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Discourse + Technology/Collaborative Learning = Fraction Success

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Abstract

Recent national public policy addresses the need for strengthening mathematics communication and reasoning skills for elementary students. This study analyzed the effects of using podcasts to increase mathematical discourse on the fraction abilities of a sixth grade mathematics class. Students collaborated within small heterogeneous groups that completed a flow map to show steps in the process representing the sequence of a fraction problem's solution. Students grappled with their understanding of mathematics by turning the flow map into a radio script which was ultimately posted as a podcast on the classroom's website. Scores from district and school based assessments measured the growth of mathematical ability to add, subtract, and regroup mixed numbers with unlike denominators over a nine week period during the first half of the sixth grade. A paired sample t-test of the sixth grade pretest and posttest scores on a criterion-referenced assessment, revealed a statically significant difference. The use of precise mathematical vocabulary, displays of proper sequence to solve for the correct answer, and accuracy of answers increased. District created measures of progress remained consistent as the level of difficulty in the curriculum increased.

A large part of the sixth grade mathematics curriculum extends students' knowledge of rational numbers to operations with fractions including proper fractions, improper fractions, and mixed numbers in both contextual and non-contextual situations. Sixth grade expectations also include increased communication skills (e.g., demonstrating conceptual understanding through models, pictures, or written explanations of a mathematical argument). The *Principles and Standards for School Mathematics* [National Council of Teachers of Mathematics (NCTM), 2000] and state-based academic standards include these operations and communication expectations in their mathematical strands, concepts, and performance objectives. Sixth grade becomes a critical juncture as students need to master the fraction curriculum as a foundation for higher level mathematics such as algebra and calculus (Wu, 2001) and demonstrate conceptual understanding of the processes of mathematics.

Communicating conceptual understanding is a crucial element allowing students to verbalize and validate their mental processes as they manipulate mathematical concepts to solve everyday problems (Blake, Hurley, & Arenz, 1995; Ginsburg & Amit,

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2008; Greenes, Ginsburg & Balfanz, 2004; Varol & Farran, 2006). Peer communication develops the "back and forth process from thought to word and from word to thought that allows learners to move beyond what would be easy for them to grasp on their own" (Truxaw, Gorgievski, & De Franco, 2008, p. 58). The National Technology Standards (NETS-S) and Performance Indicators for Students [International Society for Technology in Education (ISTE), 2007] further reinforce the need to develop communication skills in tandem with technology. Communication and collaboration skills are woven throughout the standards, but are particularly highlighted in Standard 2 (using digital media to communicate and work together collaboratively).

As classroom teachers and action researchers, designing effective teaching strategies to maximize student learning and increase student achievement is a consistent goal. Meeting performance outcomes for the fractions portion of the sixth grade mathematics curriculum had always been difficult and we decided it was time to take action. Kochendorfer (1997) identified four reasons to perform action research. These include changing practice, creating new understandings, developing new relationships, and seeking answers to problems. An action research design allowed us to engage in systematic inquiry to identify a problem, conduct a literature review, collect data, plan an implementation, interpret the data, and reflect upon the results (Mills, 2007). Accordingly, the purpose of this study was to investigate the effects that increased discourse and technology integration would have on sixth-grade students' ability to articulate a conceptual understanding of addition and subtraction of fractions and to solve the problems accurately.

Understanding discourse, defined by Cazden (2001), "as words spoken in class that affect learning," (p. 60) contributes to addressing the weakness in mathematical abilities found in our nation's students (Stigler & Hiebert, 1999). Students with opportunities to speak, listen, or write about mathematics receive more benefits than merely listening to the teacher. "They communicate to learn mathematics, and they learn to communicate mathematically" (NCTM, 2000, p. 60). This attention to communication within efforts to reform mathematics teaching encouraged the researchers to explore socially constructed knowledge and understanding, achievement, and the teacher's role within the content area of mathematics (Piccolo, Harbaugh, Carter, & Caprar, 2008; Wagner, 2007; Walshaw & Anthony, 2008).

