A Principle-based Approach to Knowledge Building: Processes, Challenges, and Implications

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Abstract: Collaborative and inquiry-based learning programs vary in the degree of prescription and specification along a continuum from procedure- to principle-based approaches. This symposium will engage researchers and practitioners in a dialogue about these approaches and analyze the enactment of Knowledge Building (Scardamalia & Bereiter, 2006) as a principle-based innovation in two specific contexts: a Canadian elementary school and a teacher network in Hong Kong. Each case will be first analyzed by researchers drawing on rich data collection and, then, reflected upon by practitioners from these two sites (i.e. teachers and principal), followed by questions and comments from symposium participants. Analyzing and discussing these two cases from both researchers' and practitioners' perspectives will help elaborate the possibility, benefits, processes, conditions, and challenges of principle-based innovation in comparison with procedure-based practices and designs. Implications of principle-based innovation to CSCL research and practice will be discussed.

Focus of the Symposium

Various collaborative, inquiry-based learning programs have been developed to enable collaborative and productive work with knowledge among students with the support of new technological environments (Barron & Darling-Hammond, 2008). These programs vary in the degree of prescription, specification, and structure (Collins, 1996), representing different practices and models for classroom innovation that fall along a continuum from procedure- to principle-based approaches (Zhang, 2010; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). At the procedure-based end innovations are translated into school practice through specification of procedures to be faithfully implemented. Principles are not made explicit but must be inferred from procedures that typically involve carefully sequenced activities and curriculum material and pre-established steps, scripts, and prompts. Collaborative inquiry is accordingly structured through setting up fixed small-groups that deal with assigned sub-topics and tasks following provided procedures, scripts, and templates (see Zhang, Scadamalia, Reeve, & Messina, 2009). At the principle-based end principles are made explicit and presented as pedagogical design parameters with teachers and students engaged as designers and innovators to continually invent and improve principle-based practice through analysis of principles, examples, and results in their contexts. At the midpoint is a principle-based procedure approach in which principles are made explicit and best practices are conveyed through pre-established activities and procedures that translate these principles into effective action. Differences among these approaches on the procedure- to principle-based continuum have triggered ongoing debates and dialogues in the learning sciences (Brown & Campione, 1996; Scardamalia & Bereiter, 2007) that relate to several specific areas of inquiry, including prescriptive, structured versus adaptive, open instructional design (Schwartz, Lin, Brophy, & Bransford, 1999), scripted versus adaptive collaboration (Dillenbourg, 2002; Zhang, in press; Zhang et al., 2009), fidelity and adaptation of curriculum implementation (Brown & Edelson, 2001; Barab & Luehmann, 2003), adoption and transformation of inquiry-based practices in international and cultural contexts (Chan, 2008; Zhang, 2010), and specification of learning design in design-based research (Dede, 2004). The goal of this symposium is to invite deeper conversations about this focal theme through analyzing the enactment of a principle-based innovation—Knowledge Building and Knowledge Forum (Scardamalia & Bereiter, 2006)—in comparison with other learning programs and models in the learning sciences.

Procedure- vs. Principle-Based Innovation

The three approaches identified above, ranging from procedure- to principle-based, are not meant to describe specific learning programs but rather to suggest the variation of approaches used by learning scientists. Any single program might incorporate aspects of all three approaches, but typically educational approaches fall into the first two (procedure-based, principle-based procedures), reflecting the assumption that educational innovation requires "starter" lessons even "rituals," so plans, tasks, and activity sequences can be integrated into classroom procedures and become effortless in execution. After teachers have experience they can deal with the

more abstract principles that underlie these procedures and adapt them to their local circumstances (see, for example, scripted collaboration reviewed by Dillenbourg, 2002 and Learning by Design--LBD--Kolodner et al., 2003; Kolodner, 2006). As Kolodner and colleagues explain,

> "The rituals give each phase of the LBD cycle some flesh, providing specifics about how to carry them out and clear guidelines for weaving back and forth from phase to phase. Iteration has become a part of the classroom culture that everybody—students and teacher—understand the purpose of and make time for." (Kolodner et al., 2003, p.536).

