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8. EXPLICIT LITERACY INSTRUCTION EMBEDDED IN MIDDLE SCHOOL SCIENCE CLASSROOMS

A Community-based Professional Development Project to Enhance Scientific Literacy

The *Explicit Literacy Instruction Embedded in Middle School Science Classrooms* project was initiated in the spring of 2005 at the request of a small group of teachers from two middle schools in a Victoria, British Columbia (BC), school district that had French immersion and English programs of instruction in Grades 6, 7, and 8. A third middle school joined the project later. Part of the motivation was that the school district was implementing the new K–7 and Grade 8 provincial science curricula (BC Ministry of Education [MoE], 2005, 2006) and the schools' had recently selected and purchased textbooks.

There were expressions of commitment to collaboration from teachers, school and district administrators, and Pacific CRYSTAL researchers that called for a community-based, emergent research and development approach to this project. A community-based approach would collectively identify needs and opportunities, design solutions, evaluate and revise solutions, and provide funding for the required instructional resources and teachers' professional learning opportunities. Such flexibility would enable university researchers and collaborators from the field to adapt and take advantage of case study opportunities throughout the project (Anthony, Tippett, & Yore, 2010). The overarching purpose of the project was to develop, field-test, refine, and eventually disseminate research and field-based activities that would integrate literacy strategies in the context of the ongoing science instruction to enhance teachers' pedagogical content knowledge and students' science literacy (Yore, Chapter 2 this book).

The community-based project has several dimensions that were within the shared authority and responsibility of the participants: school district, schools, teachers, university, Pacific CRYSTAL, and researchers. The first dimension was ongoing assessment of needs through measures of student beliefs, attitudes, and strategies in relation to science literacy, school-wide assessments of reading and writing performance, and the observations and comments of participating teachers. The second dimension, design of instructional options, arose from the identification of research-based options related to the identified needs in published research. The third dimension was the implementation and evaluation of these classroom-level solutions within the opportunities provided by the prescribed curricula, available instructional resources, school priorities, and classroom contexts, which were conducted through

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embedded case studies of classroom practices and teacher reflections. This design was to serve the goals of participating teachers and university researchers to systematically inform the professional development agenda to improve science literacy instruction.

OVERVIEW AND SUMMARY

The organization of this 5-year project centred on a series of workshops. Each series included discussion of the multimodal character of scientific discourse and the roles of oral and written discourse in doing and learning science; a variety of discipline-specific literacy strategies that reflected the nature of science and the research evidence behind each strategy was also presented. Participants had opportunities to discuss implementation of the strategies and to share ideas about embedding the strategies into their classroom science curriculum. Discussion of classroom applications and evaluative feedback on implementation were a part of each workshop. The strategy workshop activities included demonstration lessons, team teaching, and working sessions where teams of teachers collaborated in the creation of instructional resources. Due to the collaborative nature of the project, the workshop schedule reflected teachers' interests and students' needs. Over the first 2 years of the project, responsibility for the delivery of professional development workshops did shift from teachers to researchers in response to the preferences expressed by the group. However, later the leadership shifted back to the teachers as part of the community-based, cascading leadership model designed to leave a legacy of science advocates (lead teachers) in these three middle schools. The selection of workshop topics and activities remained the outcome of discussion with participants.

Participating teachers were generalists who taught a variety of subjects in addition to science. None were specialists who taught only science, and only a rare few had university degrees in science. During the project, the focus and number of participants fluctuated (see Table 1) as a result of "competing priorities within the school districts and schools, retirements, maternity leaves, staffing changes, and the relocation of one school" (Anthony et al., 2010, p. 55). Participation in the workshops changed from an open invitation to teachers to drop in whenever they chose to come, to a year-long commitment to participate in all workshop sessions in Year 4, and to broad dissemination in Y5 involving at least two potential lead teachers from each middle school (Van der Flier-Keller, Anthony, Tippett, & Stege, 2010).