Student discourse can improve mathematics achievement and encourage higher level thinking when students are involved with other students (Marzano, 2007; Stigler & Hiebert, 1999). When students engage in discourse that requires them to explain concepts verbally and listen carefully to the feedback of peers, motivation increases and immediate feedback adjusts changes in thinking right at the time of most effectiveness (Topping, 2005).

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When students collaborate, they are encouraged to help one another develop the answers to more complicated problems, an experience that mirrors the real world of problem solving (Marzano, 2007). Requiring verbal communication during classroom activities plays a significant role in exposing students to “cognitively demanding mathematical tasks” (Stein, Engle, Smith, & Hughes, 2008, p. 314) which, in turn, increases student engagement and gently forces students:

> To organize and consolidate their mathematical thinking through communication; to communicate their mathematical thinking coherently and clearly to peers, teachers, and others, to analyze and evaluate the mathematical thinking and strategies of others, and to use the language of mathematics to express mathematical ideas precisely (NCTM, 2000, p. 60).

Effectively integrating technology into the mathematical curriculum revolves more around using technology as a tool for learning and communicating than electronic worksheets for drill practice (Hansen, 2008). Loveless (2002) found that technology supported creativity in classrooms through developing ideas, making connections, creating and making meaning, collaboration, communication, and evaluation. In a study of teacher efficacy among mathematics teachers, Hansen and Zambo (2009) found that participants generally believed that good teachers could make a difference in the mathematics achievement of their students. Through learning more about technology themselves, teachers came to believe that appropriate technology use leads to higher levels of achievement in mathematics. Intuitively, teachers are aware of technology’s appeal to students and its potential for increased engagement and motivation (Brozo & Puckett, 2009; Triggs & John, 2004).

Increasingly, researchers are reporting on the value of podcasting and other interactive technology applications in fostering student understanding of mathematical terms, concepts and peer-to-peer transfer of knowledge (Anderson, 2005; Digiovanni, Schwartz, & Greer, 2009; Eddy & Patton, 2010; Franklin & Peng, 2008; Marcos, 2008; O’Bannon & Puckett, 2010). When students are tasked with creating in a medium such as a podcast, it can also help to change the intellectual work of the content, transforming the format from a mere report to a product that demonstrates an understanding that goes beyond the facts (Dlott, 2007; Porter, 2010).

Method

Participants

Having identified the problem, collecting data to identify participants became the next step in our action research design (Mills, 2007). All twenty students from one sixth grade class at Fairview School (a pseudonym) participated in the study. The teachers and administrators had organized the sixth grade mathematics classes based on

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teacher recommendations and district mathematic scores from the end of fifth grade to create heterogeneous classes. Among the members of this particular class, seventeen students entered the sixth grade with a rating of "mastery" of fifth grade mathematics concepts, one student was rated as "approaching" mastery of these concepts, one had "not mastered" the concepts, and rating scores were not available for one student who was new to the district. Of the seventeen students who rated at the mastery level of fifth grade mathematics, one had identified special needs (learning disabilities) and three were English language learners. The teacher-researcher in this study was a 30-year veteran certified in elementary and special education. Students and teachers at Fairview had access to technology resources, of relevance to this study, including a classroom set of laptops (five) equipped with Audacity (a software program used to create podcasts), wireless connection to the internet, and a district hosted classroom website.

Implementation

The next step in our action research design was to plan an implementation. Informed by the literature review, the researchers' implementation for innovation in teaching the fractions portion of the curriculum and data gathering included the following:

1. An instructional sequence for each fraction area (presented in this order: addition of unlike denominators, subtraction of unlike denominators, and regrouping for addition and subtraction of mixed numbers) which included creation of a Thinking Map ® Flow Map (TMFM) and collaborative editing for content in radio scripts which culminated in a podcast.
2. A rubric to evaluate TMFM for vocabulary, sequence, and accuracy.
3. Pre- and post-ratings on a fractions subtest and district benchmark quarterly scores to measure mathematics knowledge.
4. Observations and field notes to document classroom activity.
5. A survey to gather students' perceptions of the process.