In several other programs (e.g., Linn, 2006), procedures are conveyed through prompts for explanation, collaboration, reflection, and so forth. Brown and Campione (1994) used activity structures such as jigsaw, crosstalk, and benchmark lessons to establish Fostering Communities of Learners classrooms. They noted an important advantage of their approach: "The repetitive, indeed, ritualistic nature of these activities is an essential aspect of the classroom, for it enables children to make the transition from one participation structure…to another quickly and effortlessly." (p. 236) They also wrote about "lethal mutations" created by the fact that implementers often focus on surface features rather than the underlying principles, thus the procedures themselves became rituals that impede innovativeness (Brown & Campione, 1996). As they elaborate, the procedures lose their effectiveness because they are used too ritualistically and thus are not adapted to local contexts in reflection of the principles. Ironically then, rituals designed to enable innovation might come to stand in its way. Of course, reform-minded teachers need to consider day-to-day classroom procedures and routines. The argument set forth in this symposium is that a principle-based approach may help them to become generative and adaptive in designing, integrating, and enacting classroom processes in light of the ethos of an innovation, and, thereby, be in position to sustain the innovation.

Knowledge Building may well stand alone, far out on the principle-based end of the continuum, as a pedagogical model in use for several decades in nations spanning the Americas, Asia, and Europe, without prescribed procedures to keep it going. Knowledge Building pedagogy and technology (Knowledge Forum) attempt to refashion education in line with how knowledge work proceeds in a knowledge-creating culture (Scardamalia & Bereiter, 2006; Scardamalia, Bransford, Kozma, & Quallmelz, 2010). Knowledge workers build on and advance the knowledge assets of their community (Csikszentmihalyi, 1999; Sternberg, 2003) by generating and identifying promising ideas and improving them through incremental and sustained processes; by formulating deeper problems as solutions are developed; by engaging in idea-centered discourse involving multiple perspectives, constructive criticism, and distributed expertise; by committing themselves to creative goals and careers; by taking risks; and by assuming leadership and responsibility at the highest levels instead of relying on the leader to tell them what to do (Amar, 2002; Bereiter & Scardamalia, 1993; Dunbar, 1997; Florida, 2002; Sawyer, 2007). Correspondingly, knowledge-creating organizations provide supportive, organic, and flexible structures that encourage participatory and distributed control, adaptability, and emergent collaboration (Engeström, 2008; Gloor, 2006; Williams & Yang, 1999). Thus Knowledge Building, as a pedagogical model for enculturating students into authentic knowledge creation practice, has adopted a principle- rather than procedure-based approach to classroom practices, with teachers and their students co-constructing procedures that evolve to remedy limitations and accommodate new possibilities, and supports in place for sharing examples, bringing research to bear on their effectiveness, and in other ways facilitating continual improvement (Zhang et al., 2009, 2011).

As a point of clarification, the Knowledge Building challenge is not to avoid tasks and activities or repeated enactment of effective procedures. Tasks activities, deadlines, and responsibilities, are essential components of any work situation. The challenge is to ensure that idea improvement rather than the completion of a specific task or routine is at the centre of the educational enterprise. If idea improvement is not happening, or is only happening for a limited number of community members, that is a sign that the tasks, activities, and routines need to be improved. Activity structures and procedures must constantly evolve in the service of idea advancement (Scardamalia & Bereiter, 2006, 2007). And for that to happen, teachers and students need to initiate, monitor, and re-structure classroom activities as they proceed (Zhang, 2010).

