Does Contributing to a Knowledge Building Dialogue Lead to Individual Advancement of Knowledge?

Maria Chuy, Institute for Knowledge Innovation and Technology, OISE/University of Toronto, 252 Bloor Street West, Toronto, ON M5S 1V6, Canada, maria.chuy@gmail.com
Jianwei Zhang, University at Albany, 1400 Washington Ave, Albany, NY 12222, USA, jzhang1@albany.edu
Monica Resendes, Marlene Scardamalia, Carl Bereiter, Institute for Knowledge Innovation and Technology, OISE/University of Toronto, 252 Bloor Street West, Toronto, ON M5S 1V6, Canada, monicaresendes@gmail.com, marlene.scardamalia@utoronto.ca, carl.bereiter@gmail.com

Abstract: The goal of this research is to examine the extent to which contributing to a Knowledge Building online dialogue can predict individual advancement of knowledge for Grade 4 students. Based on the procedures of grounded theory (Glaser & Strauss, 1967), we examined notes that grade 4 students entered into an online discourse environment (Knowledge Forum) and developed the following empirically grounded list of contributor roles: asking thought-provoking questions, theorizing, experimenting, working with evidence, creating syntheses and analogies, and supporting discussion. Regression analysis was performed to examine whether any of these roles can predict various measures of individual knowledge advancement. The analysis revealed two significant predictors: theorizing and working with evidence. Theorizing accounts for variation in scientificness of students' ideas as well as knowledge test scores; working with evidence predicts epistemic complexity of students' portfolios. These results inform next steps in creating classroom interventions and technology tools for collaborative knowledge creation.

Introduction

Knowledge creation and innovation have risen to high prominence in the economic sphere (David & Foray, 2003) and for societal problem solving (Homer-Dixon, 2006). From this perspective, capacity for knowledge creation represents a major challenge for education (Bereiter & Scardamalia, 2006; Carnevale & Desrochers, 2003: Scardamalia & Bereiter, 2007). Among educational approaches that can claim special relevance in this respect (e.g., project- and problem-based learning, "21st Century Skills" programs), "Knowledge Building" stands out as most directly addressing the need for knowledge-creating talent. Defined as the deliberate creation and improvement of knowledge that has value for a community (Scardamalia & Bereiter, 2003), Knowledge Building is synonymous with knowledge creation. Individual knowledge workers, often in teams, make diverse contributions to the collective knowledge in a domain through efforts that preserve and elaborate the current paradigm, make incremental moves in existing directions, or redirect the field into a new direction or paradigm (Sternberg, 2003). Thus, Knowledge Building challenges students to be not only learners but active contributors to group efforts to produce epistemic artifacts—explanations, problem formulations, proofs, experimental methods, "state of the art" reviews, and the like. These epistemic artifacts are collectively improved through a wide variety of individual student contributions, ranging from drawing useful diagrams to suggesting pertinent analogies and theories. Being complimentary, these contributions form a highly interactive "self-organizing" system (Resnick, 1996), moving knowledge-creating dialogue forward without central authority. Both parts symmetrically benefit from this interaction: the community, as a whole, and individual contributors. However, individual benefits might fluctuate, depending on the degree of the individual's participation and his/her contributor roles in the community's dialogue. That is the focus of the present research—examining the extent to which contributing to a Knowledge Building online dialogue can predict individual advancement of knowledge in elementary school students.

A number of collaborative knowledge creating approaches make use of assigned roles. Edward de Bono (1985) distinguishes six different thinking strategies symbolized by six colored hats: a black hat is associated with critical thinking, a green hat with idea generation, a white hat with providing information and facts, etc. Leng, Lai, and Law (2008) elaborated a taxonomy of ways of contributing on the basis of levels of cognitive complexity. Hogan (1999), observing student interactions in science discourse, identified eight naturally occurring roles similar to de Bono's "six hats:" promoter of reflection, contributor of content, creative model builder, mediator of group interactions and ideas, etc. The current research aims to develop an empirically grounded list of contributor roles of a finer grain than the above, and to examine the extent to which these roles can predict individual knowledge gain in the context of Knowledge Building. Thus, analyses focus on: (a) creating a systematic inventory of contributor roles, based on analysis of student online discussions; (b) identifying measures of individual knowledge advancement; and (c) studying the relationships between these two components.

