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Connecting mathematical reasoning and language arts skills: The case of common core state standards

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Abstract

Many relationships exist between language arts and mathematics. These relations become apparent in NCTM's process standards (2000). McIntosh, (1991) emphasized the importance of using various language art skills to enhance mathematics learning. Curriculum standards have potential to show teachers the possible ways and targeted objectives of a content area (Clements et al., 2009). As a result, in this study through content analyses of Common Core State Standards- English Language Arts (CCSS-ELA) we aim to identify potential contribution of the targeted objectives and skills mentioned in ELA standards K-2 to children's mathematical reasoning and practices. Results of the study indicate that language art standards emphasize the importance of using the tools such as communication, multiple representation and understanding in mathematical reasoning.

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1. Introduction

In the past, literacy and mathematics were perceived as disjoint content areas (Rainer & Matthews, 2001). However, currently there has been a push to integrate these two content areas (c.f. NCTM, 2000). Thus, it is important to provide teachers with guidance on how to overcome the challenges of the integration process. This integration process is not merely composed of overlapping content areas; it also involves an "organizing center which serves as a context for unifying knowledge" (Beane, 1996, p. 2). Curriculum standards serve as a guide for teachers to show them how to navigate their instruction and determine the context of their courses. As a result, this study examines the potential contribution to students' mathematical reasoning. We posit that these standards may serve as a guide to first steps of an integration process.

The Common Core State Standards (CCSS) is a set of curriculum standards, released in 2010 covering language arts and mathematics from grades K-12. The National Governors Association Center for Best Practices (NGA Center) and The Council of Chief State School Officers (CCSSO) pioneered the Common Core State Standards Initiative. CCSSO and the NGA Center carried out the standards' development process in consultation with families,

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teachers, experts and administrators (CCSS, 2012). The Standards clarify independently what students are expected to learn in order to provide individual students with meaningful learning experiences. This allows for teachers and parent to know how they can assist each student. The objective of National Standard will ensure that students are getting consistent high quality education, and help teachers to build the best lessons for their classrooms according to the knowledge and skills that their students should have (CCSS, 2012).

In the United States, 45 of the 50 states are members of the initiative, with the exception of Texas, Virginia, Alaska, Nebraska and Minnesota. Each state is planning to implement the initiative by basing at least 85% of their state curricula on the Standards by 2015 (CCSS, 2012).

CCSS-ELA includes five domains; namely reading, writing, speaking and listening, language, and media and technology. The reading standards aim to help children improve their perspectives and benefit from the text they read. The writing standard objective requires students to write arguments in a logical order. Speaking and listening standards aims to develop children's ability to share arguments in small group activities and hold one-on-one academic debates which require them to listen their peers attentively. Language domain refers to the goal of improving children's vocabulary. Finally media and technology helps children to adapt to necessary circumstances.

The mathematics standards (CCSS, 2012) are primarily based on the Principles and Standards of School Mathematics, were created by The National Council of Teachers of Mathematics (NCTM, 2000). The Standards command eight principles of mathematical practice should be taught as follows: "make sense of problems and persevere in solving them, reason abstractly and quantitatively, construct viable arguments and critique the reasoning of others, model with mathematics, use appropriate tools strategically, attend to precision, look for and make use of structure and look for and express regularity in repeated reasoning" (CCSSM, 2012). The standards highlight building a strong mathematical foundation which is a requirement for student success in more complex mathematics courses. They are composed of five main domains that are larger sets of related standards. These domains are: counting and cardinality, operations and algebraic thinking, number and operations in base ten, measurement and data and, geometry (CCSS, 2012).

1.1. Language Arts and Mathematics

There exists a strong relationship between language arts and mathematics. These relations become apparent in the process standards of NCTM (1989, 2000). These process standards attend to problem solving, reasoning, communication, connections, and representations. According to Rainer and Matthews (2001) as students' progress from least to more sophisticated mathematics, communication and reasoning skills become essential for higher order mathematical thinking.

Existing literature (Braunger & Hart-Landsberg, 1994; McIntosh, 1991; Nevin, 1992; Schram & Rosaen, 1989) emphasizes the importance of using various language art skills to enhance mathematics learning. For instance, Kolstad, Briggs, & Whalen (1996) suggested that reading, listening, speaking, writing and multiple representations should be incorporated into the mathematics classroom. Also, McIntosh (1991) pointed out the importance of communicating mathematical ideas in both written and verbal formats. He suggested that through this communication students' mathematical thinking and misconceptions could be detected. According to Schram and Rosaen (1989) exploratory talks within classrooms help students to articulate their mathematical thoughts as they engage with the mathematics. The important question is: what should be the first step to fostering teachers' ability to use these language art skills in their mathematics classroom? Curriculum standards have potential to show teachers the possible ways and targeted objectives of a content area (Clements et al., 2009). As a result, examining ELA standards is important to guide teachers for integrating these skills in the mathematics classroom.

