Journal of Mathematics Education at Teachers College

Fall – Winter 2011

A CENTURY OF LEADERSHIP IN MATHEMATICS AND ITS TEACHING

The *Journal of Mathematics Education at Teachers College* is a publication of the Program in Mathematics and Education at Teachers College Columbia University in the City of New York.

Dr. Robert Taylor was selected by the Teachers College sponsored Teachers for East Africa program to teach mathematics of Uganda's Makerere University. He returned to TC as an instructor in the Department of Mathematics, Statistics, and Computing in Education where he developed an innovative programming language (FPL) intended to introduce educators to the then - new field of computer programming. His seminal work entitled *Computers: Tutor, Tool, Tutee* led to leadership in the new field of computers in education. Dr. Taylor completed 33 years as a member of the Teachers College faculty in 2009.

Dr. Carl N. Shuster completed the doctorate at Teachers College in 1940 under the guidance of William David Reeve. Shuster joined the TC faculty at Reeve's invitation and soon was recognized as the nation's leading advocate of the use of traditional technology, especially measurement technology, in the mathematics classroom. Dr. Shuster served as President of the National Council of Mathematics from 1946 to 1948 and concluded his career as Distinguished Professor of Mathematics at Trenton State University.

Aims and Scope

The *JMETC* is a re-creation of an earlier publication by the Teachers College Columbia University Program in Mathematics. As a peer-reviewed, semi-annual journal, it is intended to provide dissemination opportunities for writers of practice-based or research contributions to the general field of mathematics education. Each issue of the *JMETC* will focus upon an educational theme. The themes planned for the 2012 Spring-Summer and 2012 Fall-Winter issues are: *Evaluation* and *Equity*, respectively.

JMETC readers are educators from pre K-12 through college and university levels, and from many different disciplines and job positions—teachers, principals, superintendents, professors of education, and other leaders in education. Articles to appear in the *JMETC* include research reports, commentaries on practice, historical analyses and responses to issues and recommendations of professional interest.

Manuscript Submission

JMETC seeks conversational manuscripts (2,500-3,000 words in length) that are insightful and helpful to mathematics educators. Articles should contain fresh information, possibly research-based, that gives practical guidance readers can use to improve practice. Examples from classroom experience are encouraged. Articles must not have been accepted for publication elsewhere. To keep the submission and review process as efficient as possible, all manuscripts may be submitted electronically at www.tc.edu/jmetc.

Abstract and keywords. All manuscripts must include an abstract with keywords. Abstracts describing the essence of the manuscript should not exceed 150 words. Authors should select key words from the menu on the manuscript submission system so that readers can search for the article after it is published. All inquiries and materials should be submitted to Ms. Krystle Hecker at P.O. Box 210, Teachers College Columbia University, 525 W. 120th St., New York, NY 10027 or at JMETC@tc.columbia.edu

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Something Drawn, Something Touched, Something Scrolled: An Exploratory Comparison of Perimeter and Area Interventions Including Kidspiration

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This exploratory study compared a computer-based mathematics education intervention with two more traditional approaches with the purpose of improving instruction in perimeter and area. Kidspiration software, tile/stick manipulatives and pencil/paper-based copying/drawing of shapes were implemented in a 3rd Grade New York City public school classroom. This study demonstrated student improvement across the three interventions when comparing pre-intervention and post-intervention test scores. Students who engaged with the copying/drawing shapes intervention demonstrated the greatest test score improvement after the intervention, those who used Kidspiration ranked second and tile/stick manipulatives were third. When queried about their perceptions of the efficacy of these interventions, students generally perceived all three of the interventions as being positive in improving their learning of perimeter and area. Developing new methods to address deficiencies in current forms of assessment that would highlight the benefits of non-traditional forms of education, such as technological initiatives, is recommended.

Keywords: Kidspiration, manipulatives, perimeter, area, mathematics reform.