Y1 began late in the school year; therefore, activities were limited to providing a background for interested teachers and exploring aspects of science literacy and the role of language as a cognitive tool in science. This formed a nucleus of participating teachers who developed a tentative agenda of priority areas for the next year's workshops. At the first workshop in the fall of Y2, participating teachers from both English and French immersion streams were shown a summary of opportunities for embedding literacy strategies into the science curriculum and textbooks. Pacific CRYSTAL researchers developed the summary by classifying the instructional procedures presented in the two new textbook series (*BC Science 6, 7,* and *8*, McGraw-Hill Ryerson, 2004, 2005, 2006a; *Science Probe*, Nelson Education, 2005a, 2005b, 2006) into a descriptive framework for science literacy activities adapted from the

Science Theme Sets™ (National Geographic School Publishing, 2008). Later, the French immersion teachers developed a parallel framework for the French science textbook (*Sciences 6, 7,* and *8 Colombie Britannique*, McGraw-Hill Ryerson, 2006b, 2006c, 2006d). This writing–reading and representing–viewing framework was based on four aspects of literacy activities that should be familiar to teachers. As the project progressed, oracy was added as the fifth dimension in order to reflect provincial and school goals and to emphasize the importance of discussion in constructing understanding of science concepts. An example of the application of this framework is shown in Table 2.

Table 1. Overview of 5-year middle school science literacy project

Y1 – Exploring the problem space	– Problem clarified and potential collaborations identified by school administrators, teachers, and Pacific CRYSTAL personnel – Professional development topics initiated by teachers – Researchers as observers and facilitators
Y2 and Y3 – Building a repertoire	– Responsibility for professional development topics shifted to Pacific CRYSTAL personnel – Approximately 25 different teachers attended 14 workshops – Demonstration lessons, frequent classroom presence by researchers
Y4 – Developing lead teachers	– 10 teacher advocates created a curriculum resource – Case studies of classroom implementation, adaptation and refinement of strategies
Y5 – Disseminating resources	– Instructional resource manual edited and published during summer months – Lead teachers provide workshops (two at each middle school) to 75 other teachers as part of the schools' professional development program

In order to gain a better understanding of the range of instructional activities that were supported by the new textbooks and curriculum, the Pacific CRYSTAL team catalogued the teaching suggestions from the new textbooks into the categories of the Working Framework for Explicit Literacy Instruction and linked some suggestions to specific examples in the National Geographic Science Theme Sets. This categorization revealed literacy areas where the texts included a variety of suggested activities as well as areas where few strategies were listed. Participating teachers were invited to use this overview of teaching suggestions along with their personal preferences to identify specific instructional strategies for subsequent workshops; for example, visual literacy strategies were the focus of several Y2 workshops. The selected strategies emphasized the nature of science—concept mapping, reading and creating labelled diagrams, and creating informational posters. Along with negotiating strategies to include in the Y2 workshops, teachers expressed a desire for support with assessing students' multimedia work and, in particular, for assessing informational posters (Anthony et al., 2010).

Table 2. Working framework for explicit literacy instruction in middle school science

Vocabulary/ concept development	*Reading comprehension strategies*	*Visual literacy*	*Science reading and writing genres*	*Oracy*
– Topic-specific concept words – Greek and Latin roots – Concept mapping	– Determining importance – Synthesizing – Visualizing – Making connections – Questioning – Inferring	– Labelled diagram – Labelled photograph – Cross-section – Flow diagram – Cutaway diagram – Graphs – Posters	– Information brochure – Posters and PowerPoints – Explanation – Cause-effect – Problem-solution – Encyclopaedia entry	– Argumentation – Small group discussion

Teachers from the third middle school joined the project in Y3, which required some review of Y2 workshops with these new participants. The professional development activities focused on multimedia representations and included writing-in-science genres, using reading strategies such as THIEVES (a prereading strategy that sets the purpose for reading using an easily remembered acronym in which students learn how to *steal* information from the **T**itle, **H**eadings, **I**ntroduction, **E**very first sentence, **V**isuals/Vocabulary, **E**nd-of-chapter questions, and **S**ummary before reading the entire text selection; Manz, 2002), constructing graphs, creating informational brochures, designing posters and PowerPoint® presentations, investigating the functions of visual representations (Carney & Levin, 2002), and developing rubrics for science assessment and strategy proficiency.