Instructional sequence. Regarding instructional sequence, the teacher used structured lesson plans around the district sixth grade mathematics standards of solving problems with fractions and mixed numbers using any of the four operations, as well as using written explanations to show conceptual understanding. The teacher also used the ISTE (2007) standard, "using digital media to communicate and work together collaboratively" ("Communication and Collaboration," para. 2) and the NCTM (2000) standard, "communicate … mathematical thinking coherently and clearly to peers, teachers and others" (p. 268) as project goals. The teacher divided mathematics performance objectives into three units of instruction: addition of unlike denominators, subtraction of unlike denominators, and regrouping for addition and subtraction of mixed numbers. The teacher used the sixth grade mathematics text book for content and

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instructional suggestions. Five groups were formed, each with four student participants; the groups remained stable across the nine-week period of the study.

Instruction flowed through a sequence of introducing the content, discussion and guided practice, and independent practice. Then students completed a TMFM individually as homework with the task of explaining the steps in solving the fraction problem on the flow map. The following day, students compared and contrasted their individual TMFMs in small groups, eventually deciding on one that best represented the process and solution. Each group wrote a radio program script from the TMFM, and then produced the podcast. Instruction proceeded in this manner during the regularly scheduled 70 minutes per day allotted for mathematics instruction over the nine week period of the study. Groups identified their podcast by name of the show or by fictitious radio call letters and identified themselves through radio names, which were pseudonyms created for the project. The software program, Audacity, allowed each group to digitally record a two or three minute radio show using a laptop computer. The teacher-researcher vetted each digital recording for appropriateness and accuracy, and uploaded the files as a podcast on the school website. Once published, the students could access the podcast for homework help or to find out what other classmates had produced. Each group completed one podcast for each topic, for a total of fifteen productions.

Thinking Map ® Flow Map (TMFM). Thinking Maps (http://www.thinkingmaps.com) are a series of eight graphic organizers (templates) used to capture the visual representation of a thought process. Teachers and students at Fairview routinely use these templates as part of a school-wide professional improvement goal. The Flow Map was selected for the purposes of this study. Essentially, it is a blank flow chart that students can fill in to show understanding of each step in a process. The TMFM allowed the researchers to capture students' explanations while solving mathematics problems with the hope that, as the students verbalized their own meta-cognition, they became aware of their own thinking processes and the correct vocabulary to express their thoughts. As well, the TMFM required students to demonstrate their conceptual understandings and to communicate mathematical thinking coherently, two of the performance goals used throughout the lessons in this study.

TMFM Rubric. A rubric assessed each individual's TMFM to rate the extent to which students (a) used appropriate and sufficient vocabulary in describing the process of solving a fraction problem, (b) correctly sequenced the steps to solve the fraction problem, and (c) arrived at the correct or accurate solution. A Likert scale produced individual scores from zero to four on these dimensions as well as an overall score. TMFMs were assessed as a pretest at the beginning of the study, within each topic as the study progressed, and as a posttest on all three concepts at the end of the study.

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The teacher-researcher and another mathematics teacher at the school each scored the TMFMs identified only by the students' radio names to ensure anonymity and objectivity. Each rater scored all of the TMFMs individually and then compared ratings to establish inter-rater reliability. Any discrepancies resulted in discussion determining agreement between raters. Table 1 presents the rubric used to assess the TMFMs.