The mathematics reform movement has investigated issues like "authenticity," "understanding" and "community" (Ball, 1993, pp. 373-374) as well as motivation, problem-solving skills and student self-confidence in mathematics (Ross et al., 2002). The reform's goal was improving curriculum design to encourage student construction of knowledge through self-discovery by solving complex, open-ended, real-life problems (Ross et al., 2002). Other goals included promoting student-student interaction and integrating assessment within everyday student activities relevant to their lives (Ross et al., 2002).

The preferred role of teachers within mathematics classrooms was also re-conceptualized. It is no longer desirable for teachers to deliver direct instruction through mathematical formulae that is irrelevant to students. Instead, teachers should act as "co-learners" to create mathematical communities promoting student talk concerning mathematical reasoning (Ross et al., 2002) and a corresponding increase in student responsibility for learning (Heid, 1997).

Technology promises to improve the implementation of these types of mathematics education reforms and result in a higher probability of more positive educational outcomes (Ross et al., 2002; Heid, 1997; Jonassen et al., 1998). By leveraging its flexibility, technology could prove useful for students solving complex, real-life problems as suggested by Ross above (2001). Contributing towards this push for technology is the need to increase technology use within classrooms to meet the scientifically/ mathematically rich standards advocated by the National Council of Teachers of Mathematics (2000) and National Research Council (1996) (see Niess, 2005, p. 510).

Kidspiration (http://www.inspiration.com/Kidspiration) proved successful in increasing student motivation and enhancing scientific thinking (Shaw et al., 2004, p. 3). Its visual tools encouraged creative and flexible thinking, helped represent thinking and ideas in pictures, as well as assist revising and editing symbolic representations (Shaw et al., 2004, pp. 3-4). Also K-5 students found it easy to learn Kidspiration's interface due to its graphical richness and transparency (Shaw et al., 2004, pp. 3-4). Lastly, working with Kidspiration could help elementary students improve computer skills (Shaw et al., 2004, 2004, p. 7).

As a result, it appears that implementing a technology intervention like Kidspiration in classrooms could prove beneficial for reform.

Three Interventions: Kidspiration, Tile/Stick Manipulatives and Copying/Drawing Shapes

Given this context of mathematical reform and the push for technology use within mathematics classrooms, this exploratory study compared three educational interventions, one involving technology, with the objective of improving perimeter and area instruction. More specifically, Kidspiration computer software, tile/stick manipulatives and copying/drawing shapes were implemented within a 3rd Grade New York City public school classroom to teach perimeter and area.

The three interventions were conducted simultaneously to provide a comparison to measure the effectiveness of each specific intervention. They were compared using a written pre-intervention test of perimeter and area, a formative assessment of group engagement levels during the intervention, a written post-intervention test similar to the pre-intervention one, a group oral interview (e.g. the group was asked "What was the best (worst) thing about the way you learned perimeter and area today?," etc.) as well as a questionnaire regarding student perceptions of the interventions' efficacy (e.g. students responded to age-appropriate Likert-scale (with sad/smiley-faced icons) comments like "I can explain perimeter (or area) to a friend better because of today's lesson," "I learned more mathematics than usual today because of the way I was taught in class," etc).

The first hypothesis was that students using Kidspiration would learn perimeter and area best among the three initiatives in earning the highest improved test scores when comparing pre-intervention and post-intervention test scores. Tiles/sticks would earn the second-highest improvement while copying/drawing shapes would be third.

The second hypothesis was that students being directly instructed by a teacher as well as copying/drawing shapes on paper would find this the least engaging method.

Research Question: Which Intervention Improves Perimeter and Area Test Scores the Most?

This study's research question was which of the following methods would benefit students most in learning perimeter and area as measured by earning the highest improved test scores when comparing pre-intervention and post-intervention test scores?

1. creating shapes with color tiles and lines using Kidspiration,
2. engaging in hands-on activities using tiles and wooden stick manipulatives, or
3. being directly instructed by a teacher as well as copying and drawing shapes on paper based on direct teacher instruction.

