste chunks of coded text from your data and place it into various categories and themes. Color coding may be another option, assigning a specific color to each category or theme and highlighting appropriate excerpts from the data. Depending on the area of focus, the themes or categories may be teaching strategies, feelings, events, changes in participant beliefs, etc. Creating an organizational chart or a graphic organizer, such as a web or concept map, based on the categories and themes generated can help you in visually seeing relationships and connections. As you work through this process, you will find that it is iterative in nature. You may rename categories and themes or combine others before you make final sense of your data.

Data Interpretation

The processes of analysis cannot be separated from interpretation. The strategies of analysis help us in understanding the implications of our research or going beyond the data to develop ideas and determine how we might use those ideas in our teaching and in schooling. In considering the outcomes of your study, several authors (Fichtman-Dana & Yendol-Silva, 2003; Stringer, 2007; Sumaras, 2011) suggest that you consider questions such as:

– What did you learn about yourself as a teacher?
– What successes did you experience?

- What contradictions arose during the research process or in analyzing the data?
- What new insights did you develop about how children learn?
- What role did critical friends or colleagues play in supporting your research?
- What changes will you make to your practice as a result of what you learned?
- What new questions have arisen that need to be answered?
- How will your research inform the work of other practitioners and education in general?

Interpretation allows you to bring coherence to the analyzed data. It involves "attaching significance to what was found, making sense of the findings, offering explanations, drawing conclusions, extrapolating lessons, making inferences, considering meanings, and otherwise imposing order" (Patton, 2002, p. 480). In the last four chapters of this book, the interpretations of the teacher researchers, based on the data collected during their action research projects, are presented.

QUESTIONS FOR REFLECTION

- In Chapter 6, one of Katrina's research questions is, "How does using a webquest influence the role of both the teacher and the student in the science classroom?" How did she answer this question? How did her role change?
- In Chapter 7, Ernie wanted to find out how the concept mapping strategy would impact student learning in science. How did students feel about the approach?
- In Chapter 8, what did Lana and Sonya discover about student learning in the unit? How did implementing the project impact their classroom practice?
- In Chapter 9, the experiences of Nancy are described. Did she answer her research question? Please explain.

CHAPTER 5

GENERATING SPACES FOR SHARING

Communicating about and Representing the Outcomes of Action Research

After completing data collection, analysis, and interpretation, it is important to consider how you will share what you have learned with others. Creating a "space" for writing and identifying the "spaces" for sharing the outcomes of your research are critical. While one of the main reasons we conduct action research is to inform our current and future practice, and our understanding of that practice, it is equally important to share this knowledge with others. Cochran-Smith & Lytle (2009) describe the knowledge that practitioners generate through inquiry as local knowledge of practice. They reject the traditional notion that there are only two types of knowledge that inform our understanding of teaching − formal or professional knowledge and practical knowledge. Formal knowledge is generally considered that which is produced through conventional research by researchers; it is conceptual knowledge about education, teaching, and learning that has potential for generalization and meets the criteria for validity and reliability. Practical knowledge, in contrast, involves using one's wisdom of teaching to make decisions and judgments in concrete situations that arise during the teaching process. This wisdom may often be tacit and not easily articulated. "Local knowledge of practice" then, is generated by action researchers working collaboratively in communities as they "theorize and construct their work" (Cochran-Smith & Lytle 2009, p. 131). It is relevant to the local context, but can also be publicly shared with many others, such as school-based colleagues, university-based educators and researchers, parents, K-12 students, and those in other professional settings. It is knowledge that can be "borrowed, interpreted, and reinvented in other local contexts" (p. 132). This chapter will discuss considerations and decisions that need to be made prior to sharing action research outcomes, as well as possible formats that may be adopted for dissemination.

CONSIDERATIONS PRIOR TO SHARING

Prior to sharing the outcomes of your research with others, Sagor (2005) suggests you consider the audience, purpose, and degree of detail required. This will help you to determine the appropriate format for sharing your work. Each of these considerations is described below.

The Audience

Sagor identified several potential audiences for communicating research: a) Immediate audience (parents and students), b) Immediate colleagues (other teachers or practitioners at your grade level or those who teach the same subject(s), c) Other educators in the same context (others in your school, school district, province or state), or d) The larger educational community (all K-12 educators, policy-makers, and teacher educators and researchers). Each teacher described in the chapters 6 to 9 of this book, in addition to informing their own practice, shared the outcomes of their research with school-based colleagues at the same grade level. Their final research reports, a component of the expectations of participating in a three-year externally-funded project that I spearheaded, were shared with their principals and the local school districts, while other teachers who participated in the same project presented at local and/or national conferences.

The Purpose

The reasons for disseminating your research outcomes need to be determined. The outcomes of action research and their subsequent dissemination may be used for many purposes, such as informing decisions on future action (e.g. changes to classroom-based practice or school-based policy). An action research report may be required if the research is externally funded; decisions about future funding may be dependent on the report. Other action researchers may decide to write a paper for a professional or scholarly journal. In other instances, teachers may have participated in an action research project as a requirement for obtaining a university credit, thereby needing to produce a final report.

The Degree of Detail

Once you have identified the audience(s) for the outcomes of your action research, this will determine the degree of detail that you will need to share. For example, if you decide to prepare a short article for a professional or scholarly journal, you will need to visit the home page of the targeted journal to determine submission requirements, such as length of the article and nature of the content required. If you consider publication in *Science and Children*, a National Science Teachers' Association publication (see www.nsta.org/elementaryschool/), you need to check the link for authors contributing to this peer-reviewed journal. This provides information about the purpose of the journal, the types of content it publishes, and how the manuscript should be presented.

If you are sharing with a group of parents at a school information session, they may not require a great amount of detail about the methods and procedures used in the study. Conversely, if you were preparing a manuscript for a scholarly journal, considerable detail about the study design would need to be included.

FORMATS FOR SHARING OUTCOMES

The outcomes of action research may be shared in many formats. In my work with action research groups, I always encourage teachers to complete an action research report. Writing becomes a form of reflection and, as such, provides a means to make further sense of the study. Writing is time-consuming, and thus will require a concerted effort on your part to build time into your professional activities for writing. Mills (2003), recognizing the importance of writing for the action researcher, provides several persuasive reasons for writing − clarifying and reflecting on many aspects of the study, generating new research questions that will inform the next cycle of action research, empowering the researcher to be an advocate for change in the classroom, producing a product that can be shared with others, and instilling a sense of accomplishment in the action researcher. The format for final reports that I usually recommend to teacher action researchers includes the following components:

– Title: This should clearly and concisely reflect the focus of the study.
– Abstract: This is a brief description of the purpose of the research, the research design, and the outcomes of the study.
– Introduction: This sets the context for what is to follow. Why is this study important?
– Research focus and research questions: This is necessary if the reader is to make sense of subsequent components of the report.
– Context of the study: This provides details about the school, students, and your own experience/beliefs about teaching and learning as they relate to the focus of the study.
– Relevant literature: This presents an overview of the literature and theories that informed your study.
– Study design: This outlines the methods and sources used in data collection, how you approached data analysis and interpretation, and the criteria adopted for ensuring the study was trustworthy.
– Outcomes of the study: This may be presented in several ways – as themes, data tables, metaphors, or stories. Remember to support claims with quotes from the data!
– Implications: This allows you to reflect and report on why this study is significant. How will it inform your own thinking and classroom practice? How might it benefit others who work in similar contexts? How can educators from the broader educational community benefit from this work?
– Next steps: This describes additional questions that you would like to consider. They may then become the basis for the next cycle of an action research project. How will you find answers to new questions? Will you continue to use the resources and pedagogical approaches adopted in the study? Will others join your action research group?

- References: This includes citations of quoted work or the ideas of others that you have used. In education, citations most often adopt the protocol of the American Psychological Association for writing conventions (see http://library.concordia.ca/help/howto/apa.php).
- Modifications of this format may be adopted for writing purposes. Keep in mind, as suggested earlier, the audience, the purpose for reporting, and the degree of detail you need to provide to the targeted audience when sharing what you have learned through action research.

QUESTIONS FOR REFLECTION

- Identify the possible audiences for sharing the outcomes of your action research.
- Choose one of these audiences.
- What is the best format to adopt in sharing with this particular audience?
- What types of detail need to be shared with this audience?

PART TWO

In the next part of the book, I provide examples of how others have engaged in action research. Chapters 6 to 9 introduce four case studies and provide in-depth insights into how teachers created learning spaces through the process of action research. The teachers described in these cases studies were members of a collaborative action research project, funded by the Social Sciences and Humanities Research Council of Canada (SSHRC), a federal funding agency that supports research and scholarship in the social sciences and humanities. Teachers participated for varying periods of time ranging from one to two years, while the project was ongoing for three years. Thus, the composition of the group changed over the three-year period. Usually, school-based teams of two to four teachers participated, although, occasionally, a teacher from a school would join the project and work closely with teachers from another school on a shared research focus or question.

Each case study is presented using the same format; however, this does not imply that the process of collaborative action research is linear. Indeed, as discussed in chapters 1 to 5, collaborative action research is dynamic, recursive, and often messy. The format aligns with the action research process, as described in Chapter 1. The research focus is described first (planning), as well as teacher expectations or reasons for engaging in action research. This is followed by a description of the plan of action (e.g. data collection methods), implementation activities (action), and evaluating and amending the plan (data interpretation, generating new questions, continued implementation). It should be noted that data analysis starts during implementation and should be ongoing throughout the process. Reflection was an integral part of all stages in the process; teachers revisited previous stages, often revising or modifying their plans. For example, teachers often changed aspects of their research plans as they reflected on how their students were responding to particular activities and approaches.

Each case study involves a teacher or a group of teachers who tackle an issue or problem based on their needs and/or the needs of their students. In Chapter 6, Katrina, a grade one teacher, who wished to move from a teacher-centred learning classroom to a student-centred learning environment in science, incorporated a webquest into her science curriculum. In Chapter 7, three primary/elementary teachers worked as a school-based team to adopt concept mapping in elementary science. In Chapter 8, Lana, a science teacher and Sonja, an art teacher, developed a curriculum unit that integrated science and art learning outcomes. In Chapter 9, Nancy, a grade two teacher, worked collaboratively with four other teachers in adopting problem-based learning as a means to engage students in learning science. At the end of each case, teachers share their personal insights and reflections about how the experience informed and enhanced the development of their practical wisdom and teaching practice.