The initial goal of this project was to facilitate the shift of leadership from the Pacific CRYSTAL researchers to the participating teachers—a cascading leadership model. During Y4, participation in the workshops was limited to lead teachers willing to consider becoming professional development facilitators in Y5. The planning of Y4 workshop activities shifted to include grade-level working groups that purposefully embedded the literacy activities previously demonstrated at Y2 and Y3 workshops into authentic science units to be taught in their classrooms (three for Grades 6 and 7 and four for Grade 8, as prescribed by the provincial curricula).

There were also new instructional strategies included in Y4 workshops such as Foldables® (3-D graphic organizers that include both written and visual information; Zike, 2001) and formal argumentation (i.e., data, backings, warrants, evidence, claims, counterclaims, rebuttals). The sequence and focus of the professional development workshops that were offered throughout the project are shown in Appendix A. Of particular note is the summer institute between Y4 and Y5, where lead teachers met to prepare an instructional resource (Tippett et al., 2009) to be shared with all content area middle school teachers in the district through a series of teacher-led workshops in Y5.

Due to the collaborative nature of the project, the workshop agendas were regularly adjusted to reflect teachers' interests and students' perceived needs. The community-based design assured a balance between (a) the researchers' initial focus on science inquiry approaches, learning cycles, and specific literacy strategies and (b) the teachers' focus on selecting a repertoire of individual strategies that they perceived to be the most promising and practical within the constraints of their classrooms. As topics and strategies were selected for workshops, the participating teachers and Pacific CRYSTAL leaders reviewed and revised the summary of instructional strategies that were represented in the framework (Table 2) introduced in Y2 and updated throughout. This framework served as both a record of strategies that were available and a reminder of literacy areas that were not as fully represented. The orientation was to try to achieve balance across science literacy categories. The engineering design of the project (i.e., ongoing assessment of needs, designing solutions, evaluating and revising solutions) meant that the agenda and solutions reflected the real needs of students and generalist teachers and were constrained by the realities of classrooms, instructional schedules, and funding. Some priorities of the university participants (e.g., inquiry teaching approach, science-specific strategies, the learning cycle) were not enacted by the community, and other strategies (e.g., Foldables, PowerPoints) were embraced and implemented by the participating teachers.

Classroom observations and teacher interviews suggested that participating teachers were moving toward a literacy-infused science program (Tippett, Yore, & Anthony, 2008): As Teacher C said, *Not one of us has a science background, although many of us have literacy backgrounds, and as a result of this project we can use our expertise to enhance our science instruction*. Classroom observations and teachers' self-reports indicated that some literacy strategies presented at professional development workshops were appropriate for use in science (and other subject areas) and were adaptable for students with a range of learning needs at all middle school grade levels (6, 7, & 8). Focus group results indicated that the collaborative partnership between teachers and researchers had enriched and enhanced science instruction. One teacher reported, *It's mutually beneficial to students and teachers because we are able to collaboratively plan and share ideas to enhance our units.* (Van der Flier-Keller et al., 2010).

RESULTS

This project was evaluated by a series of reflections, teacher interviews, and case studies (Tippett, in progress). The reflections were conducted and reported as part of the ongoing annual evaluations of the Pacific CRYSTAL Project while the teacher interviews and case studies were part of the doctoral research of the first author.

Reflections on Professional Development

From its inception, this project has been conducted with deliberate emphasis on high levels of collaboration and facilitation among peers and research professionals.

This orientation not only accords with the personal orientation of the participants but also reflects the qualities that are cited as fundamental to effective professional development, particularly for science teachers (Cochran-Smith & Lytle, 1999; Hutchins, Arbaugh, Abell, Marra, & Lee, 2008; Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003). These features provide a backdrop from which to examine the qualities and challenges of professional development that were demonstrated in this project.