The position statement of The National Association for the Education of Young Children (NAEYC) sets up principles of child development and learning and guidelines for what to do concerning developmentally appropriate practice in programs for children from birth through age 8 (Bredekamp, 1987). As a result, this study examined ELA standards grades from K-2, Decisions regarding educational practice rely on many sources of information. In order to be able to give developmentally appropriate decisions, teachers must base their decisions on at least three important sources of knowledge (Bredekamp, 1987). First, they should utilize their knowledge on child learning and

development, content learning and skill acquisition. They should also consider children individually and his/her family as well. Lastly, teachers should take into account their knowledge of the social and cultural context of the children and families. All these steps emphasize the significance of primary-grades as foundation for the intellectual development of children. It is during these years that children develop peer-cooperation, tolerance, empathy, responsibility, and a positive attitude toward learning including curiosity, initiative, persistence, risk taking and self-regulation (Bredekamp, 1987).

2. Methodology

In this study, document content analysis (Hodder, 2000) was used to determine CCSS-ELA standards that have potential to enhance mathematical thinking and understanding. This document analysis was done in three stages. In the first stage, two independent mathematics educators and one language art expert analysed ELA standards and reviewed the relevant literature to determine a coding schema for the study. Three categories were determined as follows: 1) Understanding and Analysing Word Problems 2) Multiple Representations and 3) Mathematical Classroom Discourse.

In the second stage, two mathematics education experts independently determined the related ELA standards that have potential to enhance mathematical thinking and understanding. In the third stage, these experts sorted those standards into related categories and determined the level of agreement. In addition, one outside language arts expert and a mathematics educator evaluated the selection of the standards under each category and agreed with the selection. Based on the data analysis and evidence from existing literature, the narrative are composed and future research suggestions and implications are discussed.

3. Findings

This section will discuss potential contribution of selected ELA standards to enhance mathematical learning and reasoning. Table 1 shows the related CCSS-ELA standards listed under related three categories: 1) Understanding and Analyzing Word Problems 2) Multiple Representations and 3) Mathematical Classroom Discourse.

Table 1. CCSS-ELA art standards per grade aligned under related category

	ELA Common Core State Standards K-2		
	Understanding and Analysing Word Problems	**Multiple Representations**	**Mathematical Classroom Discourse**
Kindergarden	**RSL1:** With prompting and support, ask and answer questions about key details in a text.	**RSL 7:** With prompting and support, describe the relationship between illustrations and the story in which they appear (e.g., what moment in a story an illustration depicts). **SLS 5:**Add drawings or other visual displays to descriptions as desired to provide additional detail.	**RSL 2:** With prompting and support, retell familiar stories, including key details. **SLS 2:** Confirm understanding of a text read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood. **SLS 3:** Ask and answer questions in order to seek help, get information, or clarify something that is not understood. **SLS 6:** Speak audibly and express thoughts, feelings, and ideas clearly.
1st grade	**RSL 1:** Ask and answer questions about key details in a text.	**RSL 7:** Use illustrations and details in a story to describe its characters, setting, or events. **SLS 5:** Add drawings or other visual displays to descriptions when appropriate to clarify ideas, thoughts, and feelings.	**RSL 2:** Retell stories, including key details, and demonstrate understanding of their central message or lesson. **SLS 3:** Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood.

2nd grade	**RSL 1:**Ask and answer such questions as *who*, *what*, *where*, *when*, *why* and *how* to demonstrate understanding of key details in a text.	**RSL 7:** Use information gained from the illustrations and words in a print or digital text to demonstrate understanding of its characters, setting, or plot.	**SLS:** 3 Ask and answer questions about what a speaker says in order to clarify comprehension, gather additional information, or deepen understanding of a topic or issue.