CHAPTER 6

FOSTERING STUDENT ENGAGEMENT IN SCIENCE THROUGH THE ADOPTION OF A WEBQUEST

In this case study, the action research experiences of Katrina, a mid-career grade one teacher, are described as she incorporated a webquest (see Appendix-Part A) into her science curriculum. Katrina conducted her research with a group of 25 students; 16 boys and 9 girls, whom she described as "typical, active six- and seven-year olds from diverse families and mixed socio-economic backgrounds." While she was not part of a school-based action research team, she collaborated with two other grade one teachers from another school in the same district.

EXPECTATIONS/RESEARCH FOCUS

Katrina decided to become involved in action research because of her desire to change her teaching approach in science. Katrina indicated that "a lot of [her] teaching was direct instruction, and [she] wanted to do something that was more exciting and would be more engaging for the children." While she enjoyed learning science herself in school, she often placed limited emphasis on science in her own classroom, instead choosing to focus on reading and math development. Her interest in the area of technology, coupled with her wish to create a more inquiry-oriented learning environment in science, led her to pursue a project focused on webquests. She hoped this would facilitate her shift away from transmission-oriented approaches to more student-centred instruction. Her specific research questions were: a) How does a webquest engage students in learning?, and b) How does using a webquest influence the role of both the teacher and the student in the science classroom?

DEVELOPING A PLAN OF ACTION

In developing her plan of action, Katrina, in collaboration with two other action researchers in her school district, talked to other teachers and educators who had experience in using webquests. She explored a variety of websites and conducted a literature review to develop an understanding of the nature of webquests, to determine how a webquest aligns with constructivist principles of learning, and to synthesize the research on how webquests have influenced student learning.

Katrina searched the Internet to find a webquest that would align with the science outcomes in a "Living Things" unit (see Appendix-Part B for a list of targeted outcomes). She decided to use an existing webquest, rather than designing her own, as it matched her targeted learning outcomes very well. The webquest was designed by a grade one teacher and was published at the San Diego State University webquest portal (see http://webquest.org/). Katrina made some modifications to how the webquest was intended to be used, based on early feedback from her students as she implemented the unit. The website included text, numerous pictures, audio of real penguin sounds, and a real-time webcam of penguins being fed in a zoo. In addition to selecting a webquest, Katrina's planning involved designing assessment tools, a letter apprizing parents of the project work and specific learning activities, considering student grouping logistics, and choosing appropriate data collection sources and methods.

To find answers to her research questions, Katrina used her journal reflections and a parent survey to collect some baseline data about her teaching and her students' experience with using computers. Her journal entries allowed her to reflect on her beliefs about curriculum, student learning, instruction and assessment, and how they were being impacted by the project. In addition to these data sources, she recorded observational notes (e.g. changes in student behavior) during the implementation process, reviewed work generated by students, and analyzed a short survey completed by students at the end of the unit. Examples of some of these data collection tools and data sources are included in Appendix-Part D.

IMPLEMENTATION

Katrina implemented five lessons over a three-week period. She also engaged a number of grade six students in the school to act as helpers to support the grade one children as they explored the webquest. The following list provides a brief summary of what was done during each lesson:

Lesson 1: This was a general introduction to the topic and the webquest. Katrina used one computer and a computer projection unit to show the students the various components of the webquest and to introduce the main problem or task: "Why can't PB the polar bear find any penguin friends to play with?"

Lesson 2: Students were assigned specific roles (artist, geographer, and reporter) within teams as team members completed webquest activities. This session involved students in the initial exploration of the webquest.

Lesson 3: In this session, the students used a very short worksheet to record information about an assigned penguin. Katrina noted that this did not work overly well as some members of the team were becoming bored. Katrina wrote in a journal entry: "After reflecting on the session, I felt it was too cumbersome for the students; they had too many tasks."

Lesson 4: Based on the response from students in the previous session, Katrina decided to assign all students the role of artist. They were asked to draw a penguin that would reveal the physical characteristics of their team's assigned penguin. Katrina noted an increased level of engagement and more productivity during this session: "Students were much more engaged and seemed more interested in manipulating the webquest. Even though I did not ask students to write anything about their penguins, many of them recorded sentences about their penguin in addition to creating a picture."

Lesson 5: In this lesson, the students used the webquest to find information about the habitat of penguins. They had to place an "X" on a map to identify the habitat and then draw a picture of their respective penguins in the habitat.

At the end of each session, students were asked to share what they had learned with the whole class or sometimes to share with other groups. In the previous year, Katrina had only used textbooks when implementing the unit on Living Things. Katrina felt that this new approach fostered "more independence by the learner and a lot less teacher direction and more student ownership of learning" (Katrina, Conversation with the author).

EVALUATING AND AMENDING THE PLAN

While Katrina engaged in data analysis as she collected her data, the more intensive interrogation of the data occurred at the end of the project, with support from her colleagues. In the data (journal reflections, observational notes, students work, responses to the survey), Katrina looked for evidence of changes in student learning. She tabulated frequencies of responses from the parent and student surveys, grouping like-responses together to form themes. She examined student work and compared observational notes and survey responses to look for common themes related to student behavior. Her reflective entries allowed her to analyze changes in her own classroom behaviors and beliefs about teaching.

By conceptualizing and implementing a collaborative action research project, Katrina was able to change her orientation to teaching science from teacher-directed to more student-centred. She referred to this shift as "taking small steps" towards moving her teaching to a more inquiry-based approach. At the time of implementing this project, a new science curriculum framework had been introduced. Thus, she became more knowledgeable about curriculum outcomes for the Living Things unit through examining new resources and analyzing the content of a webquest to determine its alignment with new curricular outcomes.

Katrina became very cognizant of the need to obtain more feedback about student thinking in an inquiry-based learning environment and to provide more consistent feedback about student work. This is reflected in one of her journal entries: “I wasn't quick enough at giving them the feedback on what they had done the previous day. So then they stuck with what they had done from the beginning, even though every day I would say – ‘give me more; give me more; give me more.’ So when assessing this type of work, I need to be more consistent with the feedback on a daily basis to get the product that I want.” These new insights about student learning allowed her to reflect on the changing roles of the teacher and student: “Students took more control of their learning and I let go of control as the keeper of knowledge … letting students build on what they already knew about penguins” (Interview). The results of the student survey data also reinforced Katrina’s belief in the need to design classroom learning experiences that cater to the needs of all students. She was quite surprised that three of her 20 students did not enjoy the webquest experience, and concluded “Children learn in different ways and these need to be considered in science and all areas” (Debriefing session).

In the following section, Katrina shares her insights and perceptions about the nature of collaborative action research and how it impacted her professional knowledge and classroom practice.

KATRINA: REFLECTIONS ON COLLABORATIVE ACTION RESEARCH AND PROFESSIONAL LEARNING

The “Science Across the Curriculum” project was my first experience with action research. Although I had heard the “buzz” of action research during many professional development sessions with the school district, I did not have a clear understanding of what action research really was. Since participating in this project, I have learned that action research is actually more systematic than I had thought. There are steps that must be worked through towards answering a research question. Continuously reflecting on the question is an important element of action research because it allows for a greater understanding of the issues and sometimes leads to changes in the action. Data collection, through such things as surveys, students work, teachers’ journals, are essential to action research because it provides the evidence that is needed to answer the research question. The only limitation is the time it takes, above and beyond the day-to-day teaching responsibilities, to organize an action research project. Although I found each step of the process to be necessary and worthwhile, it was a process that consumed a lot of time. The support of the “Science Across the Curriculum” staff was essential for me because their experience provided informative feedback that allowed for a more efficient process for this first-time action researcher.

For me, the action research methodology provided a systematic approach towards changing my teaching instruction from mostly teacher-directed to one that was more motivating and engaging for the students. The step-by-step process allowed me to focus in on my problem and led to the development of my research questions. The process of acting, observing and reflecting on my research question kept me focused, but also led to some changes in the implementation of my research. I found journal writing to be very useful in the reflection process because it provided insights into observations and helped me to problem-solve as I implemented my plan. The collection and analyzing of student surveys, parent surveys, other student work and my own journal entries was critical in providing the evidence that really helped me to see that I had indeed made a change in my teaching and had provided a more motivating learning experience for my students.

As I think about my own understanding of science, I realize that during the past few years, I had really moved far away from the premise of science as inquiry. This project helped get me back on the path of science as a topic that is meant to be interesting and fun where students have the opportunity to investigate, observe and discover things for themselves. Science is an opportunity to tap into the natural curiosity of children and help them discover things about the world around them. This webquest provided students with a chance to hear real, live penguin calls and to see actual penguins being fed at a zoo while working towards solving a problem. To see the expressions on their faces as they stared at the computer screen while the penguins hopped from rock to rock at the zoo made me realize the importance of taking the time to take the extra step to see what resources are available to deliver the best programs we can. To hear the children ask, “Are we doing webquest today?” showed me that we need to let go of some of the control of student learning and enable them to be independent learners who are able to make connections to what they already know.

Through conducting research in my own classroom, I learned the importance of reflection on my own practice in making changes in my own teaching. Taking the time to reflect and record these reflections really gives powerful insight into student learning and encourages you to make changes that can lead to better student learning. Also, taking the time to conference with students and find out what they liked/disliked about topics and activities can also impact instruction.

I believe that action research is a viable form of professional development. However, it must be undertaken with the support of your school’s administration and someone who has had experience with conducting their own action research. The support of the administration is essential because teachers who are conducting action research in their classrooms need time to organize their plan, do research, and reflect on their actions. Having the support of someone who has had experience with action research is also essential because it helps to have a sounding board to bounce ideas and questions off and keeps you on track.

This project has impacted my classroom practice. Through webquests, I have found an approach that fosters student learning through graphics, sound clips, video clips and the solving of real problems. I have discovered that there are many different webquests for many different subject areas and different grade levels, and how easy it can be to implement webquests in my own classroom. I will definitely use this inquiry-based approach in my classroom again because of its ability to enhance student learning while at the same time allowing for independent learners that need the teacher as a facilitator rather than the controller of information.

I would like to continue with this project because it provided the opportunity for me to examine current approaches to teaching science. It also provided the opportunity for me to learn and problem-solve with a community of my own peers who deal with the same issues that I do on a daily basis. I would like to further investigate inquiry-based learning approaches and to find out what other primary teachers are doing in their classrooms to help children make connections that are more meaningful and authentic.

