Knowledge Building in Mathematics: Knowledge Building Principles Complement the NCTM Principles

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Introduction

Today's world is rapidly changing and increasingly technological. To be successful in this world, students need to learn with understanding and be flexible, creative, and adaptive. As new knowledge and technology emerge, students will need to apply what they know in new ways to solve the complex types of problems that characterize the emerging "Knowledge Age."

Two sets of pedagogical principles are explored: Knowledge Building (KB) and the National Council of Teachers of Mathematics (NCTM) principles. These principles are advocated to help prepare students for the knowledge age. Using examples, I will show that these two sets of principles are complementary.

KB Principles Complement NCTM Principles

A Knowledge Building community continuously seeks to improve ideas that are of value to the community (Scardamalia & Bereiter, 2010). Participants intentionally and purposefully explain and justify their thinking while exploring and connecting ideas; they strive to advance community knowledge, and in doing so, advance their own learning.

The NCTM (2000), which focuses specifically on mathematics learning, advocates a shift away from a view of mathematics as a goal in itself and towards a view of mathematics as a tool to understand and effectively participate in today's world.

The NCTM vision calls for students to solve complex, open, contextual problems; clearly communicate their mathematical thinking; work collaboratively; develop a mathematical disposition; and consider multiple perspectives and solution paths.

NCTM's Equity Principle

- *all* students have the opportunity to learn mathematics with depth and understanding
- high expectations and strong support for *all* students
- supported by these KB Principles:
  - **Epistemic Agency:** students are responsible for moving their collective understanding forward
  - **Democratizing Knowledge:** all participants are legitimate contributors; members participate in different ways

NCTM's Teaching Principle

- foster students' mathematical dispositions
- create a supportive environment
- provide worthwhile tasks
- supported by these KB Principles:
  - **Epistemic Agency:** students are responsible for moving their collective understanding forward
  - **Improvable Ideas:** desirable to put forth tentative ideas; continually seek to improve ideas
  - "A supportive environment and teacher effort and artistry are involved in creating and maintaining" (Scardamalia & Bereiter, 2010, p. 8) a dynamic learning environment.

NCTM's Learning Principle

- develop conceptual understanding via discourse, interaction, and inquiry
- become autonomous learners
- develop quantitative literacy
- supported by these KB Principles:
  - **Knowledge Building Discourse:** public, collaborative, cooperative; seeks progress and to develop common understanding
  - **Improvable Ideas:** desirable to put forth tentative ideas; continually seek to improve ideas
  - **Idea Diversity:** allows consideration of multiple perspectives; students compare/contrast their ideas with those of others, and refine their ideas

NCTM and KB Principles in the Classroom

Moss & Beatty (2006, 2010) explored the ways KB principles supported the mathematics learning of grade 4 students. Students used Knowledge Forum® to collaboratively solve mathematical generalizing problems. The following vignettes, extracted from Moss & Beatty's work, illustrate the ways in which KB principles complement the NCTM principles.

Vignette 1: No Teacher/Researcher Presence in Database

Students collaborated to solve complex generalizing problems* without any teacher/researcher presence in the database. No answers were provided. Prior to beginning this work, all students had used Knowledge Forum. Students took on the responsibility for requesting, and providing, evidence and justifications.

* (see appendix of Moss & Beatty, 2010 for the problems)

NCTM Principles

- Exemplifies the Teaching and Learning principles
- Students as autonomous learners
- Students were provided with worthwhile tasks and a supportive environment
- Nature of tasks conveys belief in students

KB Principles

- Exemplifies the principle of Epistemic Agency
- Scardamalia & Bereiter (2006) note that "Knowledge Building can only succeed if teachers believe students are capable of it" (p. 113).

Both sets of pedagogical principles call for a shift in the role of the teacher from disseminator of a fixed body of knowledge to facilitator of learning. This vignette shows that, while the teacher/researchers had no direct role in the work on the database, they did important work in selecting the tasks and in establishing the environment and norms.

Vignette 2: Analysis of Students' Contributions

All students participated in solving the generalizing problems, but in different ways. Higher achieving students contributed a higher proportion of original notes. Lower achieving students contributed a higher proportion of notes that were responses to other notes, reinterpreting others' ideas and offering modified representations. Many students revised their notes or changed/modified their theories after reading responses to their notes and notes contributed by their peers.

NCTM Principles

- Exemplifies the Equity and Learning principles
- All students participated in meaningful ways
- Exploring multiple perspectives through discourse developed deeper conceptual understanding

KB Principles

- Exemplifies the principles of Democratizing Knowledge, Improvable Ideas, Idea Diversity, and Knowledge Building Discourse
- Students revised notes based on input from peers and personal reflection
- All students were legitimate participants

Conclusions

Within each set of pedagogical principles, the individual principles intertwine to form a system and the boundaries between individual principles are not clearly defined. Further, the links between the KB principles and the NCTM principles are fluid and dynamic. When looking at the individual principles, the KB and NCTM principles appear quite different, but when each set is considered as a complete system, the similarities between them become more apparent.

This analysis suggests that adopting Knowledge Building pedagogy in mathematics creates a learning environment that supports the NCTM principles. Further research, designed to specifically examine the links between these two sets of pedagogical principles, will lead to better understanding of the ways in which the principles are complementary.

References

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