Loucks-Horsley et al. (2003) described five key features of professional development for science teachers; the first is *aligning and implementing curriculum.* This feature is exemplified at several places in the project. Early on, teachers had the opportunity to explore the instructional characteristics of the newly authorized curriculum and textbooks by aligning the texts with the working framework (Table 2). This descriptive framework, based on a theoretically sound model of science literacy and a successful instructional resource, situated the innovative strategies and other teaching supports provided through the workshops within a coherent and consistent frame of reference and articulated a structure for identifying areas for further development. Such an overarching framework served to avoid the sense of 'one-shot' workshops for those teachers who participated in some but not other workshops because the framework served to link the strategies that were presented and connect those strategies to the ultimate goal—enhanced science literacy. In addition to the demonstration of instructional strategies, teachers had the opportunity to meet together in grade-level groups to design new units aligned to the new curriculum that could replace units from the former curriculum.

Collaborative structures are a second feature of effective professional development identified by Loucks-Horsley et al. (2003). This feature is evident not only in the development and delivery of the school-based workshops but also in the logistical and financial collaboration. All workshops were held in district schools and during regular school hours. The significant cost of release time for participating teachers, which was not fundable by the Pacific CRYSTAL grant, could have been a major impediment. However, through the dedicated collaboration of all stakeholders, the project was able to proceed. For example, in the initial stages the school district and the district teachers' association provided funding. Such financial support reflects the high value that the school district, its administrators, and the teachers placed on the workshops. Additional funding for teacher release time was later provided by grants from the University of Victoria Vice-President Research, the Dean of the Faculty of Education, and CER-Net (the Constructivist Education Resources Network is a fund created by private donors to support research through the Faculty of Education).

Participating teachers demonstrated an especially high commitment to this collaborative project. Their commitment was demonstrated as they facilitated a plan to share a single Teacher-on-Call (TOC) to allow two teachers to attend workshops. This was accomplished by offering each workshop in two sessions, one overlapping the lunch hour and the other extending the normal workday. Through this arrangement, one participant would attend the first session and another the second session, and they would share a single TOC thereby substantially reducing the cost of teacher release time. Teacher commitment to the project extended to travel arrangements; there are considerable distances between the three middle schools. Teachers volunteered to share the travel time and cost in order to participate in the project. This commitment and collaboration was in part due to the teachers' belief in the value and authenticity of the professional learning provided; that is, planning and developing instructional units and assessments for science would be good for their students and good for them. They viewed the Pacific CRYSTAL researchers as having both theoretical and practical expertise with extensive research and school experience. The classroom teachers and university researchers saw the first author as 'one of their own' as she was a member of both the practicing teacher and academic communities, which greatly facilitated the collaborative nature of the project.

The project afforded teachers time to inquire about their practice by allowing them to be removed from their classroom's daily demands for brief, but repeated and connected, opportunities to reflect on the third attribute of effective professional development: *articulate the tacit knowledge embedded in their experiences* (Loucks-Horsley et al., 2003). The format of the workshops included reporting back on classroom experiences with strategies that had been introduced; this often included reports of variations and innovations devised by the teachers along with examples of student work to document and illustrate assessment potentials. This context allowed teachers to integrate content and pedagogical knowledge about the target science concepts and literacy strategies into pedagogical content knowledge about disciplinary literacy in science. In addition, the Y4 workshops included working sessions by grade-level teams that developed exemplary teaching units. Although each team included a Pacific CRYSTAL researcher, the discussion and decisions about content were collegial and devoid of an expert/acolyte distinction. One might speculate that after 3 years of interaction any deference to the authority of the researchers or acquiescence resulting from perceived power differential in this collaboration had dissipated.