Two theories contextualize this study, schema construction and constructivism.

Schema Construction: Affordances of Multimedia Appeal to the Capacity of Working Memory

Sweller explained that learning is associated with alteration in long-term memory (2005, p. 20) and occurs through schema construction. This can proceed consciously or automatically, and is pictorial or verbal, spoken or written (Sweller, 2005, p. 21). He further states that understanding occurs when all elements of information can be processed simultaneously in working memory (Sweller, 2005, p. 26). According to Sweller, the aim of instruction should provide missing schemas to working memory and appeal to the full visual and phonological capacities of working memory through methods such as multimedia (2005, p. 26). Given this, the instructional goal should be the "acquisition of automated schemas" (Sweller, 2005, p. 22) in long-term memory. As a result, using multimedia methods, such as software, shows promise in improving learning.

This study focuses on a multimedia application like Kidspiration because it includes visual representation (e.g. its Graphical User Interface) and can include verbal representation of the material (e.g. teacher's spoken words and text) that should, according to Sweller's schema instruction, improve learning. Further, Kidspiration gives the subject's mind the chance to receive information from two different channels (e.g. visual and verbal representation) and helps it become processed more effectively as per Mayer's dual coding (2001, pp. 32-34).

Furthermore, this study focuses on using instructional technology that leads to the construction of knowledge schemas in long-term memory. Collins described two types of knowledge—*domain knowledge* and *strategic knowledge* (2006, p. 49). He also defined three kinds of strategic knowledge—*heuristic strategies* which are hands-on tricks which may be useful in certain problems, *control strategies* that control the process and analyze problems to reach certain goals, and *learning strategies* for learning other kinds of knowledge (Collins, 2006, p. 49). Further, Collins provided six methods of instruction that emphasize cognitive apprenticeship: *modeling*, *coaching*, *scaffolding*, *articulation*, *reflection* and *exploration* (2006, pp. 50-51).

This study's use of technology focuses on the methods endorsed by Collins. It does this by giving students opportunities to observe, discuss, explore, discover, engage in and reflect on their process of acquiring knowledge. Further, the intervention allows teachers to visually *model* the concepts of perimeter and area for students, *coaches* their activities, engages their problem solving, *scaffolds* their learning based on previous learning, encourages them to think like real mathematicians by defining their own formulae, invites learners to discuss these concepts and *articulate* their learning, gives them the opportunity to *reflect* on their learning, and promotes *exploration* of concepts through applied mathematical problems, again, as per Collins (2006).

Constructivism: A Framework for Using/Designing Technology Based Lessons

Chua and Wu proposed a framework based on constructivist learning theories to assist mathematics teachers in using or designing technologically based lessons that help students actively construct experiential knowledge (2005, p. 388). This framework has four components: *exploring*, *conjecturing*, *verifying*, and *generalizing* (2005, p. 389). In *exploring*, students examine a given task (2005, p. 390). Students *conjecture* to explain the problem and hypothesize potential solutions (2005, p. 390). Students *verify* conjectures using a computer application or inter-student interaction (2005, p. 391). Finally, students are encouraged to extend their thought processes while working on an assigned task into a new problem and investigate their conjectures in this novel situation—they *generalize* these conjectures (pp. 391-392). This iterative process allows students to repeatedly cycle through the framework of exploring-conjecturing-verifying until they satisfactorily verify conjecture/conjectures (2005, p. 391). As a result, the application of Kidspiration in classrooms promises to assist mathematics teachers in using/designing technologically based lessons that help students actively construct experiential knowledge as per Chua and Wu (2005).

Methodology: Adhering to a True Experimental Design

Chua & Wu's constructivist framework shaped how technology was used in this study. A teacher-directed task for 3rd Grade students was conducted—calculating perimeter and area of a given shape. Students were encouraged to form conjectures on finding perimeter and area. Once students realized how to calculate the perimeter and area of the shape, they were encouraged to extend this task into a new problem by designing their own shapes and investigating their perimeter and area.