Organization of This Symposium

This symposium will bring together researchers and practitioners to have a theoretically informed and empirically grounded dialogue about principle- versus procedure-based approaches to classroom practice and reflect on the enactment of Knowledge Building in two specific contexts: a Canadian elementary school and a teacher network in Hong Kong. The Canadian school, the Laboratory School of Dr. Eric Jackman Institute of Child Study, has been implementing Knowledge Building as a school-wide, principle-based innovation for more than a decade. The Knowledge Building Teacher Network (KBTN), funded by the Education Bureau (Ministry of Education) of Hong Kong since 2006, aimed to scale up Knowledge Building innovation supported with a teacher network, which adopts a principle-based approach to prompt teacher ownership and knowledge creation

for sustained innovation in classrooms. Each case will be first analyzed by researchers drawing on rich data collection and, then, reflected upon by practitioners from these two sites, followed by questions and comments from symposium participants. Analyzing and discussing Knowledge Building initiatives at the above two sites from both researchers and practitioners' perspectives will help elaborate the possibility, benefits, processes, conditions, and challenges of principle-based innovation in comparison with procedure-based practices and designs. Since this symposium will focus on interactive conversations instead of presentations, participants are encouraged to read Zhang et al (2011) beforehand, if possible, and bring their questions and thoughts to the symposium for lively discussions. Questions to be explored and discussed include but are not limited to:

- What are the benefits and challenges of principle-based in comparison to procedure-based innovation?
- What are the critical components of a principle-based innovation (e.g., Knowledge Building) and how do they interact with one another to make new classroom practice possible and transparent to teachers and students?
- Can a principle-based innovation, such as Knowledge Building, be sustained school-wide and increase student engagement and achievement? How will a principle-based approach facilitate teachers and students' knowledge advances? What efforts are needed from the teachers? What conditions might be created in a school to support such efforts?
- Can a principle-based innovation, such as Knowledge Building, be sustained in a larger teacher network? What professional development strategies are effective to support principle-based innovation?
- How can new technology (e.g. collaborative learning environments, assessment and feedback tools) support principle-based innovation?
- What are the larger implications of principle-based innovation to CSCL research and the field of the learning sciences?

Contributors and Presentations

Marlene Scardamalia (University of Toronto) will provide an overview and historical background of principle- versus procedure-based approaches to classroom design and practice and elaborate why and how Knowledge Building pedagogy and technology enacts a principle-based approach. Knowledge Building in classrooms is guided by a set of 12 principles (Scardamalia, 2002), with Knowledge Forum conveying corresponding knowledge operations and interactions and providing affordances for knowledge creation in a community. Knowledge Building practice within a complex, constantly evolving dynamic system is enabled through interrelated systems of support: Knowledge Building principles and Knowledge Forum technology broadly applicable to all classroom initiatives, analytic tools providing indicators of principles in use, and automated tools providing feedback to work as it proceeds. Thus principles and technology combine to provide mutually supportive contexts for high-level knowledge processes. The various components are so intertwined and integral to day-to-day operations that efforts to isolate or prescribe procedures would undercut the dynamic that allows procedures to be continually improved.

An essential component of Knowledge Building is making ideas explicit and public so they serve as conceptual artifacts (Bereiter, 2002) for the community and can be improved by any member. Knowledge Forum provides a shared electronic knowledge space for the community where members contribute and continually advance conceptual artifacts while developing personal expertise and identities. Bringing such community knowledge space to the classroom serves to inform and enhance a focus on collective knowledge advancement, with feedback, interaction tools, and scaffolds (e.g., My Theory, I need to understand) supporting individual contributions and learning as well as collaborative work. These scaffolds are not designed as scripts, but rather as supports for highlighting and turning over to students high-level knowledge processes. To further help teachers and their students use Knowledge Building principles for design and reflection, a set of analytic tools in Knowledge Forum have been designed to provide real-time, on-demand information about students' collective and individual performances, serving as indicators of principles in use as well as providing feedback regarding advances for a broad range of 21st century competencies (Scardamalia et al., 2010). The system of interactivity and feedback to knowledge processes that results is very different from that established through activity cycles, step-by-step routines, and various other set procedures built into many educational enterprises. Teachers and students co-construct and reconstruct the flow of things as work proceeds, kicking-off a new inquiry through a new item entered into the database, rallying around an idea and formulating new problems to be addressed, deepen an inquiry by initiating new experiments, rising above previous accounts, and so forth. Visualization and feedback tools help the community identify and focus on the new effort. Overall, the process of knowledge creation is made transparent to teachers and students alike to help them sustain a principle-based approach, with less dependence on pre-established activity sequences to keep the knowledge work moving forward.