APPENDIX

Part A: Webquests − An Overview

Since they were introduced by Bernie Dodge in 1995, webquests have been widely adopted for use in many disciplines and at many levels ranging from kindergarten to higher education. According to Dodge (1995), a webquest is an “inquiry oriented activity in which some or all of the information that learners interact with comes from resources on the Internet, optimally supplemented with videoconferencing” (p. 10). Webquests may be completed in several short sessions or may span a longer period of several weeks. They usually follow a standard format and include an introduction, task, process, evaluation, and conclusion. They typically require students to work in small collaborative groups to address an issue or problem; and students are often assigned roles within collaborative groups. Many resources have been developed to guide educators in the design and implementation of webquests (see Part B below).

By working through the suggested steps in a webquest, students can engage a variety of abilities and skills such as hypothesizing; gathering, analyzing, and synthesizing information; and presenting solutions. Several authors (Dodge, 2001; Pohan & Mathison, 1998; Vidone & Maddux, 2002; Zheng, Perez, Williamson, and Flygares, 2008) have described the principles and constructs − critical thinking, knowledge application, social skills, and scaffolded learning − that should undergird webquest design and implementation.

Recently, there have been calls for more research to be conducted on the strengths and limitations of webquests as a teaching and learning tool (March, 2003; Robyler & Knezek, 2003). In 2008, Abbitt and Ophus reviewed the research that has examined the impact of webquests on teaching and learning. These authors reported that there is a scarcity of research on the effects of the webquest approach, thus it is difficult to make a recommendation regarding their ability to improve content learning and skill development. However, they did suggest, based on the research available, that webquests do have a positive impact on collaborative working skills and learner attitudes.

Part B: Selected Resources

Kathy Schrock's guide for educators. (2009). Retrieved September 23, 2009 from http://school.discoveryeducation.com/schrockguide/webquest/webquest.html

Dodge, B. (2007). The webquest.org. Retrieved September 23, 2009 from http://webquest.org/index.p

Educational Broadcasting Corporation. (2004). Webquests-Concept to classroom: A series of workshops. Retrieved September 21, 2009 from http://www.thirteen.org/edonline/concept2class/w8-resources.html

Part C: Living Things (Learning Outcomes)

Students will be expected to:

- Make and record relevant observations and measurements, using written language, pictures, and charts
- Identify and use common terms for the parts of animals
- Identify and describe common characteristics of animals, and identify variations that make each animal unique
- Listen and respond to other students' description of an animal
- Ask questions about the needs of living things that lead to exploration and investigation
- Identify and use a variety of sources of science information to answer questions about the needs of living things
- Make predictions about the movement of animals based on observations

Part D: Examples of Data Sources

Item A (Journal reflection)

Session #1: March 6
This was my introduction day to webquest! I had initially planned on setting a computer to the projector so that the webquest would be enlarged and easier for the children to see. However, the Learning/Computer Resource person suggested that the kids might be too distracted. I followed her advice and took the children to the library where they all sat in front of one computer and I went through the webquest, explaining the problem they had to solve, i.e. why can't PB Polar Bear find any penguins to play with? PB needs you to find out as much info as you can about penguins! The children seemed very interested in what was happening on the screen and eagerly watched as I moved from page to page. They especially liked the Live Cam of the Aquarium that actually showed the penguins moving

around on the rocks and an aquarium worker cleaning out the cage. I heard comments like "Miss is that real?", "show it to us again miss." A grade two class came in while I was going through the last few pages of the webquest and I noticed the teacher and assistant even stood watching as I went through the pages. The session in the library lasted for less than 30 minutes and my observations showed a class that was excited and eager to start webquest.

Item B (Student survey)

Please answer the following questions:
1. Did you like learning about penguins? Yes or No?
2. Did you like using the Internet to learn about penguins? Yes or No?
3. What did you like about using a webquest?
4. What didn’t you like about using a webquest?
5. Why could PB Polar Bear not find any penguins to play with?

CHAPTER 7

PROMOTING SCIENTIFIC UNDERSTANDING THROUGH CONCEPT MAPPING

In this case study, three school-based primary/elementary teachers adopted concept mapping in the context of their elementary science classrooms. Arlene, a late-career teacher, worked with a class of grade five students. Lisa, also a late- career teacher, used concept maps with a group of grade five students. Ernie, a teacher with 11 years of experience at the elementary level, adopted concept mapping with a grade four class. All classes ranged in size from 20-25 students. While the insights of all three teachers will be shared in this chapter, the primary emphasis is on Ernie's experiences as he engaged in collaborative action research.

EXPECTATIONS/RESEARCH FOCUS

Arlene, Ernie, and Lisa joined the Science Across the Curriculum project for a variety of reasons. Arlene viewed this as a professional development opportunity that would allow her to enhance her subject matter knowledge in science. During an initial planning session, she commented on her need to continue to be a "learner" in science: "As a non-trained science teacher, I have often felt that I need to continue to acquire knowledge about the concepts I teach, and I am concerned at times that I do not bring enough background knowledge to the topic as I teach. This is what motivates me to continue to be a learner in science." Ernie felt comfortable teaching science, but at times felt that his classes were not engaging. He viewed action research as a means to "help students learn in new ways … and to make science more exciting for students." Lisa had been involved in an action research project several years prior, and welcomed the opportunity "to go down this road again and work with other school-based colleagues."

One of the biggest challenges for this group in terms of the action research process was identifying an area of focus and then formulating a research question. They wanted to adopt a new approach to teaching in science, but were unsure about what instructional approach to pursue. During a brainstorming session with other school-based action research groups who were also interested in experimenting with teaching strategies and techniques, they identified concept mapping as a possible area of focus. While they were familiar with a range of graphic organizers, they had never used this approach in the past. They felt that this tool could be valuable in supplementing reading and writing in science, and allow students to add another learning tool to their repertoires.

In formulating their research question, they started fairly broad: "How do we use the concept mapping tool to improve teaching and learning in the elementary science classroom?" Before refining the question, they generated a set of sub-questions that would guide their research and reading: a) What is concept mapping? b) How do you teach concept mapping to children? c) How do we assess concept maps? d) How do teachers view concept maps? e) What are students' perceptions of concept mapping? Do they like it?, and f) What are some advantages/disadvantages of concept mapping? After an extensive review of the literature on concept mapping, the teachers returned to their question, revising it to be more focused. Arlene shared her experiences during this revision process in a journal entry:

> Today we clarified our question once again. We went from a "fat wondering" about how we could use concept mapping to enhance teaching and learning in the elementary science classroom to a more focused question, which reads "How does the use of concept mapping affect elementary students' conceptual understanding in science?"

PLANNING/DEVELOPING AN ACTION RESEARCH PLAN

In developing their plans of action to answer their research question, the teachers focused on different curriculum outcomes and content, although they used concept mapping in a similar manner. The following descriptions focus on Ernie and his adoption of concept mapping in a grade four classroom.

After reviewing the literature around concept mapping, Ernie explored a tool that would allow students to create concept maps using a software program called Kidspiration: K-5 (2009). Unfortunately, because of a lack of funding and time, he did not purchase and use the software in this project. Ernie decided to use the concept mapping tool in a unit on light in conjunction with his usual instructional approaches (e.g. lecture, discussion, experiments, small group work). The outcomes targeted in the light unit are included in Appendix-Part A. In the adoption process, he helped students develop the skill of concept mapping first, encouraging them to become comfortable with the technique by creating maps about topics unrelated to science. Then, throughout the unit, he asked them to create maps individually, with a partner, and then collectively as a whole class. The whole-class concept map was placed on a wall and changed constantly as students added new concepts and revised their thinking.

To answer his research question, Ernie used a variety of data collection methods and courses. Before starting implementation, he administered a short survey that included both Likert-style items and four short open-ended questions. The survey allowed him to gain insight into students' attitudes towards science and their perceptions of how they believed they learn best in science classrooms. Likewise, at the end of the unit, he administered a post-survey that focused on students' perceptions of using concept mapping as a learning tool. At least twice during the unit, Ernie held small focus groups with students to reflect on the concept mapping process; he recorded observational notes throughout the process; and he analyzed students concept maps, using rubrics, to determine the degree to which they were able to explain and make appropriate connections among scientific concepts and ideas.

IMPLEMENTATION

Ernie introduced students to concept maps through the creation of a map about St. Patrick's Day. The concepts for the map were generated by the students, while Ernie explained how to create branches, linkages, and cross linkages within a map. This was a new technique for students. Ernie noted their excitement in one of his reflections: "The concepts were offered by the students based on their prior knowledge. Students were excited, shouting out words. I used paper and magnetic clips to place the ideas on the white board." After this initial introduction, students created their own open-ended maps using the concept of water. Once they were comfortable with how to create them, Ernie used the technique in different ways in five distinct learning episodes:

– The first episode involved an open-ended activity to ascertain students' prior knowledge about light. Students were asked to select five words to describe light, and to explain the sources of light and how a rainbow is created. After some guided discussion and compilation of some key concepts about light, the class began to add words to their concept mapping wall.
– Second, Ernie read a section from the text that addressed the question, "Where does light come from?" After identifying the key concepts from the passage (e.g. sun, moon, natural, energy, etc.), each student then created an individual map as Ernie facilitated and monitored their activity by moving from table to table.
– The next episode focused on natural and artificial light. In groups of three, students identified key concepts and then created collaborative maps.
– Next, students engaged in an investigation that explored what happens when light hits smooth and uneven surfaces. Once again, they incorporated what they learned in this episode into the wall map.
– In the fifth episode, students were provided with a concept map that explained the behavior of light when it hits opaque, transparent and translucent objects. Students were then asked to write a paragraph to summarize the key ideas in the map.

The class finished the wall concept map, although after each class, it changed. Ernie noted during one class, "The map was constantly changing as students found better ways to fit the pieces together to consolidate their understanding." As a final unit activity, pairs of students created a summative concept map as a review exercise for an end-of-unit test.

EVALUATING AND AMENDING THE PLAN

In reviewing students' results from the pre-survey at the beginning of the unit, Ernie discovered that his students liked science, but wanted more opportunities to learn science in a variety of ways. Ninety percent of students reported that their past experiences in learning science involved books and doing experiments. However, when asked about how teachers assessed what they know in science, most reported that teachers used tests primarily and projects occasionally. This caused Ernie to reflect on his own assessment approaches, commenting that "My assessment is rather narrow. I use tests and projects mainly, thus I really need to expand this."