The fourth feature identified by Loucks-Horsley et al. (2003) is *teaching experience*. This project featured guided teaching experience through teaching simulations, modelling, and demonstration lessons in the context of the workshops and middle school classrooms. Teachers actively adapted and expanded the strategies that had been modelled at the workshops in their classrooms. Uncertainties arising after the workshops were addressed by invitations to the project staff to conduct demonstration lessons in one of the participating teachers' classrooms. These teaching experiences and the innovations vastly expanded the power and potential of the workshop strategies. For example, teacher participants had been using visual representations in their classrooms, primarily in the form of posters, but expressed interest in developing better assessment procedures for these visual displays. The project team responded by developing a draft assessment rubric and a PowerPoint slide set for classroom use to demonstrate the qualities of the criteria featured in the rubric. These assessment ideas were demonstrated at a subsequent workshop and, through discussion, improvements to the rubric and slide set were suggested. From this point, the participating teachers experimented with the criteria of the rubric with other visual representations in the context of a variety of subject areas. Teachers reported back examples of new assessment rubrics, such as a PowerPoint criteria, and expansion of poster representations by embedding mixed-media Foldables (another workshop topic) and, most diverse of all, informational brochures (Tippett et al., 2008). Key to these extensions of the initial workshop demonstrations was the classroom experimentation and innovation by participating teachers that empowered participants to adapt, and not just simply adopt, these robust strategies.

Loucks-Horsley et al. (2003) identified *a legacy of professional development materials and mechanisms* as the fifth essential characteristic. The print and digital materials that were produced for the workshops will have a persistent presence in the district. In addition, Science Theme Sets (National Geographic, 2008) were purchased for each participating school. These sets provided examples of opportunities for embedding explicit literacy activities into existing science programs and were used extensively as model material in workshops. It is anticipated that the *Handbook* (Tippett et al., 2009) that emerged from the grade-level lesson writing teams in Y4 and the lead-teacher writing team in Y5 will serve as the most prominent material—not only for the close connection between these materials and the curriculum in the classroom but also as a demonstration of the practical potential for close collaboration between university researchers and teachers in the field.

In summary, this community-based research and development project was envisioned as an engineering project, rather than a research inquiry, where all participants shared the responsibility for identifying problems, creating and verifying solutions, and disseminating evidence-based practices. The structure, responsibility, and agenda of the project needed to be dynamic and responsive, reacting quickly to constraints, feedback, successes, and challenges—much like a recursive engineering design. The initial expectation that teachers in the field and university resource personnel would participate as full and equal partners throughout the project was reconsidered and revised as it progressed and when participating teachers requested the university partners to take greater responsibility for suggesting and directing the workshop agendas. However in the final years, lead teachers were in the forefront of directing the development of the resource handbook and offering workshops to colleagues. The researchers did not consider imposing any particular structure onto the professional development workshops that dominated this project. Rather, the choice was to consult and, most importantly, to collaborate to ensure that the expertise, experience, and expectations of teachers and researchers would maximize the potential benefit for middle school students to achieve higher levels of science literacy. It is only in hindsight that we are able to reflect on the five characteristics of effective professional development for science teachers outlined by Loucks-Horsley et al. (2003). In doing so, we are encouraged but not surprised to realize that the features of professional development that emerged from this collaborative process exemplify these optimal features.

Teacher Interviews and Case Studies

Classroom observations and teacher interviews suggest that participating teachers did believe that they were better able to identify opportunities and strategies for infusing science literacy activities into their classroom science program (Tippett et al., 2008). Classroom observations from individual case studies and teachers' self-reports revealed that a number of teachers were making use of science literacy strategies presented at the workshops in other curricular areas. Although the focus of this project was squarely on literacy in science, there are indications that the outcomes included enrichment in other unanticipated parts of the curriculum (Van der Flier-Keller et al., 2010).