Twenty-two New York City 3rd Grade public school students were studied. Students were divided into three approximately equal groups—8 used Kidspiration, 7 used tile/wooden stick manipulatives, and 7 copied/drew shapes. The classroom teacher ensured groups were relatively equivalent in mathematical ability.

The class was a convenience sample (Baker, 1988, p. 157), or accidental sample (Kidder & Judd, 1986, p. 150), recruited through a relationship between a research team member and the classroom teacher.

The study was conceptualized to adhere to the form of a true experimental design (Baker, 1988, p. 220). One of three *independent variables*, Kidspiration, tile/stick manipulatives, or copying/drawing shapes, was introduced into the classroom (Table 1). It was hypothesized that each independent variable would create a change in the proposed *dependent variable*, the level of learning of the mathematical concepts of perimeter and area as measured by comparing pre-intervention and post-intervention test scores.

Kidspiration Grades K-5 was implemented. It was chosen because it consisted of a grid page, drawing tool and colored square blocks that would help in the instruction of perimeter and area. The *Color Tile* math tool is helpful because it provided users with a grid page, created straight line through its drawing function and included colored unit-square tiles for building shapes.

The students also used tile/stick manipulatives that could be glued onto larger colored grid paper to help them understand perimeter and area.

The final intervention directed students to copy/draw shapes written by the researcher/instructor on the blackboard onto traditional graph paper.

Students completed a diagnostic pre-intervention test (30 minutes) before the intervention. Students were initially instructed in a whole-class setting by all three of the researchers/instructors together as a group about area and perimeter. This instruction was a lecture-format introduction to area and perimeter—what these concepts are, their definitions, similarities and differences (10 minutes). After being split into three intervention groups, the researchers/instructors informed students about the nature of their task (10 minutes), disseminated learning materials (5 minutes) and the intervention task was performed by students (30 minutes) (e.g. using Kidspiration, manipulating tile/sticks or copying/drawing shapes to deepen their learning of perimeter and area). Students completed a summative post-intervention test (30 minutes) similar to the diagnostic assessment completed earlier in the day (see all segments in Table 2).

Forms of Assessment: Diagnostic, Formative and Summative

First, students were given a two-page pre-intervention test to complete before the intervention (*diagnostic assessment*). It diagnostically assessed initial student knowledge of the subject matter. The test consisted of applied perimeter and area problems that incorporated simple and complex shapes. Students were asked to define of perimeter and area as well as how to calculate them for shapes.

Table 1. Proposed Experimental Design for Perimeter and Area Intervention

Part 1 – Pre-Test	Part 2 – Independent Variable/Intervention	Part 3 – Post-Test
Pre-intervention test	Kidspiration	Post-intervention test
Pre-intervention test	tile/stick manipulatives	Post-intervention test
Pre-intervention test	copying/drawing shapes	Post-intervention test

Second, during classroom instruction, students were observed engaging with their specific intervention—Kidspiration, tile/stick manipulatives, or pencil/paper-based copying/drawing of shapes (*formative assessment*). At approximately five-minute intervals, the researcher/ instructor observed student engagement with specific tasks. The researcher/instructor marked these responses on an observation sheet and noted both whole group and individual engagement.

Third, after the intervention was completed, students were tested again in a manner similar to the diagnostic assessment (*summative assessment*). Comparing pre-intervention and post-intervention test scores across three groups gave researchers insight regarding the effectiveness of each intervention. Students also filled in a post-intervention questionnaire regarding their perception of the usefulness of the interventions as well as participated in a group oral interview with the researcher/instructor who led their intervention.

Analysis: Quantitative and Qualitative Methods

In terms of quantitative methods, the scores per group for both diagnostic/pre-intervention and summative/post-intervention tests were compared to measure the effect of the intervention. Likert-scale data recorded during formative assessment was processed to provide descriptive statistics, like measures of central tendency, both within and across groups regarding levels of student engagement.