In a post-survey, Ernie posed questions that related mainly to concept mapping (see Appendix-Part C). In response to question one, 70% of the students chose "engaging in explorations or experiments," while no one chose concept mapping as an option. While 90% of students said they enjoyed concept mapping, and said it is useful in helping them learn (e.g. organizing ideas, making connections, etc.), only four students in the class expressed a desire to complete their final chapter evaluation using a concept map. Others wanted to use a test, a form of assessment with which they were comfortable. Furthermore, students preferred to engage in concept mapping with a partner or as part of a small group. Ernie was not surprised by this, as concept mapping was a new technique and some students still needed more time to make it a staple in their learning tool repertoire. Ernie noted that a small number of students were not risk-takers and needed constant reassurance as they created maps. Ernie commented, "Three of the kids always seemed to need reassurance. They would ask questions such as 'Am I doing this correctly? Is this ok?'"

In terms of his understanding of curriculum, Ernie reported that he became more comfortable with the learning outcomes for this unit, and certainly was able to gather and select many useful resources. He had only taught the unit once in the past. Ernie viewed concept mapping as a tool that could be used for both ongoing and summative assessment, and to help students consolidate their understanding of scientific concepts. He emphasized the need to gradually introduce concept mapping to students to allow them time to develop the skill, so that they could then use it in conjunction with other learning activities and tactics (e.g. presenting assignments, writing tests, creating pictures, etc.).

ARLENE, ERNIE, AND LISA: REFLECTIONS ON COLLABORATIVE ACTION RESEARCH AND PROFESSIONAL LEARNING

Arlene:

This project has affirmed my views that children learn differently and, therefore, it is important that we, as teachers, use a variety of teaching strategies to reflect these different learning styles. The use of concept mapping has been a teaching tool and, for the most part, has been received by the students as a positive experience. But there are still students who find the construction of these maps challenging. I believe there is no one particular style that I can use as a teacher to get all students to learn but, rather, there has to be a variety to cater to the individual learning needs of the children.

There are many instructional strategies which may be used in science just as in other subject areas. I particularly believe that "hands on" teaching and "visual" teaching are highly effective for a lot of students. I also believe that my approach to teaching depends on the group of students I have in any particular year. I never seem to use the lesson outlines that I have used in previous years just because a different group of children often require different teaching approaches. Concept mapping will be a strategy that I will continue to use, not just in science, but in my other subject areas as well. As I have gone through this project, I have become more in tune with my children and their learning styles. I have seen obvious differences in the construction of maps, which indicates different levels of learning.

This research project has given me the motivation to do extensive reading on concept mapping and to review my course outcomes a little more closely so I am better able to guide the children in the construction of the concept maps for science. I still feel I need to continue my reading on concept mapping to continue to learn about using these effectively because I feel it is a worthwhile strategy and, more particularly, a great assessment tool.

I think action research extends your teaching ability in a number of ways. We are all supposed to be reflective practitioners. When you are in the classroom, everything is so busy and you have so many children with behavioral issues. It is definitely hard to find that time to reflect, but if you embark on an action research project, then you have to sit back and figure out exactly what you're doing, and force yourself to think about why you do what you do. And that is why I like the action research because it not only helped me examine why I do what I do, but it also helps me to extend what I was doing in a better way. I feel that I have grown and developed into a more experienced science teacher. I now have confidence in my ability to conduct action research within my classroom and see that the process can be one which is beneficial and can inform my future teaching.

Ernie:

I feel my intended goal was achieved. My students learned science while doing concept mapping and, overall, my students and I enjoyed doing something new and we both learned from the experience. I feel concept mapping helps students to organize key words/concepts and their relationships with each other. They retain more information and develop a better understanding of what they're doing, and are able to reflect and put that into their concept maps.

Most of my assessment in science has always been a test, worksheet, research assignment or oral presentation, and a science journal. Now, I would include concept maps as a formal and informal assessment. The concept mapping techniques would help students organize their thoughts when writing responses to answers on tests/worksheets or writing/presenting assignments.

Action research is an appropriate way of doing research, because you research a question that is meaningful and interesting to you. It helps you reflect on your teaching. I feel the project was very worthwhile because it made me look critically at a topic (concept mapping) to see if I would use it in my class. It also made me look critically at myself as a teacher. I developed an understanding of a new teaching strategy and a different means of evaluation, and made my classes more exciting. I will continue to do concept mapping in my class. Through this project, various other questions have come up. Some action research questions I may look at in the future are: How can I make my students more independent learners? How can my students become risk-takers? How can I have all my students participate equally when in groups? Although action research can be very time-consuming, I learned a lot about action research. It's open yet there is still a format you follow, but you have lots of leeway within the process to make changes.

Lisa:

Concept mapping has affirmed what I believe and given me a visible tool to use, thus making students' knowledge more transparent to me and enabling the students to communicate their knowledge and to generate discussion. It has been centred on science concepts I have found difficult to do with all students. Using the concept mapping strategy with students has helped me to get a better grip on how science concepts relate to each other. In fact, the whole notion that science [or anything else] can be viewed as interrelated concepts is helpful in and of itself. The process of working through concept maps with my students has helped me to identify my own shortcomings with respect to science content background.

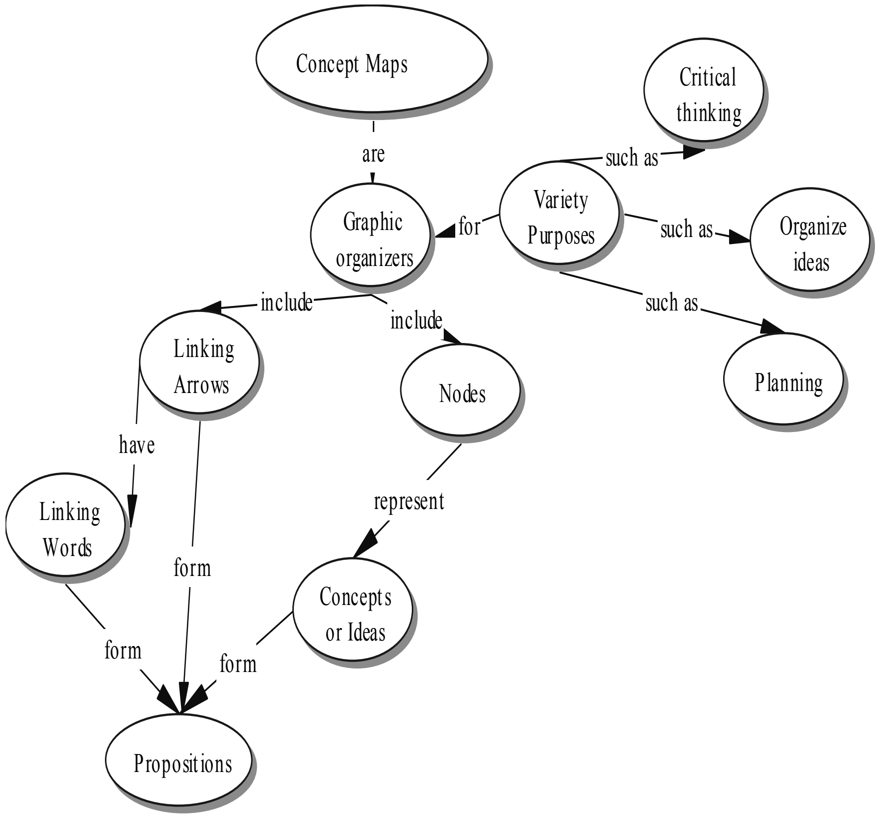
It has been a real reflective process … interesting … so insightful. You need to let the data speak to you. Ernie would say, “You know, I never thought much about that before, but I can now see how I could be doing more.” He wasn't asking the kids enough about their ideas and, you know, when you ask kids things … you get to know your kids. I was challenged in pulling together all the data and interpreting it. I was challenged in the implementation, but everything I've done around it, about it and through it has been valuable for me, so I want it to be a mainstay for us.

You need release time to be able do action research. Somebody said the other day, you know, we're the most unprofessional professionals, but we never get time to go back and reflect and make contact with the latest research and stuff like that. You know, it's a big challenge! So it's not a built-in part of our profession. Action research can help in this area. I would love it if the teacher inquiry stance became a commonplace stance to professional development in schools and school districts.

APPENDIX

Part A: Concept Mapping

Concept maps are visual representations in which concepts and their relationships are shown spatially through positioning. While many graphic organizers are available − such as timelines, flowcharts, and mind maps − concept maps are created using very specific rules proposed by Novak and Gowin (1984).



A properly constructed map will include nodes that represent concepts or ideas that are linked with arrows and connecting words to show the relationship between two concepts. In the preceding example, the concepts are enclosed in nodes and the directional arrow indicates that a relationship exists between the concepts. A pair of concepts and their link form a proposition. Links may be represented with uni- or bi-directional arrows and several propositions may exist in a map.

While the concept mapping technique has been used and researched in science education for a long time, it is currently used in many other disciplines and at many educational levels for a variety of purposes. The tool provides a means for garnering insight into student thinking or, as Hay, Kinchin, and Lygo-Baker (2008) suggest, it provides a means to make student thinking visible. These authors have summarized the many ways concept mapping has been used in teaching and learning: to assess change in learning over time by having students create several maps; to identify student misconceptions or partial understanding of concepts and ideas; to assist with teacher planning; to help students consolidate their understanding; to foster collaborative learning through the creation of shared maps; to test knowledge; and to ascertain differences in the knowledge base of experts and novices in a profession. One of the theories underpinning concept mapping is Ausubel's theory of meaningful learning (Ausubel, 1968). According to Ausubel, learners actively connect new concepts to pre-existing knowledge or exiting cognitive structures. Thus, creating concept maps provides a framework for facilitating this process (Novak, 1998).

Part B: Selected Resources

Novak, J. D. & A. J. Cañas. (2008). The theory underlying concept maps and how to construct them. Pensacola, FL: Florida Institute for Human and Machine. Retrieved September 20, 2010 from http://cmap.ihmc.us/Publications/ResearchPapers/TheoryUnderlyingConceptMaps.pdf.

Novak, J. D. (1998). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations*. Mahwah, NJ: Lawrence Erlbaum Associates.

Novak, J. D. (1993). How do we learn our lesson?: Taking students through the process. *The Science Teacher*, *60*(3), 50-55.