Method

Knowledge Building Environment

In order to answer the research questions, we selected an elementary school site— Dr. Eric Jackman Institute of Child Study of the University of Toronto—where "Knowledge Building discourse" supported by Knowledge Forum technology (Scardamalia & Bereiter, 2003) is integral to the day-to-day work of the class. Students reference, evaluate, build on, and work to continually improve ideas—their own and those of community members. The quality of Knowledge Building discourse is increased through giving students greater collective responsibility for advancing ideas (Zhang, Scardamalia, Lamon, Messina and Reeve, 2007). Mirroring and extending their face-to-face discussions, students work in an online environment—Knowledge Forum (Scardamalia, 2002)—that provides a community space for collaborative work with ideas, the stored record of which constitutes data for the present research. Of particular relevance to this research are the following characteristics of Knowledge Forum: (a) "build-on," reference, linking, and annotation features that support interaction; (b) views that support graphical as well as textual literacy; (c) "rise-above" notes that facilitate the creation of higher-order knowledge structures; and (d) "scaffolds" (*i.e.* "My theory", "I need to understand", "New information") that make it easy for users and researchers to identify and tag contributor roles. These features enable research of a depth not possible with typical discourse environments, yet findings will be applicable to efforts to improve discourse in other on-line and face-to-face environments.

This study focuses on a Grade 4 inquiry of optics supported by Knowledge Forum. Both the teacher and students had multiple years of experience with Knowledge Building pedagogy and technology, so the situation represents what Fischer and Bidell (1997) call "optimal conditions" for identifying cognitive developmental goals. The study uses the same dataset as examined by Zhang et al. (2007), but focuses on individual ways of contributing to the collective discourse, to complement group-level variables. It explores students' patterns of contribution and examines how these patterns enhance (or impede) advancement of individual knowledge.

Participants and Dataset

The participants were 22 Grade 4 students (11 girls and 11 boys) and their teacher from the Dr. Eric Jackman Institute of Child Study, University of Toronto. The teacher has been committed to Knowledge Building and used Knowledge Forum for the previous two years. He worked collaboratively with students to identify problems of understanding and to discuss diverse ideas and theories through class face-to-face discourse. During the lessons, students were encouraged to conduct self-generated experiments, to search libraries as well as the Internet for interesting facts and to share new resources through cooperative reading. In parallel to these offline activities, students recorded their ideas, theories and findings in the Knowledge Forum database. This shared database helped students to keep their top-level questions in sight, while refining and improving newly generated theories. On a daily basis students were free to explore any problem related to the topic in question, and to contribute to the database.

The dataset analyzed below covers four months of online discourse on optics, including topics such as "How light travels," "Colors of light," "Natural and artificial light," "Shadows" and so forth (see Zhang et al., 2007 for details of the inquiry processes). A total of 318 notes have been analyzed in this study: 70% of all notes were students' personal notes (written by individual students), 20% were group notes (written by small groups of 2-5 students) and 6% were teacher's notes. This analysis examined only personal notes.

Analysis

Ways of Contributing List

On the basis of informal observation and the knowledge creation literature, a provisional list of contribution types was first created. This list was used to inform and guide our analysis of student online discourse that followed a grounded theory approach (Glaser & Strauss, 1967), with the categories elaborated, refined, then modified, and extended. Table 1 displays six major categories identified through the above process, consisting of 20 sub-categories in total.

Table 1: Ways of Contributing to Knowledge Building Dialogues.

Main category	Sub-category	Description of the category
Formulating thought-provoking questions	Formulating an explanatory question	Questions asking "why does it happen" and "how does it work"?
	Asking a design question	Questions asking "how can we prove/ test something?"