Jianwei Zhang (University at Albany) will present a study on the implementation of Knowledge Building in the Laboratory School of Dr. Eric Jackman Instituted of Child Study located in downtown Toronto, Canada. Results were analyzed from the perspective of student, teacher, and principal engagement to identify

conditions for Knowledge Building as a school-wide innovation (see Zhang et al., 2011 for details). This study analyzed 39 Knowledge Building initiatives, each focused on a curriculum theme and facilitated by nine teachers over eight years. Analyses of students' Knowledge Forum discourse in the Knowledge Building initiatives showed interactive and complementary contributions to a community knowledge space, conceptual content of growing scope and depth, and collective responsibility for knowledge advancement. More substantial advances for students were related to years of teachers' experience with Knowledge Building. For example, social network analysis of student note reading and note linking interactions indicates that teachers, even in their first year implementing Knowledge Building, created engaged and connected Knowledge Building communities. As the teachers proceeded, they were able to facilitate Knowledge Building initiatives with more productive and sustained contributions, as indicated by the number of notes students created, problems worked on collaboratively, and increases in complementarity of these efforts, which were significantly correlated with the depth of understanding students achieved (Zhang & Sun, 2011).

Analyses of teacher and principal engagement included interviews, observations of weekly teacher meetings, teacher journals, and field notes from classroom observations. A number of supportive conditions were identified for this school-wide, principle-based innovation. At the classroom level, Knowledge Building principles help focus and inform teachers' pedagogical thinking, decision-making, experimentation, and reflection on practice. Contributing factors include teachers' trust in students' capabilities and efforts to continually turn greater agency over to them; ever-deepening understanding of Knowledge Building principles aided by design, experimentation, reflection and research; and teacher willingness to embrace emergence and foster student collective responsibility for co-evolving classroom processes. At the teacher community level, Knowledge Building innovation is sustained by principle-based discourse among the teachers (as well as their students). Knowledge Building principles provide a common language and shared goals—ideals to strive for as they collaboratively deepen the meaning of the principles and co-develop designs, strategies, and resources to support Knowledge Building. At the school level, the Knowledge Building principles help to establish social and cultural norms conducive to creative knowledge work at classroom and teacher-community levels. Collaboration, professional discourse, creativity, autonomy, flexibility, and collective responsibility for high achievements become social values and norms, as well as criteria in hiring new teachers. The principal supports efforts of the individual teachers within their local community as well as dynamic interactions with communities beyond the school.

Elizabeth Morley and Richard Messina (Dr. Eric Jackman Institute of Child Study of the University of Toronto) will present teacher and principal perspectives on the enactment of Knowledge Building as a school-wide innovation. Specifically, Richard Messina will reflect on his improvement of classroom designs in light of deepening understanding of the Knowledge Building principles (e.g., epistemic agency, collective responsibility for community knowledge, Knowledge Building discourse). His practice has evolved from fixed small-groups to adaptive, opportunistic collaboration and incorporated increasingly effective designs of Knowledge Building conversations, enabling high-level agency and collective responsibility among students coupled with increase in learning outcomes (Zhang et al., 2009). Elizabeth Morley will reflect on the history of incorporating Knowledge Building and Knowledge Forum into their school and elaborate on her role as the principal, such as: communicating high expectation for teaching excellence and autonomous action; encouraging exploration of new ideas, and conveying trust in teachers; creating social structures and opportunities for teachers to share and collaborate, etc. The teachers and principal meet weekly to share their understanding of the Knowledge Building principles and discuss advances and challenges of classroom designs and practices in light of the principles and evidence collected using the analytic tools of Knowledge Forum.

