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Meeting of the minds: A comparison of thinking processes exhibited during reading and math think-alouds.

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Elementary teacher candidates and first year teachers often find themselves immersed or, more likely, submerged in a sea of standards, practices, and taxonomies of processes and behaviors across disciplines. As they plan for assessment and instruction, they have to learn and apply terminology that addresses processes and behaviors across reading, math, science, social studies, and more. In addition, in these early years, they have to learn how to manage a classroom that meets many diverse needs, and they have to learn how to account for standards and educator practices to children, parents, administrators, legislators, and themselves. Candidates and new teachers often ask how all of the different standards, taxonomies, and practices fit together; many are too overwhelmed to even ask or recognize the question.

A typical teacher education program will include a taxonomy of teaching and learning (Anderson et al., 2001; Marzano & Kendall, 2007). During recent years, teacher preparation programs and school districts have added effective teaching frameworks (Danielson, 2007; Marzano, 2007). Added to these lists of behaviors and practices are state requirements such as Florida Educator Accomplished Practices (Florida Department of Education, 2012) and standards such as Common Core State Standards (Council of Chief State School Officers & National Governors Association, 2010). Of course, each discipline has its own list of key principles, practices, and/or processes. An elementary teacher typically teaches two or more disciplines. The new teacher who aims to excel might consult professional literature for best practices in reading, math, science, social studies, arts, and health. An experienced teacher can handle the addition of new layers through the years, but for a novice to have to address all of those items at once is quite a daunting task.

The ultimate goal of the current study is to offer a solution that would combine tasks or processes across disciplines in an effort toward more efficient teaching and learning in elementary classrooms. More specifically, the researchers investigated the possibility of common thinking processes used in reading and mathematics tasks. If there are common processes, then teachers may be able to teach the processes in one discipline and make quick connections and applications within the other discipline thereby shortening the overall lists of tasks to accomplish. In an attempt to create a common list of reading and mathematical processes, this study was designed to answer the question: "What thinking processes do reading comprehension and mathematical problem-solving have in common as exhibited through experts' think alouds?"

Perspectives/Theoretical Framework

Before comparing reading and mathematics thinking processes, the separate sets of processes were determined. Mathematical problem solving processes emerged as early as 1957 (Polya) and have continued to be refined throughout the past 55 years, first as a part of the mathematics curriculum (Garofalo & Lester, 1985; Hyde,A.A & Hyde, P.R. 1991; Whitin, D.J., et al., 1990) and most recently as the goal of mathematics instruction (NCTM, 2000; NCTM 2006). Table 1 includes a synthesis of prevalent mathematical problem solving processes.

Table 1
Mathematical Problem Solving Processes

Problem Solving Processes Used in Mathematics
Looking for relationships
Analyzing patterns
Finding out which methods work and which don't work
Justifying procedures
Justifying results
Evaluating and challenging thoughts of others
Drawing on knowledge in order to develop new knowledge
Exploring
Taking risks
Questioning
Monitoring to check understanding
Adjusting process based on monitoring
Representing the meaning of the problem
Recording/describing solution strategies
Choosing a representation/model that's most appropriate to the problem
Making connections between math concepts
Making connections to daily life
Predicting usefulness of strategy/concept for future problem-solving experiences
Speaking, writing, reading, and listening
Conjecturing (informed guessing)

Proficient reader research (Duke & Pearson, 2002) supplied the most prevalent list of thinking processes that is used in the development of reading curriculum and instruction throughout the country. This list of processes has been applied and reported in numerous practitioner resources (Keene & Zimmerman, 2007; Harvey & Goudvis, 2007; Miller, 2002). Table 2 includes the list of thinking processes that stem from proficient reader research.

Table 2
Reading Comprehension Processes

Cognitive Processes Used During Reading (from proficient reader research)
Monitoring/Metacognition/Fix Up
Visualizing
Inferring
Connecting
Questioning
Determining Importance
Synthesizing / Summarizing

Most recently researchers have begun to explore possible relationships between processes used in reading and mathematics (Hyde, A., 2006; Fogelberg, et al., 2008; Siena, 2009; Brummer & Macceca, 2010; Sammons, L., 2010; Halladay & Neumann, 2012). Careful inspection of recent literature reveals, however, that whereas authors are suggesting the use of reading processes to teach mathematics, there is scant evidence that thought processes used to unlock meaning of text are the same as those used to solve mathematical problems.

The investigators of the current study proposed a synthesis across thinking processes in reading and mathematics in a rough attempt to identify a possible alignment. Table 3 communicates that proposed alignment.