	Asking a factual question	Questions asking "what", "who" and "when"?
Theorizing	Proposing an explanation	Student proposes a theory that explains certain phenomena for the first time
	Supporting an explanation	Student supports an already existing theory (i.e. theory that has been proposed by another student) and provides a justification
	Improving an explanation	Student improves an already existing theory through elaborating, specifying details and using new evidence
	Seeking an alternative explanation	Student looks for a different explanation
Designing an experiment	Proposing/describing an experiment	Student proposes/describes an experiment to test an idea
	Identifying a design problem	Student describes an experiment that did not work, and identifies possible causes why it did not work
	Thinking of design improvements	Student tries to fix design problems and proposes a new/improved experiment
Working with evidence	Looking for evidence	Student asks or looks for evidence to support a particular idea
	Providing evidence or a reference to support an idea	Student provides evidence that comes either from his own experience or from authoritative sources to support a particular idea
	Providing evidence or reference to challenge or falsify an idea	Student provides evidence that comes either from his own experience or from authoritative sources to challenge or falsify a particular idea
	Finding new facts	Student brings up new interesting facts that do not support or reject a previous idea, but extend it
Creating syntheses and analogies	Synthesizing available ideas	Student synthesizes available ideas to create a better understanding of some phenomenon
	Creating analogies	Student moves to a higher level of understanding by creating an analogy to explain a particular phenomenon.
	Initiating a rise-above	Student summarizes previous ideas by integrating multiple notes into a rise-above note.
Supporting discussion	Using diagrams to communicate ideas	Student draws diagrams to communicate or support ideas.
	Giving an opinion	Student gives an opinion, but no explanation or justification
	Acting as a mediator	Student supports discussion by focusing on social roles rather than ideas.

Three independent raters used these categories to code the notes. When the same note fell into more than one contribution type, all related categories were counted. For example, if in the same note a student asked the question (e.g. "How light travels?"), proposed a theory to answer this question (e.g. "My theory is that light travels in a straight line") and included a diagram to make this theory visual, then three contribution types were counted: formulating an explanatory question, proposing an explanation, and using diagrams to communicate or support ideas. The three raters agreed in 80% of the coding. The remaining 20% were discussed to achieve consensus. Finally, in order to examine individual contributor patterns, the total number of contributions made by any individual student was calculated for each major category and sub-category.

Measures of Individual Knowledge Advancement

Individual knowledge advancement was assessed through content analysis (Chi, 1997) of student personal portfolio notes and a teacher-designed test. Each student wrote a portfolio note at the end of the optics inquiry to summarize what he/she had learned about light. Each portfolio note was divided into idea units, which were analyzed focusing on the scientific and epistemic levels of student ideas (see Zhang et al., 2007 for details).

Scientificness of student ideas was assessed using a four-point scale: 1–pre-scientific (containing a misconception while applying a naive conceptual framework), 2–hybrid (containing misconceptions that have incorporated scientific information), 3–basically scientific (containing ideas based on a scientific framework, but not precise) or 4–scientific (containing explanations that are consistent with scientific knowledge). This coding scheme was developed on the basis of Galili and Hazan's (2000) facets'-scheme framework for analyzing student optical knowledge.

Epistemic complexity of ideas was assessed using a rating scale with the following levels: 1–Unelaborated facts (containing simple description of terms, phenomena or experiences without elaboration); 2–Elaborated facts (containing elaborated description of terms, phenomena or experiences); 3–Unelaborated explanations (containing reasons, relationships or mechanisms without elaboration); 4–Elaborated explanations (containing elaborated versions of reasons, relationships, or mechanisms). To assess inter-rater reliability, two coders independently coded 12 portfolio notes: *Cohen's Kappa* = .83 for scientific sophistication and .75 for epistemic complexity (see Zhang & Messina, 2010 for details).

Teacher-designed test. The test was composed of 18 questions and administered at the end of the unit. It covered 10 of the 28 themes addressed in online discussions (e.g. shadows, rainbows.), with a full score of 54.

Results and Discussion

Distribution of Contributor Roles

Table 2 reports the frequency and percentage of each way of contributing identified from the student-generated optical discourse, including major and sub-category. Diverse ways of contributing were evident, connecting to and supporting one another for sustained, deepening discourse. The most frequent contribution types were those related to theorizing and working with evidence.