Carol Chan, Jan van Aalst, Fung Yuen Han, and Hidy Tse (University of Hong Kong) will present an ongoing four-year research into a group of teachers in their Knowledge Building Teacher Network in Hong Kong that adopts a principle-based approach. The obstacles, opportunities, refinements and impacts will be discussed. The theme of procedure-based versus principle-based approach is particularly useful for examining classroom innovations in the international context considering culture, technology, and innovation. A delicate tension may exist between lethal mutation when teachers distort the research model to fit with their existing practice (Brown & Campione, 1996) versus adapting and transforming the model in light of the socio-cultural milieu. Principle-based innovation may address such issues of pedagogical transformation in cultural contexts (Chan, 2008; Zhang, 2010). The set of Knowledge Building principles (Scardamalia, 2002) can be used as scaffolds and indicators; while teachers are to retain the deep principles, the classroom activity structures may vary considerably across contexts with scope for the creation of new principles, designs, and practices. Earlier work has shown that teachers in the Hong Kong teacher network tended to focus on activities and resources, but those who grappled with principles had more sophisticated Knowledge Building practice than others focusing on procedures. With two researchers (Chan and van Aalst) and two teachers (Fung and Tse) involved, this presentation will elaborate design efforts towards developing principle-based understanding including how principles are objects of inquiry in teacher discourse and how teachers engage their students in meta-discourse to examine Knowledge Building principles in classrooms. Data analyses will include teachers' changing

understanding of principles intertwined with improvement of practice, and how changes in their epistemology and practice are reflected in student collective knowledge advances in their classrooms over the years. Analyses of how principle-based innovation takes place in the Asian classrooms will also be discussed (Chan, 2008), suggesting the need to continually invent and improve adaptive classroom designs and strategies in light of Knowledge Building principles in response to culture-specific conditions, opportunities, and challenges.

Janet Kolodner (Georgia Institute of Technology), as the discussant, will revisit the variations between a principle- versus procedure-based approach to classroom practice in relation to the implementation of Learning By Design (Kolodner, 2006), a project-based inquiry model in which students deal with authentic design challenges through creating sharable artifacts following clearly laid out activity cycles. She will comment on the enactment of Knowledge Building in the above Canadian and Asian contexts, provide critical analysis, and highlight implications and challenges.

References

Amar, A.D. (2002). *Managing knowledge workers: Unleashing innovation and productivity*. Westport, CT: Quorum Books.

Barab, S. A., & Luehmann, A. L. (2003). Building sustainable science curriculum: Acknowledging and accommodating local adaptation. *Science Education, 87*(4), 454-467.

Barron, B., Darling-Hammond, L. (2008). How can we teach for meaningful learning? In L. Darling-Hammond, B. Barron, D. Pearson, A. H. Schoenfeld, E. Stage, et al. (Eds.), *Powerful learning* (pp. 11-70). San Francisco: Jossey-Bass.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Erlbaum.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. La Salle, IL: Open Court.

Brown, A. L., & Campione, J. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289-325). Mahwah, NJ: Erlbaum.

Brown, A. L., & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilly (Ed.), *Classroom lessons: Integrating theory and practice* (pp. 201-228). Cambridge: MIT Press.

Brown, M., & Edelson, D. C. (2001, April). Teaching by design: Curriculum design as a lens on instructional practice. Paper presented at the Annual meeting of the American Educational Research Association, Seattle, WA.

Chan, C. K. K. (2008). Pedagogical transformation and knowledge-building for the Chinese learner. *Evaluation and Research in Education, 21*, 235-251.

Chan, C. K. K., van Aalst, J., & Law, N. (2008, March). Developing principle-based understanding for knowledge-building in a teacher community. Paper presented at the Annual Meeting of American Educational Research Association, New York.

Collins, A. (1996). Design issues for learning environments. In S. Vosniadou, E. De Court, R. Glaser, & H. Mandl (Eds.), *International perspectives on the design of technology-supported learning environments* (pp. 347-361). Mahwah, NY: Erlbaum.