Method

The current descriptive study was designed to compare and contrast cognitive processes used by reading and mathematics experts during reading comprehension and mathematical problem solving tasks. Processes identified for exploration are identified in Table 3 above. "Experts" were defined as teacher education faculty who taught reading or mathematics methods courses for elementary teacher candidates. Teacher education faculty were selected because they focus on how to teach thinking processes; therefore, researchers assumed the experts would be aware of these thinking processes in their own reading and problem solving. Four experts, two reading faculty and two mathematics faculty, participated in two think aloud tasks: reading the first pages of an adolescent/adult novel and solving a mathematical story problem. Both tasks were selected to be sufficiently challenging to the adult expert in order to try to tap into thinking processes that were not automatic or tacit.

Table 3
Proposed Alignment: Mathematics – Reading Thinking Processes

Mathematics-Problem Solving	**Reading Comprehension Processes**
Looking for relationships	Synthesizing
Analyzing patterns	Synthesizing
Finding out which methods work and which do not work	Monitoring/Metacognition
Justifying procedures	Monitoring/Metacognition
Justifying results	Connecting/Monitoring
Evaluating and challenging thoughts of others	
Drawing on knowledge in order to develop new	Connecting/Synthesizing
Exploring	Asking questions
Taking risks	(Affective)
Questioning	Asking questions
Monitoring to check understanding	Monitoring/Metacognition
Adjusting process based on monitoring	Monitoring/Metacognition
Representing the meaning of the problem	Visualizing
Recording/describing solution strategies	Visualizing/Monitoring/Metacognition
Choosing a representation/model that's most appropriate to the problem	Connecting/Visualizing/Synthesizing
Making connections between math concepts	Connecting
Making connections to daily life	Connecting
Predicting usefulness of strategy/concept for future problem-solving experiences	Connecting/Visualizing/Synthesizing
Speaking, writing, reading, listening	
Conjecturing (informed guessing)	Inferring

The think aloud method was used to try to capture experts' spontaneous thinking. While there are issues with self-reporting one's own thinking processes (Pressley & Afflerbach, 1995), think aloud methodology seemed the least invasive technique for imposing thought processes on the reader or problem solver.

The reading task involved thinking aloud while reading the first two chapters of *The Book Thief* (Zusak, 2005). This text was selected because there is mystery from the beginning about who is telling the story and who the book thief is. The text offers possibilities for predicting, connecting, inferring, monitoring, and questioning. The mathematics task involved a ratio problem that also lends itself to inferring, questioning, connecting to prior knowledge of mathematics, and monitoring.

Each expert was asked to think aloud while "solving" the reading text and mathematics problem. The reading faculty performed the reading task first; the math faculty performed the mathematics problem solving task first. All four experts performed both reading and math tasks while reading and talking aloud; think alouds were recorded and transcribed. Three scorers listened to audio recordings of the think alouds, analyzed, and labeled processes independently and then met to discuss until they reached 100% agreement. Labels for processes were selected from the right column of Table 3 since it was easier to map the math processes onto the shorter

list of reading processes than vice versa.

Results

Table 4 includes the results of the analyses of the think aloud tasks. While no consistent patterns emerged, the analyses did indicate that there are processes used in both reading comprehension and mathematical problem solving. The processes used most frequently in both reading and mathematics were monitoring, inferring, connecting, and questioning. Monitoring was identified by phrases such as "I'm confused by", "I got it!", and "I don't understand." Inferring was indicated by phrases such as "I'm guessing", "I'm inferring", "That means." Connecting was implied by phrases such as "I know" or "This reminds me of". Questioning was identified by phrases such as "I wonder" or "I am questioning" and the insertion of a question with rising intonation. Visualizing did occur in reading but was used more frequently in the mathematics problem solving. Monitoring, questioning, and visualizing were used with more frequency in mathematics than reading; while connecting and inferring were used with more frequency in reading than in mathematics problem solving.

Table 4
Results of Think Aloud Analyses

	Cognitive Processes During Think Alouds							
	The Book Thief				Teacher Ratio Problem			
RE=Reading Expert ME=Math Expert	RE1	RE2	ME1	ME2	RE1	RE2	ME1	ME2
Monitoring	9	6	3	0	27	13	6	9
Visualizing	0	2	2	0	14	6	4	1
Inferring	16	10	16	7	3	5	6	1
Connecting	22	4	8	3	7	1	4	0
Questioning	9	5	4	0	18	4	1	0
Evaluating Language	0	1	0	1	0	1	0	0
Synthesizing/	0	0	0	1	0	2	0	1

Conclusions

Results indicated that there are common processes across reading comprehension and mathematics problem solving. Future research will address various text genres, include additional types of mathematics problems, and add experts including teacher educators and experienced classroom teachers. In addition, future research will investigate the effects on children's reading comprehension and mathematics problem solving after instruction in the use of these common processes across both disciplines.

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