Part C: Learning outcomes targeted in the Light unit

Optical Devices

Students will be expected to:

- describe that knowledge of the properties of light has led to the development of optical devices that extend our ability to observe
- compare how light interacts with a variety of optical devices
- construct an optical device that performs a specific function
- identify women and men in their community who have careers that deal directly with lenses, mirrors, and prisms

Sources of Light

Students will be expected to:
- distinguish between objects that emit their own light and those that require an external source to be seen
- make observations and collect information during investigations to determine if an object emits its own light, and draw conclusions based on the evidence gathered
- provide examples of how human-made sources of light have been designed to solve problems in the home and at school
- identify positive and negative effects of exposure to light
- identify ways of conserving energy through conservative use of home lighting

Light Radiates from a Source

Students will be expected to:
- make observations about how light is dispersed from a variety of light sources
- demonstrate that light travels in all directions away from a source
- conclude that light travels in a straight line based on evidence gathered through their own research and observation

Objects that Absorb, Transmit, and/or Reflect Light

Students will be expected to:
- investigate how light interacts with a variety of objects in order to determine whether the objects cast shadows, allow light to pass, and/or reflect light
- classify objects as opaque, transparent, or translucent
- predict changes in the location, shape, and relative size of a shadow when an object is placed in different positions and orientations relative to the light source and screen
- make observations and collect information about the reflective properties of surfaces of different shapes and textures

Bending Light

Students will be expected to:
– demonstrate and describe how a variety of media can be used to change the direction of light
– make observations and collect information about the refractive properties of materials of different shapes

Dispersion of Light

Students will be expected to:
– demonstrate that white light can be separated into colors, and use the term “dispersion” for this process
– follow a set of procedures to make and use a color wheel
– communicate and listen to others during investigations with color wheels

Part D: Student Survey

1. People like to learn in different ways. From the list below, choose three ways that you prefer to learn things in science:

❒ Taking science notes
❒ Engaging in explorations or experiments
❒ Writing answers to questions
❒ Making models
❒ Drawing pictures
❒ Playing games
❒ Doing worksheets
❒ Creating concept maps
❒ Doing projects
❒ Delivering oral presentations
❒ Listening to the teacher explain things
❒ Watching demonstrations
❒ Reading books
❒ Watching videos
❒ Using science computer software programs
❒ Reading the science text book
❒ Participating in class discussions
❒ Following written directions

2. I like to do my work in science class:

❒ By myself
❒ With a partner
❒ In a small group (3 or 4 people)
❒ In a larger group (6 plus)

3. Do you like using concept mapping to learn about science? Why or why not?

CHAPTER 8

INTEGRATING ART INTO SCIENCE IN A SIMPLE MACHINES UNIT: FOSTERING STUDENT-CENTRED LEARNING

In this case study, the experiences of two junior high teachers, Lana and Sonja, are described as they developed and implemented a collaborative action research project with a grade eight science class consisting of 25 students (12 females and 13 males) with varied academic ability. All students addressed prescribed science curriculum learning outcomes. Lana, an experienced teacher of 13 years, was science department head in the school of 700 junior high students (grades seven to nine). Sonya, the art teacher in the school, had been teaching for six years. Lana and Sonja worked closely with a learning resources teacher in the school to develop a curriculum unit on simple machines that integrated science and art, and implementation of the unit involved team teaching. The unit had characteristics of both fusion and interdisciplinary approaches (see Appendix-Part A); students were required to examine ideas and concepts across science and art although, for the purposes of the action research project, assessment was confined to the discipline of science. The teachers devoted a tremendous amount of time and energy to planning, and all lessons with the simple machines unit were co-taught.

EXPECTATIONS/RESEARCH FOCUS

Lana and Sonja were asked by their principal, Lori, to attend an information session about the Science Across the Curriculum action research project. Once they understood what the project entailed, they became very excited. Lori noted in chatting with me during one of my school visits, "Our school has been encouraging cross-curricular connections, and the art teacher, Sonja, has been doing it with some disciplines. We thought this project would be another way to strengthen the cross-curricular model in our school." Lana also viewed this project as another opportunity to provide leadership in science in her role as department head. She hoped that the resources and the teaching approaches that would be developed and/or adopted would be utilized by other teachers in the school. Sonja also welcomed the opportunity to be involved in the project. Because she was the only art teacher in her school, she felt isolated at times. This project provided her with the opportunity to work with two other teachers, and to explore how to integrate art activities into another discipline. She wanted to do some "team teaching and to see how other curricular areas are taught."

PLANNING/DEVELOPING A PLAN OF ACTION

Once the teachers determined their focus area, integrating art into the science curriculum, they generated a broad research question: "How will the integration of art and science affect student learning in a simple machines science unit?" After considerable brainstorming and drafting and re-drafting several sub-questions, they focused on the following for the action research project: a) What are the most feasible approaches for incorporating art into the science curriculum? b) How will participation in a student-centred unit, with a focus on integrating art and science, affect student engagement in learning science?, and c) How will participation in a student-centred unit, with a focus on integrating art and science, impact student understanding of concepts and principles in a unit on simple machines?

After identifying a research focus and generating a set of research questions, the teachers developed a set of learning experiences that would use Leonardo da Vinci, an artist, inventor, and scientist, as a focal point to target learning outcomes in a simple machines unit (Appendix-Part B provides a list of science learning outcomes targeted in the unit). They chose this particular topic for several reasons: a) Typically students have difficulty understanding the concepts and principles related to simple machines, b) In the past, the science teachers reported that students expressed little interest in the topic, and c) The content lent itself well to integrating art through an emphasis on the life and work of Leonardo da Vinci. To ensure the unit was student-centred, and to align with many of the school's new curriculum development initiatives, they adopted multiple intelligences theory (Gardner, 1983) as a lens through which to plan the unit, and incorporated many cooperative learning structures (Kagan & Kagan, 1998; Kagan, Kagan, & Kagan, 2000).

To answer their research questions, the teachers adopted a variety of research methods and sources:

a) Interviews: Ten students were randomly selected and interviewed after the first lesson to determine their interest in the upcoming unit. Teachers posed questions such as "Identify something you enjoyed about the lesson," "Identify something you did not like about the lesson," "How do you feel about the team teaching approach being used in the unit?" "Based on the introduction, what are your expectations for the Unit?"

b) Surveys: At the end of the unit, students were asked to complete a ten-item survey indicating how strongly they agreed or disagreed with the statements (refer to Appendix-Part A).

c) Teacher observation checklists: Each teacher randomly observed student groups on three separate occasions, recording her observations on the checklist. Items included: actively engaged in group work, working independently, demonstrating an understanding of the concept, and using art skills to complete a science task. Each item was rated from 1 (strongly disagree) to 5 (strongly agree).

d) Student journals: After completing each activity centre, students were asked to reflect on what they found the most interesting about each centre and what they found the least interesting.

e) Students artifacts: In each of the eight activity centres (described below), students completed a piece of assessment. The teachers also administered an end-of-unit test. The results from these assessments assisted the teachers in determining to what degree students understood the key principles and concepts in the unit.

f) Teacher collaborative reflection: The teachers met on an ongoing basis to discuss and analyze observations. Notes were recorded, and these observations and conversations became sources of data.

IMPLEMENTATION

Prior to introducing students to the specific ideas and concepts related to simple machines, the teachers held a classroom session that explicitly introduced students to connections between art and science by discussing the work of Leonardo da Vinci. As well, the art teacher, Sonya, implemented a lesson that introduced students to simple sketching techniques so they would be comfortable sketching simple machines. The teachers created a series of learning centres in which small collaborative groups were required to complete a range of activities. Most of the centres required students to work with actual materials or manipulatives.

Discovery Centre A: In this exploratory activity, completed at the outset of the unit, students were presented with a problem scenario, such as the one below:

What a day! You just fell down the stairs coming from English class and now you are late for Science class. Mrs. L. is about to begin class and you drop your book on the floor. Using the materials provided, develop two ways to lift your book from the floor to the desktop without breaking the string. You can also use materials at your desk to complete the designs.
Using a limited number of materials, they were asked to design two ways to lift a book from the floor to the top of a desk; to sketch the designs; to list materials used; to outline advantages and disadvantages of each design; and to identify problems encountered in generating the designs. This provided insight into what students already knew about simple machines. All activity centres used real simple machines and manipulatives.

Activity Centre One (Levers): Students explored the properties of levers; the concepts of load, effort, and fulcrum; and examined the differences between first-, second-, and third-class levers.

Activity Centre Two (Wheels and Axles): Students examined various examples of wheels and axles, and how they can be used to develop speed or distance advantage.

Activity Centre Three (Ramps and Pulleys): Students explored how an inclined plane or ramp could be used to reduce the force needed to move an object form one level to another.

Activity Centre Four (Gears): Students examined different types of gears, and examined the concept of gear reduction.

Activity Centre Five (Wedges): Students examined the characteristics of a wedge, and how it is different from an inclined plane.

Activity Centre Six (Screws): Students examined the characteristics of screws and how they can be used to fasten materials together.

Activity Centre Seven (Unfinished Business): This centre allowed students to return to the life and work of Leonardo da Vinci to explore the notion of creativity, and how it informs the creation of knowledge and products in both art and science. Students created a horse sculpture similar to one da Vinci had worked on for many years without finishing it.

Discovery Centre B: This activity was completed at the end of the unit as a post-assessment to ascertain what students had learned as a result of participating in the unit. In this activity, Homer Simpson has exposed his egg to a nuclear reactor, and a neighbor runs into the house telling him he must dispose of the egg immediately. Using materials provided, students must generate two designs that will move the egg from point A to point B. Once again, as in the introductory activity, students were asked to sketch their designs; list materials used to create each apparatus; outline advantages and disadvantages of each design; and to identify problems encountered in generating the designs. At the end of the unit, in addition to completing discovery centre B, students completed a unit test and recorded reflections that addressed questions such as “Which of the activity centres did you find the most interesting and why?”

EVALUATING AND AMENDING THE PLAN

In analyzing the data from various sources, all students indicated they enjoyed the approach that was adopted in the unit. All students reported that they preferred this approach to learning, when compared to their previous science classes, and 92% agreed or strongly agreed that they enjoyed working in groups. As well, on the survey, all students agreed or strongly agreed that the focus on art helped them in understanding the science concepts related to simple machines. The teachers, in reviewing the data they collected during classroom observation using the checklist, reported that students were highly focused and on task. They noted two exceptions: one student was "overeager and attempted to take control of the group on a regular basis, and another student did not participate to any degree in any of the collaborative work." During one of the teacher conference meetings, the teachers talked about how pleased they were that the students were becoming self-directed throughout the unit and needed less and less assistance over time. Sonya noted: "After initial explanations, students now need very little teacher guidance and can carry out tasks on their own."

When asked to identify the activities that they enjoyed to the greatest degree, students preferred creating a sculpture, designing an invention, and constructing a merry-go-round using Legos in the centre on gears. The two centres with no manipulatives were ranked the lowest. One surprise to the teachers was the students' results on the chapter test. While students obtained an average of 70% and above on the performance-based activities in the unit, the scores on the teacher-made activities were "average," according to Lana and Sonya, and did not reflect the powerful learning that was demonstrated throughout the unit. They concluded, after considerable reflection, that there was a mismatch between the learning activities and the assessment activities. Lana commented at a planning meeting that "we should have provided them with manipulatives and visual aids during the testing as we did during instruction."