Table 2: Frequency of Occurrence and Percentages of Contribution Types (Means and Standard Deviations)

Major category	N		%		**Sub-category SD**	N		%	
	M	*SD*	*M*	*SD*		*M*	*SD*	*M*	*SD*
Formulating questions	**3.73**	**2.66**	**17.89**	**8.14**	Explanatory questions	2.05	2.19	8.77	7.76
					Design questions	.14	.35	0.81	2.09
					Factual questions	1.55	1.14	8.31	7.11
Theorizing	**6.09**	**3.05**	**30.66**	**8.07**	Proposing an explanation	1.45	1.30	6.98	5.51
					Supporting an explanation	2.18	1.40	11.56	7.15
					Improving an explanation	1.55	1.74	7.25	6.63
					Seeking an alternative explanation	.91	1.15	4.86	5.95
Designing an experiment	1.05	1.00	5.27	5.06	Proposing/describing an experiment	.68	.78	3.42	4.00
					Identifying a design problem	.32	.57	1.76	3.15
					Thinking of design improvements	.05	.21	0.09	0.44
Working with evidence	**4.86**	**3.93**	**21.34**	**10.46**	Asking or looking for evidence	.23	.53	0.95	2.51
					Providing an evidence or reference to support a particular idea	1.55	1.41	7.13	5.33
					Providing an evidence or reference to challenge or falsify a particular idea	.55	.67	2.86	4.04
					Finding new facts	2.55	2.67	10.40	8.74
Creating syntheses and analogies	**1.18**	**1.30**	**5.74**	**6.19**	Synthesizing available ideas	.68	.78	3.38	3.60
					Creating analogies	.32	.57	1.35	2.55
					Initiating a rise-above entry	.18	.50	1.01	2.70
Supporting **discussion**	3.64	2.61	19.10	13.15	Using diagrams to communicate or support ideas	2.64	2.22	13.96	10.02
					Giving an opinion	.73	.88	3.93	5.59
					Acting as a mediator	.27	.55	1.21	2.49

Regression Analysis

Multiple linear regression analyses were performed to predict scientificness, epistemic complexity of ideas, and test scores from different contributor roles. Considering low occurrences observed for certain sub-categories, only major categories were used as candidate predictors, notably: questioning, theorizing, experimenting, working with evidence, creating syntheses and analogies, and supporting discussion.

Scientificness of Ideas

The overall regression, including 1 of the 5 candidate predictors, was statistically significant $R = .43$, $R^2 = .19$, adjusted $R^2 = .15$, $F(1, 20) = 4.57$, $p < .05$ (using a stepwise method). As indicated in Table 3, *working with evidence* accounted for about 19% of the variation in idea scientificness. The other five predictors did not enter the equation, failing to add to prediction based on scientificness alone.

Table 3: Results of Statistical Multiple Regression (Stepwise) to Predict Idea Scientificness from Six Major Contributor Roles (N = 22)

	Zero-Order r		*b*	β	sr^2
	Scientificness	Working with Evidence			incremental
Working with evidence	.43*		.06*	.43	.186
Questioning	.19	.57**	—	—	—
Theorizing	.32	.77***	—	—	—
Experimenting	.19	.27	—	—	—
Creating syntheses and analogies	.13	.44*	—	—	—
Supporting discussion	.23	.19	—	—	—
			Intercept = 2.21***		
Mean	2.50	4.86			
SD	.54	3.93			

Analysis of results showed that *working with evidence* during Knowledge Building dialogue was a significant predictor of scientificness of individual ideas. More precisely, students who were actively searching authoritative sources, bringing new facts to discussions and using these facts to support or falsify ideas were able to increase scientificness of their own understanding. Thus, searching and processing the information for the community had a beneficial effect on individual knowledge.

Epistemic Complexity of Ideas

Multiple linear regression analysis was performed to predict epistemic level of ideas in portfolios from six major contributor roles. The overall regression, including 1 of the 5 candidate predictors, was statistically significant $R = .61$, $R^2 = .37$, adjusted $R^2 = .34$, $F(1, 20) = 11.76$, $p < .01$ (using stepwise method). As shown in Table 4, *theorizing* accounted for about 37% of the variation in the epistemic level of ideas. The other five predictors did not enter the equation, failing to add to prediction based on *theorizing* alone (even though most of these predictors had a significant zero-order correlation with it).