Lead teachers arose as advocates for the value of participating in their schools. These teachers, who often had more experience with a particular grade or topic or who had more confidence in their ability to teach science, became increasingly involved in the project and in Y5 directed the professional development activities. In Y2, Y3 and Y4, lead teachers acted as mentors by providing encouragement and day-to-day support for colleagues who were beginning to implement science literacy strategies. Through demonstration lessons conducted by the researchers at the workshops and in participating teachers' classrooms, the university partners were able to contribute to the implementation of science literacy strategies (e.g., concept mapping, creating informational brochures) and support teacher-initiated innovations (e.g., Foldables, CSI Chemistry, science fair projects). This in-class professional development allowed teachers to observe specific literacy, knowledge construction, and metacognitive strategies while assessing classroom management needs. Researchers team-taught in classrooms to provide scaffolding for teachers attempting to implement unfamiliar instructional approaches. In addition, researchers developed teaching resources such as PowerPoint presentations for classroom use (e.g., how to create informational posters).

At each workshop, teachers were invited to report on their experiences trying out the strategies that had been suggested and to share samples of student work. During the Y5 summer writing workshop, a small survey of lead teachers was conducted (Appendix B). A summary of the responses is reported in Table 3. The limited sample size cannot be taken as representative of all participants, but it does point to some factors that influenced the substantial variation in the uptake of particular strategies. Some strategies were tried repeatedly while others were hardly attempted at all. It is not possible to identify what contributed to this. It might be assumed that strategies regarded as more effective would have been tried more often, but this is not consistently the case. For example, the ABCDarium is little used but regarded as highly effective, while labelled diagrams were used quite often and yet not regarded as highly effective.

The culminating contribution of this project was the creation of the *Handbook of Strategies for Developing Literacy across the Curriculum* (Tippett et al., 2009). Each teacher who participated in the summer workshop that resulted in the creation of this resource had an opportunity to implement, reflect on, and revise a number of literacy strategies that had been presented during the then 4 years of the project. During the summer writing workshop, the teachers discussed the benefits and challenges of those strategies that a majority of them rated as high in effectiveness. The group also considered the cross-curricular applicability of each strategy because strategies selected for demonstration in the workshops were chosen for their relevance

Table 3. Summary of strategy uptake

Strategy	*n*[a]	*Avg. no. times used*[b]	*Rank (usage)*[c]	*Avg. effectiveness*[d]	*Rank (effectiveness)*
THIEVES	6	3.83	1.5	2.50	2
Concept maps	6	1.83	5.0	1.67	8
Argumentation	5	1.50	6.5	2.00	5
Foldables®	6	3.83	1.5	2.17	4
Brochures or posters	6	1.50	6.5	n/a	
Brochures	4	0.67		1.75	7
Posters	5	0.83		2.50	2
Vocabulary	6	2.33	4.0	n/a	
Foldables	4	1.33	7.5	2.50	2
Interpretation	3	0.50		2.33	3
ABCDarium	2	0.33		3.00	1
Other	6	1.33	7.5		
Labelled diagrams	6	3.17	3.0	1.80	6

[a] Total number of teachers surveyed = 6; *n* = number who reported using a particular strategy.
[b] Number of times used = 0 to 5; average calculated by dividing total times used by 6.
[c] Ties indicated by an intermediate rank (i.e., a tie for 1 is indicated as 1.5 for each).
[d] Effectiveness = low (1.0), average (2.0), or high (3.0); average calculated by dividing the sum of effectiveness ratings by the number rating the strategy.

to science education. Additional considerations included school and district goals, ease of implementation, and the teachers' estimates of the probable effectiveness of the strategy for increasing science literacy for all students. Identifying the six strategies or techniques that were included in the resource *Handbook* turned out to be less contentious than anticipated. Teachers had a very high level of agreement about including a particular strategy or not. There were no instances of a significant divergence of opinion.

The teaching strategies agreed upon were: THIEVES (Manz, 2002), vocabulary acquisition, Foldables (Zike, 2001), argumentation, informational brochures and posters, and concept mapping. These strategies are generic and can likely be applied with slight modification in language arts, mathematics, and social studies (Shanahan & Shanahan, 2008). The *Handbook* was composed of three parts:

– *Part 1*: A guide containing descriptions, rationales, key features/functions, connections to science goals, ideas for implementations, cross-curricular connections, interactive whiteboard connections, ideas for assessment, student samples, related articles, blackline masters, and references for each of the six strategies.
– *Part 2*: Sample instructional frameworks for Grades 6, 7, and 8 science units that illustrate some ways in which these literacy strategies could be incorporated along with other science activities to meet the Prescribed Learning Outcomes

contained in the *Science K to 7: Integrated Resource Package* (MoE, 2005) and *Science 8: Integrated Resource Package* (MoE, 2006).