LANA AND SONYA: REFLECTIONS ON COLLABORATIVE ACTION RESEARCH AND PROFESSIONAL LEARNING

Lana:

Taking part in Science Across the Curriculum has forced me to reflect upon my teaching practices. In the past, I always believed that, as the teacher, I needed to take the central role in every class. I have come to understand and appreciate that students can work independently to teach themselves and each other. I can step back and take on a guiding role. This is a huge step for me but the students have shown me that once they are motivated I can have confidence in their abilities. I can see that this broadened view will change how I will teach many of my classes in the future.

This was my first time involved in an action research project. Until I became involved in this project, I had never had any exposure to action research and really had no idea what to expect. I feel that this has been a very worthwhile experience; it has forced me to re-evaluate my own instruction techniques and think about how to motivate students to enjoy leaning science more. The opportunity to work with other teachers in developing a cross-curricular project with art and science was also eye-opening. It has shown me that there is more than one way to approach student understanding of a concept. Students may find help and inspiration in places that you least expect.

What I have learned through this project will have a lasting impact on my classroom practices. I am already thinking of different ways to approach concepts for next year, where can I incorporate other curricular areas, and where can I motivate students just a little more. Thanks to this project I don't feel that I will be afraid to try new things. Was our project a success? I would say YES! Students were motivated and on task and loved coming to class. The look of disappointment on their faces when the unit was completed showed me just how much they enjoyed this new approach.

Sonya:
Taking part in this project has provided insight into many areas of learning and teaching styles. I started this project with a minimal science background and a feeling of insecurity about my abilities as a teacher in a science classroom. I studied quite hard and I am excited with the scientific information that I have learned. My newly acquired knowledge and understanding of the science curriculum have given me new levels of self-confidence, supporting my goal of providing the students with a link between art and science. I feel that I can learn anything if I put my mind to it … my positive attitude rubbed off on the students, who were quick to note "if Miss can do it, so can we!"

I work in a variety of subjects on cross-curricular projects, and I find that students are better able to see art as significant when linked to a core subject area. This project took us a step further, showing students that art and science not only have things in common, but that using art to study science can make the understanding of science concepts much easier. Providing an alternative method of learning science – such as using various art skills – can help a larger number of students garner a higher appreciation and increased understanding of the curriculum outcomes.

I started this project with absolutely no understanding of action research. As the unit progressed, I developed an appreciation of what action research can do. I believe action research can be used as a tool to discover new ways to further develop our abilities as educators; it can be used to find new approaches to teaching and learning; and it can be used to determine if the needs of our students are being met.

Using action research to determine if art would benefit students in the science classroom was definitely an appropriate method. As a team, working to develop and implement our unit, we were able to discuss and analyze ideas and opinions almost immediately. As well, having a set of goals led us to ask more questions and therefore brought forth more answers.

I will continue to work with other curricular areas and it is my hope to work with the teachers to integrate art into their subject areas rather than on individual projects. Although I was not prepared for the time expectations, I truly enjoyed working on the Science Across the Curriculum project. I believe it was a success. I was able to work closely with other teachers and with the students, filling me with a feeling of accomplishment and pride in my work. The sheer enthusiasm exhibited by the students and their disappointment when the unit was completed are definite signs of a successful project.

APPENDIX

Part A:Integrated Curriculum

The notion of integration across disciplines is not new (Pate, 1996; Wineburg & Grossman, 2000). Advocates of this approach cite many reasons for its adoption, such as making learning more relevant and meaningful by helping students make connections across subject areas, eliminating duplication across subject areas, supporting the application of principles underpinning learning theories (e.g. multiple intelligences theory), and relating knowledge to real life experiences. These ideas align with a report released by the National Research Council that synthesized research on human learning. For example, the authors suggest that curricula promote the "development of integrated knowledge structures" (Bransford, Brown, & Cocking, 2000, p. 139). In addition to the potential benefits of integration, there are inherent challenges in the design and implementation process, including lack of time, cost, classroom management, and gaps in teachers' knowledge (Kysilka, 1998; Meir, Nichos, & Cobbs, 2008; Shanhan, 1997; Stinson, Harkness, Meyer, & Stallworth, 2009).

Interdiciplinarity can take many forms in terms of how it is conceptualized and implemented. Integration will vary depending on the context (e.g. the beliefs of those who are integrating, the disciplines being considered for integration, etc.). This opens opportunities to use integrated approaches that are responsive to the particular needs of students. Fogarty (1991) outlined ten approaches to curriculum integration, including perioscope models or traditional approaches (the disciplines are separate and distinct with a singular focus on the discipline), binocular models (shared planning and teaching occur in two disciplines and shared concepts and principles are team taught), and kaleidoscope models (patterns across several disciplines are identified and content is approached through these patterns; there may be team teaching as well), to describe a few. Drake (2007) describes four degrees of integration that are hierarchical in nature, reflecting more connections and time for planning in moving from one level to the next. Fusion, the first approach, involves adding content from a discipline to the curriculum. For example, if more time is spent on mathematics and language in the elementary curriculum, other subjects may become marginalized. Thus a deliberate focus is made to teach the ideas of the marginalized subject in every other class, although assessment remains subject-specific. In a multidisciplinary approach, disciplines remain separate; however, connections are made among the disciplines. For example, at the elementary level, a theme may be developed and students work within learning centres with each centre representing the discipline that reflects that theme. In high school, students may study a similar theme in different classes. Content and assessment reside with the particular discipline and students are often expected to make the connections themselves. In an interdisciplinary approach, big ideas and skills become the organizing focus. Unlike the previous approach, interdisciplinary concepts are emphasized across the disciplines rather than within each discipline. In a transdisciplinary approach, the starting point is not the disciplines, but a real-world issue or problem, and far more emphasis is placed on student interest. Big ideas and skills are addressed and large assessment tasks are adopted within a unit of study. Blurring across these approaches may occur, as the categories are not rigid.

Part B: Learning Outcomes

Students will be able to:
- demonstrate the importance of using the languages of science and technology to communicate ideas, processes, and results
- identify examples of scientific knowledge that have developed as a result of the gradual accumulation of evidence
- describe instances where scientific ideas and discoveries have led to new inventions and applications
- describe examples of technologies that have been developed to improve their living conditions
- propose questions to investigate and practical problems to solve
- suggest improvements to a design or constructed object
- communicate questions, ideas, and intentions, and listen to others while conducting investigations
- investigate different kinds of forces used to move objects or hold them in place
- demonstrate and describe the effect of increasing and decreasing the amount of force applied to an object
- investigate and compare the effect of friction on the movement of an object over a variety of surfaces
- demonstrate the use of rollers, wheels, and axles in moving objects
- compare the force needed to lift a load manually with that required to lift it using a simple machine
- differentiate between the position of the fulcrum, the load, and the force when using a lever to accomplish a particular task
- design the most efficient lever to accomplish a given task
- compare the force needed to lift a load using a single pulley system with that needed to lift it using a multiple pulley system

Part C: Student Survey

Please circle the answer next to each item that reflects how you feel about the statement.

St. XXX Junior High School
Grade 8
Simple Machines
Student Survey

Strongly Agree 1 **Agree 2** **No Opinion 3** **Disagree 4** **Strongly Disagree 5**

1. I enjoyed working in a group.	1	2	3	4	5
2. I have learned a lot from the people in my group.	1	2	3	4	5
3. I have contributed as much as the others in my group.	1	2	3	4	5
4. I have contributed more than the others in my group.	1	2	3	4	5
5. I have not contributed as much as I would have liked to.	1	2	3	4	5
6. This approach to learning is different from my other classes.	1	2	3	4	5
7. I prefer this approach to learning science.	1	2	3	4	5
8. This approach has helped me to learn better.	1	2	3	4	5
9. I never noticed how art and science can be linked.	1	2	3	4	5
10. Using art has made learning about machines easier.	1	2	3	4	5

CHAPTER 9

EXAMINING THE ROLE OF STUDENTS AND TEACHERS IN PROBLEM-BASED LEARNING

In this case study, five primary/elementary teachers adopted Problem-Based Learning or PBL (refer to Appendix-Part A for background information about this approach) as a way to make teaching and learning more relevant and meaningful in science. Except for Lois, who was an early-career teacher in her second year, the other four teachers (Deidre, Judi, Nancy, and Samantha) were mid- to late-career teachers with 15 to 23 years of classroom experience. All teachers developed and shared a common research question. However, their action research plans varied in response to science topics and learning outcomes targeted. While the insights of all five teachers about action research and professional learning will be shared at the end of the case, the experiences of Nancy, a grade two teacher with 23 years of teaching experience, will be highlighted.

EXPECTATIONS AND RESEARCH FOCUS

The teachers who participated in this collaborative action research project were from one school district and three different schools located in remote communities. While the whole group worked together during the design and implementation of the project, Judi and Samantha, colleagues in the same school, worked together to implement a shared action research project with their grades one and three students respectively; Deidre and Lois developed a shared plan of action for implementation with their grade four classes; and Nancy, the only teacher working at the grade two level, developed her own plan of action. After spending the initial part of the project learning about the nature of action research and examining the literature about PBL, the group was ready to generate research questions. First attempts to draft a question focused on student achievement and PBL. However, after considerable discussion, the group shifted away from the notion of achievement and, instead, generated a question that examined student engagement and PBL. Their research questions were “How does the adoption of PBL engage all students in my classroom? What are the roles of teachers and students in PBL environments?” The teachers worked with classes that ranged in size from 20 to 25, and each teacher had a small number of students in their respective classes who were unmotivated and/or who had been identified as special needs students requiring programs with modified learning outcomes. Thus, it was very important to the teachers that they examine the potential of PBL for engaging all students in learning science.

The teachers joined the action research for a variety of reasons. As new action researchers, they welcomed the opportunity to participate in professional development that would be ongoing, and to work collaboratively with other teachers in the school district. The notion of PBL also appealed to the teachers because they viewed this approach as having potential to offer student-centred, inquiry-based learning experiences in science. As Nancy noted during one of our early meetings, “It is difficult to ensure that science activities are engaging, hands-on, and student-centred, considering the lack of time and resources and an environment that is not focused on professional development in science.”