Table 1

Thinking Map® Flow Map Rubric

	0	Poor –1 Pt.	Fair – 2 Pts.	Good – 3 Pts.	Best – 4 Pts.
Vocabulary used	No attempt	Vocabulary is used incorrectly	1 or 2 vocabulary words used correctly	3 to 4 vocabulary words used correctly	5 or more vocabulary words used correctly
Sequence of problem solution	No attempt	No logical sequence	1 – 2 steps shown are in the correct order	3 – 4 steps shown are in the correct order	5 or more steps shown are in a correct order
Accuracy of solution	No attempt	The solution is not correct	The solution comes close to the answer but falls short	The solution is correct but not written in simplest terms	The solution is correct and written in the simplest terms
TOTAL					

Fractions snapshot and benchmark scores. Sixth graders at Fairview take a 60 item snapshot test at the beginning and end of the school year. The sixth grade teaching team created the snapshot test as a criterion-referenced measure of progress in mathematics. The teacher extrapolated the part of the snapshot test that related to the ability to add or subtract proper fractions and mixed numbers with unlike denominators with regrouping. This subtest provided a pretest measure and re-administering the same items at the end of the study provided posttest results. Statistical Package for the Social Sciences (SPSS) was used to analyze pre- and post-measures as paired scores, and a test of significance (t-test) was calculated. The results were further analyzed to determine the number of students who had either

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mastered the content or were making adequate progress. A student who scored 70% or higher on the posttest was considered to have mastered that content. For students who did not score at the 70% level, the difference between their pre- and post-score was determined to find out if they were making progress toward mastery. An increase of at least 20 percentage points between the pretest and posttest scores was considered a satisfactory gain.

Fairview District requires quarterly mathematics assessment for all students. The October benchmark norms for sixth grade students provided a measure of progress in this content area at the mid-point of the study and it closed with the December benchmark ratings. In addition to an overall percent correct and rating, each of these tests have five to seven subtest scores that are expressed as a percentage correct, and rated as Not Mastered (1), Approaching (2), and Mastered (3). The sixth grade October benchmark subtest measured addition and subtraction of fractions with unlike denominators and the December benchmark subtest rated progress on addition and subtraction of mixed numbers with and without regrouping. The rating scores (Not Mastered, Approaching, and Mastered) were used for comparison because each test had a different, progressively more difficult content and, therefore, the percent correct score would not provide an equal comparison.

Observations and field notes. The teacher researcher kept field notes on her observations of the classroom and recorded student comments. These notes were collected while the students were collaborating within their groups about their TMFM, writing their scripts, or during the recording of their podcasts. Observations included quotations of students' words as they described how to solve fraction problems from the podcasts. These observations and notes were used to confirm the implementation of the project goals of using digital media to communicate and work together collaboratively, and communicating mathematical thinking coherently and clearly to peers and teachers.

Student survey. An open ended survey at the end of the study was used to determine overall student attitudes, perceptions, likes and dislikes. The students were asked to explain whether or not they liked making the TMFM and the podcasts to help solve fraction problems.

Results

TMFM Scores

A rubric scored vocabulary, sequence, and accuracy for each of the fraction problem types (addition of fractions, subtraction of fractions, and addition or subtraction of fractions with regrouping). Figure 1 presents a graph of the means for the class.

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Numeric values for the scores indicate inaccurate or no mathematical terms (0), poor (1), fair (2), good (3), and best (4).