– *Part 3*: A CD containing Parts 1 and 2 in electronic form, along with full-colour examples of student samples. The CD also included articles about the strategies and the PowerPoint slide sets that had been developed for classroom use. All blackline masters included on the CD were formatted so that they could be adapted to suit particular activities and/or students or used with technology such as interactive whiteboards.

Challenges Facing Community-based Professional Development

The teacher participants in this project demonstrated powerful commitment to engaging in the enhancement of their science teaching classroom practices. The effectiveness of the outcomes attests to the level of commitment. The experiences of this project revealed some features that critically influence such community-based professional development. Previous studies of best practices for teacher professional development are quite clear that there needs to be time set aside for teachers to devote their attention to reflecting on their own practice and setting goals for changing practices (Cochran-Smith & Lytle, 1999; Hutchins et al., 2008; Loucks-Horsley et al., 2003).

In the face of such a well-attested characteristic of effective teacher development, there was no point in undertaking a project that did not include plans for teacher release time in order to focus intently on personal practices. Unfortunately, the conditions on expenditures from the national funding agency (Natural Sciences and Engineering Research Council, Canada) for Pacific CRYSTAL did not permit paying for teacher release time. Thus, from its inception, this project was burdened with the logistical task of securing resources to provide this essential release time. There was great enthusiasm for the project from teachers and administration in the school district, and our partners (University of Victoria, CER-Net, and local teachers association) were willing to transform this personal support into several contributions of resources for release time. The scramble for release time occupied the project team in each of the 5 years of the project. Through the contributions of many partners combined with more than a little 'good luck,' the necessary release time was financed and the prospects for successful outcomes of the project greatly enhanced. Nonetheless, the uncertainty about funded release time was an encumbrance on long-term planning as well as project presentation.

The reporting back by teachers at each workshop, along with classroom observations and survey results, demonstrated that the material selected for presentation had influenced classroom practice. Each strategy selected for inclusion in the workshops was identified through consultation with participants about their perceived needs and in relation to curricular goals and available published research about the strategy's effectiveness. Some strategies, such as informational brochures, were widely taken up and further developed by a large proportion of participants. Other strategies, such as concept mapping, were less extensively adopted. The factors that contribute to the uptake of some strategies but not others remain unclear.

CLOSING REMARKS

As this project reached its end, it was tempting to speculate on its legacy. There are a number of material contributions that will remain: the print and digital resource materials that were distributed and modelled at each of the workshops and especially the *Handbook* (Tippett et al., 2009). The personnel legacy is more difficult to predict. It was heartening to see the emergence of a team of lead teachers from each school. The project afforded these teachers a context in which to interact and to develop and express their leadership. The lead teachers took an increasingly prominent role as the project progressed. In the final year, the production of the resource handbook and the presentation of the school-wide workshops were primarily in the hands of the lead teachers. After the presentation of the highly successful workshops offered at each participating school, but open to all teachers in the district, there was an invitation to the lead teachers to present at a multidistrict professional conference. On this occasion, none of the lead teachers accepted the invitation and it fell to a university team member to conduct the sessions. There is some uncertainty as to whether the cascading leadership model actually worked as intended and if the lead teachers will continue their advocacy role beyond the framework that was provided by the Explicit Literacy Instruction Embedded in Middle School Science Classrooms project.