Table 4: Results of Statistical (Method = Stepwise) Multiple Regression to Predict Epistemic Complexity of Ideas from Six Major Contributor Roles (N = 22)

	Zero-Order r		*b*	β	sr^2
	Epistemic Complexity	Theorizing			incremental
Theorizing	.61***		.05**	.61	.370
Questioning	.50**	.71***	—	—	—
Experimenting	.30*	.33	—	—	—
Working with evidence	.40*	.77***	—	—	—
Creating syntheses and analogies	.33	.39*	—	—	—
Supporting discussion	-.06	.10	—	—	—
			Intercept = 1.72***		
Mean	2.05	6.09			
SD	.27	3.05			

Analysis of results indicated several positive correlations between epistemic complexity of ideas in portfolios and major contributor roles played by participants during Knowledge Building discussions, i.e. theorizing, questioning, experimenting and working with evidence. However, only *theorizing* proved to be a significant predictor of epistemic complexity. More precisely, being dedicated to creating, supporting and improving explanations in a community context helped students to increase the epistemic complexity of their own ideas: portfolios of such “theorizers” contained elaborated reasons, relationships or mechanisms, instead of merely isolated facts.

Knowledge Test Scores

Multiple linear regression analysis was performed to predict knowledge test scores. The total *N* for this sample was 20; two cases were dropped due to missing data on at least one variable, and therefore for this analysis $N = 20$. The overall regression, including 1 of the 5 candidate predictors, was statistically significant $R = .51$, $R^2 = .26$, adjusted $R^2 = .22$, $F(1, 18) = 6.33$, $p < .05$ (using stepwise method). *Working with evidence* was the only significant predictor, explaining approximately 26% of the variance in the knowledge test scores (see Table 5 for details). Other five factors were not significantly predictive of the scores (even though there was a significant zero-order correlation for *theorizing*).

Table 5: Results of Statistical (Stepwise) Multiple Regression to Predict Knowledge Test Scores from Six Major Contributor Roles (N = 20)

	Zero-Order r		*b*	β	sr^2 incremental
	Post-Test Score	Working with Evidence			
Working with evidence	.51**		.49*	.51	.260
Questioning	.33	.53**	—	—	—
Theorizing	.39*	.72***	—	—	—
Experimenting	-.09	.19	—	—	—
Creating syntheses and analogies	.17	.31	—	—	—
Supporting discussion	-.12	.17	—	—	—
			Intercept = 40.96***		
Mean	43.25	4.86			
SD	3.65	3.93			

Correlation analysis indicated that there was a relationship between knowledge test scores and two major contributor roles: *theorizing* and *working with evidence.* Both roles were positively associated with content knowledge, but only the second one was significantly predictive of this knowledge. More particularly, active search of information in authoritative sources and exposure of this information to the community in order to support or falsify existing explanations helped students to increase their own content knowledge.

Conclusion

The goal of this study was to examine the extent to which contributing to a Knowledge Building online dialogue can predict individual advancement of knowledge in elementary school students. Toward this end, a systematic inventory of contributor roles was created including six major ways of contributing: questioning, theorizing, experimenting, working with evidence, creating syntheses and analogies, and supporting discussion. These roles were entered as candidate predictors of three individual knowledge measures: scientificness, epistemic complexity of ideas in portfolios and knowledge test scores. Analysis of results revealed two significant predictors: *working with evidence* and *theorizing*. The first one proved to significantly account for scientificness of ideas in student portfolios and knowledge test scores. Active use of empirical evidence and information from authoritative sources to support and develop ideas in community discourse led to high scores in both individual knowledge measures. The second predictor, *theorizing*, explained significant amount of variation in epistemic complexity of ideas in students’ portfolios. More precisely, active generation, support and improvement of explanations during Knowledge Building discourse predicted high epistemic complexity of student understanding. Developing deeper explanations and examining them in light of information and knowledge from the larger field and collected evidence represent major ways of contributing to knowledge advancement in real world knowledge-creating communities (Bereiter, 2002; Sternberg, 2003). The present study confirmed the importance of fostering such contributions among students in order for them to work as productive Knowledge Building communities. Complimentary qualitative analysis of these ways of contributing is in progress. The combined findings will inform next steps of creating classroom interventions and technology designs (e.g., visualizing theory-evidence coherence, scaffolding, etc.) to support theorizing and working with evidence and authoritative sources for knowledge advancement. The sample size in this study was relatively small; future studies will use a larger sample of participants to re-examine the findings of this study, as well as identify new predictive relationships at the finer sub-category level.