PLANNING/DEVELOPING A PLAN OF ACTION

Nancy, a 23-year veteran teacher, working with a grade two class of 18 students, described them as “grouped heterogeneously in terms of ability with varying degrees of strengths and needs.” She added that her class is motivated and interested in learning, with the exception of one child who had been diagnosed with an oppositional defiant disorder. Because the project started in January, the teachers felt they would not be ready for implementation until September of the following academic year. Thus, Nancy chose to develop her PBL experience by targeting science outcomes in a life cycles unit that would be implemented in the fall. In addition to targeting science outcomes, Nancy targeted outcomes from language arts (Refer to Appendix-Part B for a list of these outcomes).

After identifying learning outcomes that would be targeted in the unit, Nancy then developed a concept map representing the scientific concepts and principles and student learning abilities and skills that would be emphasized during the PBL experience (see Appendix-Part C). This allowed Nancy to develop a better understanding of the science content underpinning the unit, as well explicitly consider the skills students needed to develop to engage in PBL. Next, with support from the other teacher researchers and myself, Nancy followed the challenging task of developing a problem scenario for the unit. The scenario needed to be engaging and relevant, align with curriculum outcomes, place students in particular roles, and foster inquiry (see Appendix-Part D). After designing the problem scenario, Nancy began making decisions about the types of assessment and learning activities that would be used in the PBL experience (described in the next section).
In answering her research question and to gain insight into how students were learning through PBL, Nancy used a variety of data collection methods and sources such as:

- Informal student interviews: These were conducted throughout implementation during classroom activities. This helped Nancy to ascertain how students were understanding concepts and to what degree they were enjoying the PBL project.
- Student journals: These were completed regularly by students and included statements such as “This was my science question,” “This is what I did to find an answer” and “This is what I learned.”

- Teacher observation checklists: Although Nancy noted that these were difficult to use, they helped her in recording specific student's behaviors (e.g. generates new questions, organizes information appropriately, presents information in an effective manner, gives details and examples, listens attentively, and encourages others).
- Student artifacts: This student-generated work included notes collected during the unit and materials used in preparation for final presentations.
- Teacher observation/reflective notes: These were recorded by Nancy throughout implementation as she observed students during collaborative group work, and as they completed individual tasks.

IMPLEMENTATION

Nancy used a range of assessment and learning activities to support students in helping Mrs. Bartlett to solve the problem of how to prevent the caterpillars from destroying her garden plants (see Appendix-Part D for a description of the problem hook). After the class was introduced to the problem, and they explored the nature of the problem and clarified their roles as entomologists, the class generated a list of questions they would need to answer in order to find a solution to the problem. Some of the questions they posed were: How do you get caterpillars out of the garden? What does a larva eat? What does a butterfly eat? How long does it take for a larva to turn into a butterfly? Other questions were added to this list as the unit progressed (e.g. What is a pupa? What color will the butterflies be?). The questions guided the collaborative PBL as students engaged in research using several sources (books, guest speaker, newspapers, magazines, the internet, etc.). While Nancy admits that the front end of the PBL implementation was more teacher-led, she eventually assumed the role of facilitator, as reflected in her comments, "Once the class was comfortable with the problem and their roles, I stepped back and took on the role of facilitator. The students were ultimately responsible for the direction of the learning."

Students worked collaboratively in groups of four throughout the unit and, according to Nancy, everyone was involved in information-gathering and data collection. One of the main focal points of the PBL experience was caring for and observing the development of butterflies as they transformed from larva to adult Monarch butterflies. This was part of a larger North American initiative of tracking and monitoring the Monarchs. Students recorded observations three times per week during metamorphosis, using words and pictures, and recorded questions as they engaged in observation. The groups had informal discussions about what they were learning as they cared for the larva and collected data. An expert gardener visited the class to talk about caterpillars and gardens and shared her views on how to control for caterpillars. Throughout the process, students kept returning to their original set of questions to see if they had been answered and to add new questions. The students also created a range of projects such as poetry, art projects, letters, posters, illustrations, videos, and game boards to present their final solutions and what they learned about the life cycles of organisms to the class and a visiting entomologist. See Appendix-Part E for an example of text written by a PBL group and used during a final presentation.

EVALUATING AND AMENDING THE PLAN

Nancy felt she was successful in answering her research question "How does the adoption of PBL engage all students in my classroom?" Reflecting on this in one of her journal entries, she wrote "I set out to create a learning environment, through PBL, where ALL learners would be involved. With the exception of one child, all learners in my class were highly involved and engaged. The child who was not highly involved has so many academic and behavioral challenges that she was an exception, although there were times when she was involved and her behavior did improve."

Nancy had considerable evidence that most students were engaged during PBL. For example, they completed all unit learning activities, and went beyond required expectations by seeking extra resources outside of class time, and volunteering to do research on particular issues. Nancy also reported that the students became more comfortable with the PBL process over time, were able to generate more questions as they delved more into the research on the life cycle of a butterfly, enhanced their higher level thinking skills, and improved their collaborative learning skills. Nancy had offered this same unit many times in the past, but had never done so through the lens of PBL. The PBL framework, according to Nancy, allowed her students to become "hooked." While acknowledging that PBL is complex and requires both students and teachers to adopt new roles, Nancy noted several perceived strengths of PBL:

– The PBL process is an effective one for teachers to use in their classrooms.
– Primary teachers demonstrated that with a little more teacher direction, PBL could be used successfully with young children.
– Even though students may feel intimidated at first, with support and encouragement, they can become self-directed learners capable of asking questions and identifying gaps in their own knowledge.
– Professionals also benefit as they can reflect on and reassess their teaching to ensure that the best possible learning opportunities are available for their students.
– Since completing this project, Nancy has continued to use PBL in her teaching and to enhance her understanding of how to support student learning through PBL.

DEIDRE, JUDI, LOIS, NANCY, AND SAMANTHA: REFLECTIONS ON COLLABORATIVE ACTION RESEARCH AND PROFESSIONAL LEARNING

Deidre (Grade 4):

Through conducting research in my classroom, I learned that science must be about inquiry. This is where new learning occurs. Students are more motivated when there is a real life problem that they have to solve. Student engagement is increased when they take ownership of a problem (e.g. It was their own garden they were creating). Students also love working in groups and the shier kids often came out of their shells and contributed in small group settings. Group dynamics are very important to observe. My three behaviorally challenged students were moved several times so that I could find the right fit for them. My higher achieving students thrived in small groups, taking on many of the leadership roles yet delegating and designating at times.

Action research can be messy and humbling. It is definitely a form of professional development, as it leads to reflection and new learning. Having time for reflection is key to changing and improving your teaching practice. I believe action research is a viable form of professional development because it directly impacts classroom practice. This is what professional development should do. I do believe that it would be better to have two teachers in a school working on the same topic. This would allow a better opportunity for collaboration as well as a sounding board to step back and look at it from a different angle.

This project helped to validate what was part of my philosophy of teaching, that students can be the generators of knowledge and that learning is social. We learn more from each other than we do alone. Through this project, I realized that this view of learning was something that I had adopted from the social sciences (language arts, social studies, health, etc.) but not science or math. I still owned a traditional view of these subjects as a body of facts to be learned. I now feel more confident that I can hold back on some of the facts until they become one of the student's inquiry questions. I wonder how this would work with math??

I feel my research was successful, as it helped me see that there are many ways to make science come alive for students and motivate and excite them. Students learn so much by doing and when they are able to roll up their sleeves and get their hands dirty. That is when they really took ownership of the PBL process. On top of feeling proud at their accomplishment, all students were engaged and motivated.

Lois (Grade 4):

The action research approach, I feel, engages teachers in an inquiry process that is important to that individual teacher; teachers research something that is relevant and important to their practice rather than something that an outside "expert" sees as important in the profession. This makes it very practical and useful to teachers. Often times, what the experts see as important is felt by teachers to be far-removed from daily practice and thus teachers are not motivated to engage themselves in research surrounding these issues.

My involvement in this project has had many implications for my own beliefs on teaching and learning science as well as my beliefs about teaching and learning in general. My beliefs about science and science instruction were validated throughout the project. I have long stated that my belief is that science instruction must be hands-on, engaging, and appeal to children's natural curiosity. I strongly believe that the basis of problem-based learning, engaging students in a messy, open-ended, realistic problem, is exactly what I believe science instruction should encompass. This is not to say that there is no place for factual information in science, but that students should be given an opportunity to apply this factual knowledge in meaningful contexts to help internalize their learning. Without applying, synthesizing and evaluating information, students will very quickly forget factual information that they have committed to memory.

Although this has been my belief, I have not always put it into practice. I have fallen victim, on some occasions, to challenges presented in the form of lack of time and lack of resources. Participating in this project has rejuvenated my philosophy and has helped me realize that although not always easy, it is important to work through such challenges so that, in the end, students are benefiting from learning experiences that have been meaningful. I will carry this rejuvenation with me into my future teaching and keep it at the forefront when determining particular instructional approaches to implement in my classroom.

Participating in this project has also taught me a lot about how students learn and their potential for learning. It has made very clear to me the differences in student learning styles and the importance of designing activities and opportunities to appeal to all. Students' attitudes were so much more positive when they felt that they were able to complete something well and they were excited to be able to share what they had learned. Students were engaged in many practical activities aside from those designed to cover the specific curriculum outcomes. For example, students wrote a letter to the principal telling him what they had learned and asking for benches for their garden. They were very excited and proud to share what they had learned with him.

The amount of reflection that was involved in this project on my part was also very beneficial to me. I was able to recognize the difference between intended reflection and the reflection that I engage in on a daily basis.

Nancy (Grade 2):

Through conducting research in my own classroom, I reinforced my belief that teaching should be interdisciplinary. You should not teach science or any other subject in isolation. The scientific process should be engaging, interactive, and explore areas that children find exciting. Children's interests and insights should be capitalized upon and, wherever possible, they should drive the learning.

My present conception of action research is a process that enhances classroom practice and effects educational change. It involves specific teachers within their own classroom setting with their specific problems. Understanding is met through the engagement and interaction of all. Information is gathered, organized, and data is interpreted. The teacher is a facilitator, and self-reflection is an important part of the process. It is classroom-based research that is practical to you and your students.

This project will have a long-term effect on my classroom practice. I found the process of engaging in action research to be motivating and engaging for all learners. As I continue to teach I will certainly keep this in mind and try to *hook* the students as I strive to enhance their learning by creating meaningful contexts for them. There is no reason why problem situations relating to the students real world cannot be woven into our learning outcomes.