RSL: Reading Standards for Literature
SLS: Speaking and Listening Standards

Understanding a given text, representing and expressing your understanding of the text in different formats and describing the observed situations using a correct language are crucial pillars of language art education (Kolstad, Briggs, & Whalen, 1996). Pape and Mourat (2001) stated that with the skill of using multiple representations students become more competent in mathematics learning. RSL 7 (grades K-2) and SLS 5 (grades K-1) standards in table 1 have the potential to increase students' ability to illustrate the events and understand the relations within the given situation. Also, they emphasize the importance of students' ability to use multiple representations to demonstrate understanding of a settings and its components. These language arts abilities are also emphasized in mathematics learning. For instance, Izsak (2003) stated "representing and solving problems about the surrounding world has always been central to mathematical thinking, and recent K-12 curricula place more emphasis on such activities" (p. 191). In CCSS-ELA standards multiple representations were listed as visual display and verbal display. Similarly, in mathematics multiple representations can be in the form of pictorial, concrete, written, graphical and verbal (Ainsworth, 1999).

Students may encounter some difficulties as they engage with given mathematics problems (Driscoll, 1999). For instance students need to answer the following questions to understand the presented problems: What is problem actually asking?, What are the unknowns in the problem?, Which information given within problem context?, How do children convey their solution strategies? As seen in table 1 standards related to understanding and analyzing word problems and multiple representations may help students to understand the problem better and capture the bigger idea of the mathematical tasks (NCTM, 1989). For instance, 1st grade RSL 1 stated "Ask and answer questions about key details in a text"(CCSS, 2012). Students' ability to detect key details in a given text will facilitate students' understanding of presented word problems. In mathematics word problems students should identify what the problem is asking, what the givens are and how the given information can be used to reach the correct solution. Thus in order to determine the answer to these questions, students should acquire a strong background of understanding of what they have read and excel in analyzing the given text. RSL 1 standards through K-2 grades emphasized acquisition of this skill, starting with the least complex skills to the most complex skills

Supporting young children in acquiring communication and discourse skills is one of the aims of CCSS-ELA (CCSS, 2012). Similarly it is also essential in mathematics classrooms. As Pape and Mourat (2001) indicated "…[w]hen the goal of instruction is to learn to represent mathematical concepts or to solve problems involving mathematical representations, student must be given the opportunity to interact with one another and the teacher" (p. 124). The ability to detect patterns in a given text, using multiple representations of information presented in a text and the ability to explain thoughts and ideas are the important skills that children should acquire in language art courses (Burton, 1992). These skills are represented in table 1 under the category of standards related to mathematical classroom discourse. For instance, SLS 6 standard pointed out that as a result of learning to communicate effectively in language art classroom, students can also: 1) organize and elaborate on their mathematical thinking, 2) express and communicate their mathematical understanding precisely and clearly, 3) evaluate and reflect on their mathematical strategies and those of their peers and 4) use language effectively to express mathematical ideas in mathematics classroom (Principles and Standards of Mathematics, 2000). SLS 3 kindergarten standards state "Ask and answer questions in order to seek help, get information, or clarify something that is not understood." Smith and Stein (2012) stated, "teachers should support their students as they engage with and discuss their solutions to cognitively tasks" (p.1). Accordingly, a typical high-level mathematics classroom

starts with launching a mathematical task that underlies important mathematical ideas. After that in the launch phase, a teacher introduces a task and required materials are available to engage with the presented materials. In this phase students will "Ask and answer questions about what a speaker says in order to gather additional information or clarify something that is not understood." (SLS3, 1st grade) and "Confirm understanding of a text [presented mathematics task] read aloud or information presented orally or through other media by asking and answering questions about key details and requesting clarification if something is not understood" (SLS 2, Kindergarten). In the last phase, which is called explore phase, students start to engage with a presented task then they will "Speak audibly and express [mathematical] thoughts, … , and ideas clearly" (SLS 6, Kindergarten). Then they communicate their mathematical approach, strategies and reasoning to their friends. In addition, students in the classroom ask questions to further clarify their understanding of their friend's explanations and critically examine their mathematical approaches. These behaviors of students in a mathematics classroom are also emphasized in the ELA standards: RSL 2 (grades K-1) and SLS 3 (K-3). All these findings indicate that students can acquire certain communication skills in LA arts classroom that may potentially help them to articulate their mathematical thoughts with their teachers and peers. Moreover through asking questions they can get additional information and clarification about presented mathematical tasks, check their own understanding of the task and examine their classmates' mathematical reasoning.