The variety of ways of contributing to Knowledge Building dialogues that were examined in this study address knowledge creation and collaboration skills that lie at the core of 21st Century Skills (Partnership for 21st Century Skills, 2004). With all so-called "higher-order skills," a crucial and frequently ignored issue is their transferability (Bereiter & Scardamalia, 2006). Although it was beyond the scope of this study to examine transfer beyond the classroom, further research will be needed to examine transfer across different curriculum topics; positive results will lend support to the idea that developing distinctive ways of contributing can give students something transferable and helpful for them to become productive citizens in a knowledge society.

References

Bereiter, C., & Scardamalia, M. (2006). Education for the Knowledge Age: Design-centered models of teaching and instruction. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of educational psychology* (pp. 695-711). Mahwah, NJ: Lawrence Erlbaum Associates.

Carnevale, A. P., & Desrochers, D. M. (2003). *Standards for what? The economic roots of K-16 reform* (Educational Testing Service Leadership 2003 Series). Princeton, NJ: Educational Testing Service. Available November 2008 at http://www.learndoearn.org/For-Educators/Standards-for-What.pdf

Chi, M. T. H. (1997). Quantifying qualitative analysis of verbal data: A practical guide. *Journal of the Learning Sciences, 6,* 271-315.

David, P. A., & Foray, D. (2003). Economic fundamentals of the knowledge society. *Policy Futures in Education*, *1*(1), 20-49. Retrieved July 18, 2004, from http://2_David_PFIE_1_1. Pdf

de Bono, E. (1985). *Six thinking hats*. Boston: Little, Brown.

Fischer, K. W., & Bidell, T. R. (1997). Dynamic development of psychological structures in action and thought. In R. M. Lerner (Ed.) & W. Damon (Series Ed.), *Handbook of child psychology: Vol 1. Theoretical models of human development* (5th ed., pp. 467–561). New York: Wiley.

Galili, I., & Hazan, A. (2000). Learners' knowledge in optics: Interpretation, structure and analysis. *International Journal of Science Education*, *22*(1), 57-88.

Glaser, B.G. & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. New York: Aldine.

Hogan, K. (1999). Sociocognitive roles in science group discourse. *International Journal of Science Education, 21*(8), 855-882.

Homer-Dixon, T. (2006). The Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization. Washington, DC: Island Press.

Partnership for 21st Century Skills (2004). *Collaboration skills*. Retrieved on September 20, 2008, from http://www.21stcenturyskills.org/index.php?option=com_content&task=view&id=263&Itemid=132

Resnick, M. (1996). Beyond the centralized mindset. *Journal of the Learning Sciences, 5*(1), 1-22.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Eds.), *Liberal education in a knowledge society* (pp. 76-98). Chicago: Open Court.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopedia of education* (2nd ed. pp. 1370–1373). New York: Macmillan Reference.

Scardamalia, M., & Bereiter, C. (2007). Fostering communities of learners and knowledge building: An interrupted dialogue. In J. C. Campione, K. E. Metz, & A. S. Palincsar (Eds.), *Children's learning in the laboratory and in the classroom: Essays in honor of Ann Brown.* Mahwah, NJ: Erlbaum.

Sternberg, R. J. (2003). The development of creativity as a decision-making process. In R. K. Sawyer et al. (Eds.), *Creativity and development* (pp.91-138). New York: Oxford University Press.

Leng, J. Lai, M., & Law, N. (2008, October 28). *Characterizing patterns of interaction in knowledge building discourse.* Paper presented at the 16th International Conference on Computers in Education, Taipei, Taiwan.

Zhang, J., & Messina, R. (2010). Collaborative productivity as self-sustaining processes in a Grade 4 knowledge building community. In K. Gomez, J. Radinsky, & L. Lyons (Eds.), *Proceedings of the 9th International Conference of the Learning Sciences* (pp. 49-56). Chicago, IL: International Society of the Learning Sciences.

Zhang, J, Scardamalia, M, Lamon, M., Messina, R. & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in the work of 9- and 10-year-olds. *Educational Technology Research and Development*, *55*, 117-145.

Acknowledgments

This research was funded by a Research Grant from the Social Sciences and Humanities Research Council of Canada titled "Ways of contributing to dialogue in elementary school science and history." We would like to express our gratitude to the students, teachers and principals of the Dr. Eric Jackman Institute of Child Study, University of Toronto for the insights and the opportunities enabled by their involvement.