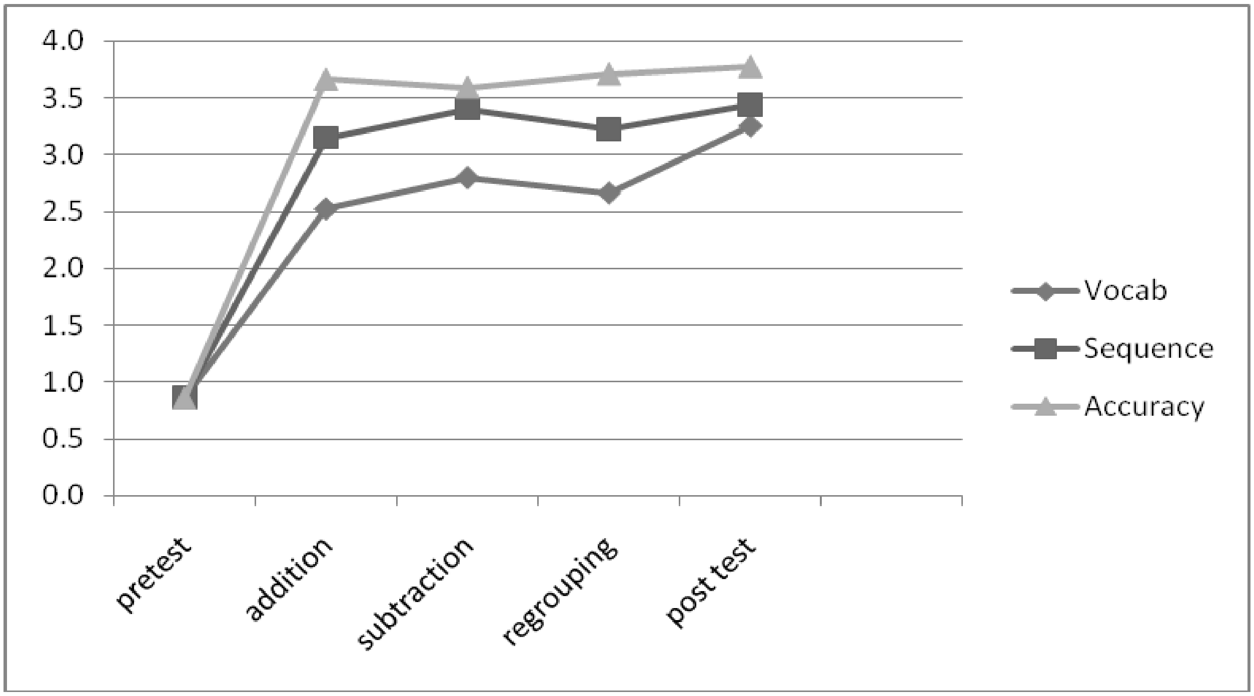

Figure 1.Thinking Map® Flow Map Class Mean Scores

The vocabulary mean score at pretest was 0.9, indicating use of inaccurate vocabulary or a lack of mathematical terms. Examples included using “top number” instead of numerator, or “plus” instead of “add.” Vocabulary scores increased with each new set of topics to mean scores of 2.5 for addition of fractions, 2.8 for subtraction of fractions, and 2.6 for problems involving regrouping. The vocabulary posttest mean score was 3.3.The gradual improvement in these scores indicated use of more precise terms, such as “find the least common factor.”

The sequence score (ability to delineate the correct order and details in operations) at pretest was 0.9 indicating lack of experience in this skill. Mean scores for sequencing increased to 3.1 for addition of fractions, to 3.4 for subtraction of fractions, and to 3.2 for problems involving regrouping. The sequencing posttest mean score was 3.4. Students produced near-accurate results in sequencing.

Mean scores of 0.9 reflected lack of skill in accuracy on the pretest but increased for addition of fractions to a mean score of 3.7, for subtraction of fractions to a mean

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score of 3.6, for problems with fractions involving regrouping to a mean score of 3.7, and a posttest mean score of 3.8.

The collective mean on TMFM scores increased as the collaboration cycles progressed. The scores increased most for accuracy and the least for vocabulary.

Snapshot and Benchmark Scores

Snapshot scores allow teachers to quickly identify student progress or lack thereof. Table 2 lists these snapshot results. At the time of the pretest, no student (0) had yet mastered the fractions concepts. After completing this project, eight of the twenty participants scored at the mastery level (70%). Six students demonstrated “adequate progress” towards mastery of the concepts by achieving at least a 20 percentage point increase between pretest and posttest scores. Six students did not make adequate progress. Furthermore, teacher records indicated that the three students classified as English language learners showed positive gains. Two scored more than 70% on the posttest and the third showed adequate progress. The student with special needs did not achieve mastery at the 70% criterion but did show adequate progress with a gain of 47 percentage points between pretest and posttest scores. The results also indicate positive gains from pretest to posttest for the class as a whole. A paired sample t-test revealed that the difference between the pretest mean (4.5) and the posttest mean (8.05) was statistically significant at the 95% confidence level, t (19) = -4.32, $p< .05$.