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APPENDIX A

The Sequence and Focus of Professional Development Activities

Session	Focus	Activity	Intended outcomes
Year 1 (2005–2006): Exploring the Problem Space			
Workshop 1	Information	The literacy component of science literacy	Generate interest in the project and recruit participants
Workshop 2	Information	Language as a cognitive tool	Develop understanding of theories of language and reading
Workshop 3	Information	Feedback on the process and workshops	Project planning and prepare of an agenda for Year 2
Year 2 (2006–2007): Building a Repertoire			
Workshop 4	Information	Project review	Establish procedures for quantitative data collection Set goals for upcoming workshops
Workshop 5	Information	Identify literacy foci in textbooks	Generate a list of science literacy strategies to be explored in upcoming workshops
Workshop 6	Vocabulary/ concepts	Concept mapping	Use concept maps to assess pre- and postunit understanding of science concepts
Workshop 7	Information (district wide)	*Learning Odyssey* PowerPoint presentation	Develop understanding of the interaction of fundamental and derived science literacy
Workshop 8	Visual literacy	Emphasize visual representations	Read and create labelled photographs and flow diagrams
Workshop 9	Visual literacy Genre writing	Create posters and PowerPoint presentations	Develop alternative methods to assess understanding of science concepts
Year 3 (2007–2008): Building a Repertoire			
Workshop 10	Genre writing	Guided inquiry with pillbugs	Use inquiry as a springboard into writing a variety of science genres: argument, description, instructions, and explanation
Workshop 11	Reading comprehension Genre writing	THIEVES Informational brochures	Use a prereading strategy to improve comprehension Integrate visual and print elements Develop confidence implementing a common science genre

Workshop 12	Visual literacy	Functions of visual elements	Identify functions of visual elements Use functions to create visuals that enhance understanding
Workshop 13	Visual literacy	Assessment of visual elements	Establish criteria and develop rubrics for diagrams, tables, graphs, etc.
Workshop 14	Genre writing	Unification of rubrics for informational genres	Establish a framework for assessing a range of multimodal informational genres (e.g., posters, PowerPoint presentations, brochures)
Year 4 (2008–2009): Developing Lead Teachers			
Workshop 15	Vocabulary/ concepts Visual literacy Reading comprehension	Foldables	Introduce a teaching strategy (using Foldables) that uses visual and written information Incorporate Foldables into unit planning
Workshop 16	Oracy	Argumentation (I)	Develop understanding of the aspects of argumentation
Workshop 17	Oracy	Argumentation (II)	Incorporate argumentation into mandated units
Workshop 18	Vocabulary acquisition Genre writing	Sharing of strategies Mystery powders	Establish a repertoire of vocabulary-acquisition strategies Identify aspects of laboratory reports
Year 5 (2009–2010): Developing and Disseminating Resources			
Summer Planning Sessions	Literacy strategies with cross-curricular utility	Create a resource for district-wide dissemination	Select strategies and determine format of presentation Finish purposeful embedding of strategies in science units
Presentation Day 1	School A School B School C	THIEVES Vocabulary acquisition Foldables	Present three literacy strategies in an interactive school-based workshop for content area teachers
Presentation Day 2	School A School B School C	Argumentation Informational brochures and posters Concept mapping	Present three literacy strategies in an interactive school-based workshop for content area teachers
District-wide K–12 Conference		Foldables Informational brochures and posters THIEVES Argumentation	Present literacy strategies to a wider audience (more schools and extended grade range)

APPENDIX B

Strategy Implementation Survey

Pacific CRYSTAL Literacy Strategies in Middle School Science
Strategy Implementation Survey (2008-2009)

Name: ______________________ School/Grade: ______________________

Class Description: ____

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Literacy Strategy	Number of times used	Effectiveness	Comments and Suggestions
THIEVES	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Concept Maps	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Argumentation	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Foldables	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Brochures	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Posters	0 – 1 – 2 – 3 – 4 – 5	low – average – high	

Literacy Strategy	Number of times used	Effectiveness	Comments and Suggestions
Vocab: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Vocab: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Vocab: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Labelled Diagrams	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Cross-sections	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Flow charts	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Other: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Other: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	
Other: _________	0 – 1 – 2 – 3 – 4 – 5	low – average – high	