In general the coding schema of the study is in line with Lesh (1987)'s identified three-step procedure for solving a given mathematical problem. The first step is to transfer a verbal problem into mathematical forms which requires the use of multiple representations and understanding the given text. The second step is to write these mathematical forms using algebraic symbols, which is also related to multiple representations category. The last step is to explain the variety of solutions to the problem through verbal or written communication, which is, related to the last category mathematical classroom discourse. All these steps include the skills that can be gathered from ELAs and used to enhance mathematics learning.

4. Discussion

All these findings suggest that language art skills have the potential to help students' understanding in mathematics classroom. Language art skills give students tools for questioning their and their peers understanding of presented mathematics. Also it gives tools for analyzing and representing the given mathematics problem in multiple ways such as presenting a mathematics task visually. Language arts standards emphasize clearly articulating thoughts. This helps students to communicate what they think mathematically and what they have learned. Finally all these skills provide the teacher and students with the opportunity to clarify and document students' understanding of mathematics involved. Also they serve for active mathematics learning in the classroom that incorporates mathematical classroom discourse (Smith & Stein, 2012), appropriate feedback, usage of multiple representations (Izsak, 2003) and identification of mathematics itself behind the presented tasks (Driscoll, 1999). All these active mathematics learning methods or tools have potential to increase students' ability to reason mathematically.

Further research must be undertaken to test these tools' effectiveness through empirical research. Pilot studies should be conducted to test the effectiveness of integrating mathematics and language arts in the classroom and further investigate how this integration helps students to understand mathematics better. Teachers should be informed on how to incorporate language arts skills in their mathematics classroom through professional development.

References

Ainsworth, S.E., (1999) A functional taxonomy of multiple representations. *Computers and Education*, *33*(2/3), 131-152.

Braunger, J. & Hart-Landsberg, S. (1994). *Crossing boundaries: Explorations in integrative curriculum.* Portland: Northwest Regional Educational Lab.

Beane, J. (1993). Problems and possibilities for an integrative curriculum. *Middle School Journal, 25*(1), 18-23.

Beane, J. (1996). *Curriculum integration.* New York: Teachers College Press

Bredekamp, S. (1987). *Developmentally appropriate practice in early childhood programs serving children from birth through age 8*. Washington, DC: National Association for the Education of Young Children.

Burton, G. (1992). Using language arts to promote mathematics learning. *The Mathematics Educator*.

Clements, D., Sarama, J., & Julie, A. (2009). Learning and Teaching Early Math. *In the learning trajectories approach* (pp. 18). New York: Routledge.
Common Core State Standards Initiative. (2012). Retrieved November 17, 2012, from http://www.corestandards.org/frequently-asked-questions
Driscoll, M. *(1999). Fostering algebraic thinking: A guide for teachers grades 6-10*. Portsmouth, NH: Heinemann.
Hodder, I. (2000). The interpretation of documents and material culture. In N. K. Denzin, & Y. S. Lincoln (Eds), *Handbook of qualitative research* (pp. 703-715). Thousand Oaks, CA: Sage Publications.
Izsak, A. (2003). We want a statement that is always true: Criteria for good algebraic representations and the development of modeling knowledge. *Journal for Research in Mathematics Education, 34*(3). 191-227.
Kolstad, R., Briggs, L., & Whalen, K. (1996). Incorporating language arts into the mathematics curriculum: A literature survey. *Education, 116*(3), 423-431.
Lesh, R., Post, T., & Behr, M. (1987). Representations and translations among representations in mathematics learning and problem solving. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (33-40). Hillsdale, NJ: Erlbaum.
National Council of Teachers of Mathematics (1989).*Curriculum and evaluation standards for teaching mathematics*. Reston, VA: National Council of Teachers of Mathematics.
National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.
McIntosh, M. (1991). No time for writing in your class? *Mathematics Teacher*, *84*(6)423-433.
Nevin, M. (1992). Language arts approach to mathematics. *Arithmetic Teacher, 40*(3), 16-22.
Pape, S. J., & Mourat, A. T. (2001). The role of representation(s) developing mathematical understanding. *Theory into Practice.Realizing Reform in Middle School Mathematics, 40*(2). 118-127.
Rainer, M. W. & Matthews, C. D. (2001).The quandaries of teachers and teacher educators in integrating literacy and mathematics. *Language Arts, 78*(4), 357-364.
Schram, P., & Rosaen, C. (1996). Integrating the language arts and mathematics in teacher education. *Action in Teacher Education, 18*(1), 23-38.
Stein, M. K., & Smith, M. S. (2012). *Five practices for orchestrating productive mathematics discussions.* Reston, VA: Corwin.