Table 2

Number of Students Progressing Towards Mastery on Fraction Snapshot Measures

N=20	Mastery	Adequate	Inadequate
Pre-test scores	0	NA	NA
Post-test scores	8	6	6

District benchmark scores before the study began (fifth grade scores), during the course of the study (October), and after the study’s conclusion provided insight into general mathematics ability. As shown in Table 3, 17 students started sixth grade with a mastery rating of fifth grade mathematics concepts. One student was rated as approaching, one had not mastered concepts, and rating scores were unavailable for a student new to the district. At the October measure, 16 students remained at the mastery level, three were approaching benchmark goals, and one had not mastered mathematics concepts to date. Nine weeks later, at the conclusion of the study, 17 students demonstrated mastery of benchmark goals, one student was classified as approaching, and two ranked at not mastered.

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Table 3

Number of Students Progressing Towards Mastery on Benchmark Measures

Benchmark	Fifth Grade Benchmark	October Benchmark	December Benchmark
Mastery	17	16	17
Approaching	1	3	1
Not Mastered	1	1	2
Not Available	1	0	0

Analyzing for individual differences, the three students classified as English language learners scored as mastered, as did the student identified with special needs. Fractions content continued to be difficult for three students, however. The student who entered sixth grade without mastery of fifth grade content scored as approaching the demands of the sixth grade curriculum in October, but nevertheless scored as not mastered in December. One student dropped from mastery in October to approaching in December, and another dropped from mastery in fifth grade to not mastered on both October and December measures. Although these three students did not show adequate progress on district benchmark scores, the informal snapshot test developed by the sixth grade team indicated remediation was not necessary at that point.

Observation and Field Notes

Observation and field notes revealed rich student discourse and active engagement during their work in collaborative groups. Vocabulary often focused discussion with reminders from students to each other to say “plus” instead of “add,” “minus” instead of “subtract” and the more precise use of “sum, difference, product, or quotient” instead of the generic “answer.” When students used simplistic terms while negotiating sequence and accuracy in their TMFM, the phrase “that’s so fifth grade” evoked more precise mathematical terms and students began to listen carefully for an opportunity to use those words and began to monitor their own discourse so they did not get tagged with that moniker.

Field notes and student quotes also indicated student engagement and time on task while developing and recording podcasts. The class looked forward to the recording days. Representative comments included, “Do we get the computers out?” “Are we podcasting today?” “Can we come in at lunch recess to finish?” and “Will you be here after school, so we can work on our podcast?” Representative samples of the podcasts can be accessed at http://applepodcast.peoriaud.k12.az.us:16080/weblog/cshea/. A transcript of a representative podcast is provided in Figure 2.

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El Pollo Loco:	This is radio 1727100000
Ironhide:	Wow that's a mouthful!
El Pollo loco:	Hi this is el Pollo Loco a.k.a. Crazy Chicken coming to you live from the classroom as with me as always is Ironhide, Cookie Monster, and Pamila.
Ironhide:	We are going to be subtracting 9 3/8 by 6 5/8. Did you know that 3/8 can't be subtracted by 5/8?
Pamila:	First you regroup from the 9 to make 8/8 add to the 3/8 to make 11/8 that means the 9 is an 8. Next you subtract the numerators.
Cookie Monster:	Then the fractions when they are subtracted is 6/8. Then you subtract the whole numbers, the whole number subtracted is 2.
Ironhide:	Then you simplify 6/8 by 2 and then you have the answer of2 ¾.
El Pollo Loco:	Thanks for turning to radio 1727100000. Adios mis amigos.
All:	Boom chicka wa waaa chicka chicka wa waaa, WORD.
El Pollo Loco:	WORD