In terms of qualitative methods, text provided by interviews and open-ended questions on the student questionnaire helped contextualize both the formative assessment data as well as post-intervention interviews. Data were used for categories that analyzed the information provided by student participants. These qualitative data were elicited to corroborate/contrast with the quantitative data found through the assessments discussed above.

Results: Positive Impact of Each Intervention

It appears that each of the three interventions helped students learn perimeter and area when comparing pre-intervention and post-intervention test scores.

With respect to specific intervention groups, the pencil/paper group had the greatest overall increase in test scores when comparing pre-intervention and post-intervention test scores, followed by Kidspiration and the tiles/sticks group. These differences suggest that students would benefit most by using the paper/pencil method in learning perimeter and area in increasing test scores.

Smaller standard deviations in post-intervention test scores with respect to the pencil/paper intervention and larger deviations in the computer intervention suggest that pencil/paper intervention creates a more similar level of improvement in student scores than computers. With Kidspiration, some students appeared to learn a great deal, while others appeared to learn less.

In terms of the two major hypotheses, the first was that students using Kidspiration would learn perimeter and area best in earning the highest improved test scores when comparing pre-intervention and post-intervention test scores, tiles/sticks would earn second while copying/drawing shapes would earn third. This hypothesis appears incorrect. Close to the opposite was true. Pencil/paper earned the greatest improvement, Kidspiration second and tiles/sticks third in overall test score differentials between pre-intervention and post-intervention test scores.

The second hypothesis asserted that students being directly instructed by a teacher as well as copying and drawing shapes would find this the least engaging method. However, they would learn perimeter and area at a slightly lower level than the other two interventions when comparing pre/post-test scores. This was partially correct. It appears that students, anecdotally based on post-intervention group discussion, found Kidspiration the preferred method of intervention (e.g. regardless of the intervention they were involved in, each group of students preferred to use Kidspiration, even if they were involved in an intervention not including Kidspiration), ahead of both

Table 2. Timeline of Classroom Instruction

Segment length (in minutes):	Educational objective:
30	diagnostic pre-intervention test regarding perimeter and area
10	initial whole-class instruction regarding perimeter and area
10	instructions regarding the nature of the in-class task for students
5	dissemination of learning materials to students
30	performance of in-class task (teacher observes/formatively assesses student engagement with tasks)
30	summative post-intervention test regarding perimeter and area

pencil/paper and tiles/sticks. There did not appear to be a noticeable trend towards either pencil/paper or tiles/sticks as a second preference. The hypothesis that students will learn perimeter and area at a lower level than the other interventions was incorrect and was best in terms of improving post-intervention test scores. Although it may have appeared less engaging than the other interventions, pencil/paper copying/drawing was effective in improving student learning of perimeter and area as measured by post-intervention test scores.

Implications: Leveraging Student Interest in Technology

Student interest in using computers in learning environments holds promise for their use in formal classroom environments. The generally positive feelings towards computers should be leveraged and the reasons informing these attitudes teased out so that their potential can be maximized.

Given the lower effectiveness of Kidspiration in improving test scores, at least compared to pencil/paper in this study, it begs the question about how to implement this technology best to maintain student interest while concurrently improving learning. Perhaps allocating greater time to experimentation with the interface before the intervention will provide additional dividends in terms of promoting greater learning of concepts and, as a result, improved test scores. Also, trying to figure out ways to maximize the affordances of technology in improving learning is important.

Finally, both tests were paper-based due to restrictions in time and resources. For example, there was insufficient time to develop an online test for Kidspiration, there were challenges in ensuring an equitable assessment for students who were engaged with physical manipulatives, etc. In an era of increasing test-based accountability, one of the biggest challenges may be demonstrating how new technologies benefit students in important ways that further curricular mandates and minimizing the negative effects of traditional paper-based assessments when learning will increasingly be located in non-traditional, technologically-enhanced, methods that may not appeal to these older forms of assessment.