Csikszentmihalyi, M. (1999). Implications of a systems perspective for the study of creativity. In R.J. Sternberg (Ed.), *Handbook of creativity* (pp. 313-335). Cambridge, UK: Cambridge University Press.

Dede, C. (2004). If design-based research is the answer, what is the question? A commentary on Collins, Joseph, and Bielaczyc; diSassa and Cobb; and Fishman, Marx, Blumenthal, Krajcik, and Soloway in the JLS special issue on design-based research. *Journal of the Learning Sciences, 13*, 105-114.

Dillenbourg, P. (2002). Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In P. A. Kirschner (Ed.), *Three worlds of CSCL. Can we support CSCL* (pp. 61-91). Heerlen, Netherlands: Open Universiteit Nederland.

Dunbar, K. (1997). How scientists think: Online creativity and conceptual change in science. In T. B. Ward, S. M. Smith & S. Vaid (Eds.), *Conceptual structures and processes: Emergence, discovery and change* (pp. 461-493). Washington, DC: APA Press.

Engeström, Y. (2008). *From teams to knots*. Cambridge, UK: Cambridge University Press.

Florida, R. (2002). *The rise of the creative class*. New York: Basic Books.

Gloor, P. A. (2006). *Swarm creativity: Competitive advantage through collaborative innovation networks*. Oxford, UK: Oxford University Press.

Kolodner, J. L. (2006). Case-based reasoning. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp.225-242). Cambridge, UK: Cambridge University Press.

Kolodner, J.L., Camp, P.J., Crismond D., Fasse, B., Gray, J., Holbrook, J., Puntembakar, S., Ryan, M. (2003). Problem-based learning meets case-based reasoning in the middle-school science classroom: Putting Learning by Design™ into practice. *Journal of the Learning Sciences, 12*(4), 495 - 548.

Linn, M. C. (2006). The knowledge integration perspective on learning and instruction. In R. K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp.243-264). Cambridge: Cambridge University Press.

Sawyer, R.K. (2007). *Group genius: The creative power of collaboration*. New York: Basic Books.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society*(pp.67-98). Chicago, IL: Open Court.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 97-115). New York: Cambridge University Press.

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* (pp. 197-212). Mahwah, NJ: Erlbaum.

Scardamalia, M., Bransford, J., Kozma, R., & Quellmalz, E. (2010). *New assessments and environments for knowledge building. Assessment and Learning of 21st Century Skills*. Paper posted to http://www.atc21s.org/home/

Schwartz, D., Lin, X., Brophy, S., & Bransford, J. (1999). Torward the development of flexibly adaptive instructional designs. In C. Reigeluth (Ed.), *Instructional design theories and models Vol. II* (pp. 183–213). Mahwah, NJ: Lawrence Erlbaum Associates.

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.

Williams, W. M., & Yang, L. T. (1999). Organizational creativity. In R.J. Sternberg (Ed.), *Handbook of Creativity* (pp. 373-391). Cambridge, UK: Cambridge University Press.

Zhang, J. (2010). Technology supported learning innovation in cultural contexts. *Educational Technology Research and Development, 58*, 229-243.

Zhang, J. (in press). Designing adaptive collaboration structures for advancing the community's knowledge. In D.Y. Dai (Ed.), *Design research on learning and thinking in educational settings: Enhancing intellectual growth and functioning*. Philadelphia, PA: Routeledge.

Zhang, J., & Sun, Y. (2011). Quantified measures of online discourse as knowledge building indicators. In *Proceedings of the International Conference on Computer Supported Collaborative Learning (CSCL 2011)*. International Society of the Learning Sciences.

Zhang, J., Hong, H.-Y., Scardamalia, M., Toe, C., & Morley, E. (2011). Sustaining knowledge building as a principle-based innovation at an elementary school. *Journal of the Learning Sciences*, *20*, 262–307. (Online available at http://tccl.rit.albany.edu/papers/Zhang_2011JLS.pdf)

Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *Journal of the Learning Sciences, 18*, 7–44.