I believe action research is a valuable form of inquiry for both educators and students for many reasons. It is very practical because its focus is within a specific context and classroom setting. Practical improvements are the focus. Participation is a key feature of action research. Learners are actively involved in meaningful ways rather than the traditional approach of sitting in their seats and being passive learners where the teacher is all-knowing, passing their knowledge to students through lecture-style teaching. It is also empowering for students and teachers alike. All participants can contribute to and benefit from the process. There is also an interpretive feature where meaning is constructed using different perspectives.

Judi and Samantha (Grades 1 and 3, respectively):

Action research helped us to engage in daily reflection through journal writing and ongoing discussion, and to analyze and revise our teaching to better meet the needs of our students. Through conducting action research in our classrooms, we have learned that it is important that students see themselves as scientists and that they be able to take on that role in asking, observing, exploring, sharing, recording and making connections in order to solve real-life problems. The PBL approach to learning fits very well with our new science curriculum and its role of inquiry-based learning. For example, we are now supposed to use the AEA style of teaching science. This simply means Activate (What do we want to know? What do we know?), Explore (How do we find out?), and Apply (What did we learn?).

We have discovered a very close relationship between PBL teaching and learning and our new curriculum supports. We have also discovered that, like teachers, students want to have input in changing the ways they learn. They are like mini action researchers working together, thinking and re-evaluating what they have learned in science.

Having gone through this process of implementing a PBL unit through action research, we feel it has been a wonderful experience and would recommend that all teachers be exposed to the process. This project has definitely impacted our teaching practices in a positive way. We have seen much enthusiasm and student growth for ALL of our learners and we now know the many benefits of problem-based learning. We both feel that action research is one of the best types of professional development that can benefit teachers willing to try new methods of learning and teaching and to learn from mistakes in order to experience growth as teachers. As teachers, we often encourage our students to be risk-takers and think outside of the box. So, like our students, we should be willing to take risks and try new approaches to teaching if it is beneficial to our students' growth.

APPENDIX

Part A: The Nature of Problem-Based Learning (PBL)

The early adoption of PBL can be traced back to the early 1970s at McMaster University's medical school. Since then, it has gained prominence not only in medical schools but in other professional schools, the sciences, and humanities. It has seen growing popularity in recent decades in K-12 education (Barrows, 2000; Dochy, Segers, van den Bossche, & Gijbels 2003; Gallagher, Stepien, & Rosenthal, 1992; Hmelo-Silver, 2004; Hmelo, Holton, & Kolodner, 2000; Torp & Sage, 2002; Williams & Hmelo, 1998), and has been touted as having the ability to facilitate the development of communication, problem-solving, and self-directed learning skills (Albanese & Mitchell, 1993; Vernon & Blake, 1993). Proponents of PBL also believe it has the potential to promote many of the principles that are foundational to constructivist and student-centred forms of learning.

PBL does not represent a unitary approach, and a variety of methods and procedures may be used in the design and implementation of the approach depending upon the goals and objectives being targeted, student readiness to engage in learning through PBL, and the teacher's readiness to design and implement a PBL experience. The learning process in a PBL experience is driven by a realistic, well-structured problem that provides a context for students to enhance their knowledge skills (Barrows, 2000; Hmelo-Silver, 2000). Barrows and Kelson (1995, as cited in Hmelo-Silver, 2004) highlight five goals of PBL: a) Constructing extensive and flexible knowledge, thus requiring the learner to integrate information across multiple domains, b) Developing effective problem-solving skills to necessitate that learners use a range of meta-cognitive practices, such as planning, monitoring and evaluating, which enable reflection upon the problem-solving process, c) Engaging meta-cognition which entails students demonstrating an awareness of what they are able to comprehend, an ability to identify and set learning goals, how to take an appropriate course of action to reach their goals, and evidence of how to reflect upon whether or not their goals have actually been attained (Zimmerman, 2002), d) Promoting effective collaboration through the development of team-oriented skills such as negotiation, conflict resolution, and consensus building, and e) Fostering intrinsic motivation through PBL groups with shared goals, challenges, and interests (Hmelo-Silver, 2004).

One of the most challenging aspects of designing a PBL experience is articulating the problem (Angeli, 2002). Teachers need to consider several factors in the design process, such as identifying the learning outcomes to be targeted; writing relevant, authentic problems that will be engaging and have several possible solutions (open-ended); anticipating the questions or learning issues students will generate as they solve the problem; and selecting appropriate resources. Likewise, the plan for implementation of a PBL experience needs to be considered carefully. Planning involves making decisions about how big the PBL groups will be, how much time will be devoted to the PBL, and how students will be assessed. Students will need to meet as a group frequently and the teacher will need to monitor group progress, providing feedback as groups engage with the problem. The PBL cycle involves the introduction of the problem to students, identification of what students already know about the problem and questions that need to be answered, group discussion and ongoing research, proposing solutions, creating group and individual products to represent learning, and presentation of a solution. PBL assumes new roles for students in which they direct and take responsibility for their learning. The experience is student-centered and should promote integrated, inquiry-based learning.

Part B: Learning Outcomes Targeted in Nancy's PBL Unit

- Observe and describe changes in the appearance and activity of an organism as it goes through its life cycle
- Ask questions that lead to exploration and investigation
- Select and use materials to carry out their own explorations
- Make and record relevant observations and measurements, using written language, pictures, and charts
- Identify constant and changing traits in organisms as they grow and develop
- Identify and use a variety of sources of science information and ideas
- Communicate procedures and results, using drawings, demonstrations, and written and oral descriptions
- Respond to the ideas and actions of others and acknowledge their ideas and contributions

– Propose an answer to an initial question or problem and draw simple conclusions based on observations or research
– Identify new questions that arise from what was learned

Part C: PBL Hook

Every summer, Mrs. Bartlett likes to sit in a chair and enjoy her beautiful garden where she has lots of plants and flowers with butterflies flying from one to another. However, before Mrs. Bartlett can enjoy her peaceful summers, she always has to fight with hungry caterpillars who love to eat the leaves of her plants in the spring. She noticed that these caterpillars always appear around the same time, eating the plants, and then disappear. Then they appear again the next spring, just like the butterflies who come to visit the flowers in the summer and then disappear. Mrs. Bartlett thought it would be wonderful if she could get rid of these caterpillars so that she would not have to work so hard to save the plants, and the butterflies would have more flowers to visit in the summer. You and your teammate are entomologists (bug experts) in training. Your team and other teams of entomologists are called in to help Mrs. Bartlett with her problem. These insects are devouring her plants and flowers. What can your team tell Mrs. Bartlett about caterpillars? What can your team do to help Mrs. Bartlett with her problem without destroying her garden? Mrs. Bartlett will choose the best solution to her problem from all the proposals.

In order to produce an effective and trustworthy solution proposal, your team should use scientific methods, such as continuous, consistent observation, and keep a journal of your research plan, how the plan has been carried out, and whether any revisions to your research plan are needed after a period of doing your research. Mrs. Bartlett will also pay your team a visit and interview you on the progress of your research. So, your team will need to prepare to answer Mrs. Bartlett's questions concerning her problem with caterpillars destroying the plants. And finally, in order for Mrs. Bartlett to select the best solution to her problem, each team will give a presentation of its research and solution to her problem. Mrs. Bartlett is anxious to find a good solution to keep her plants healthy, and to attract butterflies to her garden since spring is coming and the caterpillars are about to come out.

So, get started and help Mrs. Bartlett!

Part D: A Teacher-Created Concept Map of Concepts, Principles, Abilities, and Skills Targeted in the Unit

Part E: The Text From A Final Presentation Prepared by One of the PBL Groups.

Video Report
This is Jake. Ms. Burke has a very big! prplem (*problem)* her garden is being dstored (*destroyed*). There are caterpillars eat her gadin (*garden*) away. Ms. Burke worked very hard on her garden. She wrode (*worked*) 5 years on it. She needs help so her class is stiding (*studying*) the life cycle of the monarch butterfly. Thay (*They)* have a monarch butterfly in there (*their*) class. They had a gardener in to tell them some informaytaon (*information)* and this is what she side (*said*). You can

get some dish liquid and a little water and put it in a spray bottle then spray it on your garden and it … won't kill the caterpillars and they will go away. There is a n gtheher (*another*) way get something hot and spicy put a little water then put it in a spray bottle. The caterpillars will go away. Ms. Burkes class is reading a lat (*lot*) of books to lrom (*learn)* some more informayshon (*information*). If you do what the gardener side (*says)* you won't kill the butterflys.

CONCLUSION

While individuals may engage in action research as a lone enterprise, it can be far more powerful if it is conducted within the context of a community of practice (Wenger, 1998). Communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger, McDermott, & Synder, 2002, p. 4). Communities of practice are ubiquitous and individuals are often members of a variety of these communities. Like all communities in which learning occurs, action research communities of practice need careful cultivation. Wenger et al. (2002) offer guidelines that may be adopted by those who support and participate in communities of practice. Attention must be given to allowing group members to take ownership of the process. Communities of practice are composed of members who have different roles; thus, all perspectives need to be considered and respected, and different levels of participation should be welcomed. For examine, a principal may be part of a school-based action research group, offering support to group members. Yet, she may not be engaged in conceptualizing and implementing an action research project herself. Furthermore, action research involves both individual and group collaboration, and both should be supported. The members of an action research community of practice should value their work, the work of others, and recognize the value of the community in promoting professional sharing and learning. Within the community, learning activities should be varied (e.g. whole-group meetings and small-group meetings), while allowing enough time to engage in the action research process. Without dedicated time to engage in action research, group members are likely to become frustrated and the community may be less productive. Learning spaces can only be created through action research if group members pay particular attention to creating the conditions for optimal group functioning.

In productive action research communities, the experience of conducting collaborative action research allows practitioners to create new learning spaces, examine their preconceived beliefs about teaching and learning, and develop new understandings about student learning and professional practice. While learning and changes in classroom and school practices can be a result of many approaches to professional learning (e.g. conferences, curriculum development groups, study groups, peer teaching, etc.), collaborative action research provides a powerful way to develop practical wisdom about teaching. Teachers examine and reflect on their perceptions, beliefs, and developing knowledge as they interact in new ways with students and others educators. Practical wisdom, then, can only be developed if learning is contextualized and connected to the everyday lives of teachers' classrooms. By engaging in the action research process, teachers are afforded the opportunity to critically examine and contribute to theory about teaching and learning and teacher education and to integrate experience and theory to inform practical wisdom. The potential for action research to effect change and foster renewal can be far-reaching, encompassing teachers' daily practice and the policies and practices of schools and school districts. I hope this book provides you with the impetus to venture into the world of action research and to seek out colleagues who would like to share with you in a process that will lead to change, ongoing inquiry and reflection, and renewal.

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