References

Baker, T. L. (1988). *Doing social research*. New York: McGraw-Hill Book Company.

Ball, D. L. (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal*, 93(4), 373-397.

Chua, B. L. & Wu, Y. (2005). Designing technological-based mathematics lessons: A pedagogical framework. *Journal of Computers in Mathematics and Science Teaching*, *24*(4), 387-402.

Collins, C. (2006). Cognitive apprenticeship. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 47-60). New York: Cambridge University Press.

Heid, M. (1997). The technological revolution and the reform of school mathematics: Reforming the third R: Changing the school mathematics curriculum. *American Journal of Education*, *10*(1), 5-61.

Inspiration Software Inc. (2008). Kidspiration Grades K-5 (Version 3) [computer software]. Beaverton, OR: Inspiration Software Inc. Available from http://www.inspiration.com/productinfo/kidspiration/index.cfm

Jonassen, D., Carr. C, Yueh H.P. (1998). Computers as mind tools for engaging learners in critical learning. *Tech Trends*, *43*(2), pp. 24-32

Kidder, L. H. & Judd, C.M. (1986). *Research methods in social relations*. New York: Holt, Rinehart and Winston, Inc.

Mayer, R. E. (2005). Cognitive theory of multimedia learning. In R.E. Mayer (Ed.), *The Cambridge handbook of multimedia learning* (pp. 31-48). New York: Cambridge University Press.

National Council of Teachers of Mathematics (NCTM). (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Research Council. (1996). *National Science Education Standards*. Washington, DC: National Academy Press.

Niess, M. L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education*, *21*, pp. 509-523.

Ross, J. A., Gray, A.H., McDougall, D., Bruce, C. (2002). The contribution of technology to the implementation of mathematics education reform: Case studies of grade 1-3 teaching. *Journal of Educational Computing Research*, *26*(1), 87-104.

Shaw, E. L., Baggett, P.V., Salyer, B. (2004). Kidspiration® for inquiry centered activities. *Wilson Web*, *41*(1), pp. 3-8

Call for Papers

The "theme" of the fall issue of the *Journal of Mathematics Education at Teachers College* will be *Evaluation*. This "call for papers" is an invitation to mathematics education professionals, especially Teachers College students, alumni and friends, to submit articles of approximately 2500-3000 words describing research, experiments, projects, innovations, or practices related to evaluation in mathematics education. Articles should be submitted to Ms. Krystle Hecker at JMETC@tc.columbia.edu by January 21, 2012. The spring issue's guest editor, Ms. Heather Gould, will send contributed articles to editorial panels for "blind review." Reviews will be completed by February 1, 2012, and final drafts of selected papers are to be submitted by March 1, 2012. Publication is expected by April 15, 2012.

Call for Volunteers

This *Call for Volunteers* is an invitation to mathematics educators with experience in reading/writing professional papers to join the editorial/review panels for the spring 2012 and subsequent issues of *JMETC*. Reviewers are expected to complete assigned reviews no later than 3 weeks from receipt of the manuscripts in order to expedite the publication process. Reviewers are responsible for editorial suggestions, fact and citations review, and identification of similar works that may be helpful to contributors whose submissions seem appropriate for publication. Neither authors' nor reviewers' names and affiliations will be shared; however, editors'/reviewers' comments may be sent to contributors of manuscripts to guide further submissions without identifying the editor/reviewer.

If you wish to be considered for review assignments, please request a *Reviewer Information Form*. Return the completed form to Ms. Krystle Hecker at hecker@tc.edu or Teachers College Columbia University, 525 W 120th St., Box 210, New York, NY 10027.

Looking Ahead

Anticipated themes for future issues are:

Spring 2012	Evaluation
Fall 2012	Equity
Spring 2013	Leadership
Fall 2013	Modeling
Spring 2014	Teaching Aids

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