Figure 2: Transcript of Podcast for Subtracting Mixed Numbers

Student Survey

Qualitative analyses of comments from the student survey were predominately positive in nature. Student responses such as "it was fun," "I learned more" and "I liked working together," suggest that most of the participants enjoyed the increased collaboration and enhanced discourse expectations. Less positive comments suggested that varying ways to learn content to some was "very difficult," or "too complicated." Other students expressed dissatisfaction with required collaboration, making statements such as "I did it all" and "…it gets confusing when you try to explain." Increased expectation for writing was troublesome to one student who "did not want to write."

Implications

Buoyed by Stringer's (2007) challenge to educators, we focused on an issue of importance to us, turned theory into practice, and are now telling the story of this work. This action research study combined discourse and technology in an area of the mathematics curriculum that is difficult for sixth grade students (fraction operations) and yet, is essential as a foundation for higher level mathematics such as algebra and calculus. Rewarding individual learning and collaborative negotiation of mathematical concepts with the opportunity to communicate knowledge through podcasting maintained interest, cooperation, and increased student discourse about fractions in the areas of vocabulary, sequence, and accuracy.

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The action research design of this study met the needs of the teacher who identified a problem, planned an implementation, and interpreted and reflected upon the results to inform subsequent practice (Mills, 2007). The strength of this design, solving a local problem and seeking solutions for improved practice, could also be considered one of its major limitations. This action research project was considered a one-group pretest posttest study that was conducted in one teacher's classroom. Accordingly, the effects of the intervention cannot be measured against a similar group of sixth graders, with similar demographic features, during a similar time in history. The results are complicated by the fact that an increase in ability to add, subtract, and reduce fractions would be expected for any sixth grader who received nine weeks of instruction in the subject. Therefore, one cannot totally attribute the academic growth noted in this study to the effect of the intervention. Future research could use an experimental design to further investigate the effectiveness of mapping and podcast technology, or similar strategies, with diverse groups of students. Nevertheless, with cautions regarding interpretation noted, several implications arise based on these findings.

During the course of the study, the students produced relatively high levels of achievement on a teacher created, criterion-referenced measurement, indicating that the goal to accurately add or subtract proper fractions and mixed numbers, with unlike denominators, with regrouping, was met for most students. Differences from pretest to posttest demonstrate that 14 out of 20 students achieved mastery or approaching mastery levels at the end of the nine week intervention. Four of the remaining six students increased their scores over the course of the intervention, but not enough to reach the approaching mastery level. Only two students did not show a measurable increase in scores. Students who started with strong scores also ended with strong scores. The students in the middle, the English language learners, and the student with special needs, in general, showed increased knowledge about fraction operations. District benchmark measures corroborated these results. Despite the increasing difficulty of the mathematics curriculum between fifth and sixth grade, students maintained high levels of curriculum mastery, with 90% of the class at the mastery or approaching mastery level. Similarly, rubric scores revealed that students increased their skills in explaining how to complete problems involving fractions, thus meeting the goals of communicating coherently and demonstrating conceptual understanding of a mathematical argument through models. Emphasis on building mathematics communication skills resulted in large improvements in sequence and accuracy, and somewhat smaller improvements in vocabulary, or using the precise mathematical terms. The podcasts, observations, field notes, and student survey results supported this progress in conceptual understanding and verified that the students were using digital media to communicate and work together collaboratively.

For the teacher, these results indicated that this method of increasing discourse in math through collaboration and technology integration was successful. The possibility of applying this experience to other mathematical concepts or with subsequent groups

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of students was encouraging. Thus, the project achieved what Lincoln and Guba (1985) term a high degree of transferability. Furthermore, we demonstrated that positive results can be achieved using tools that were generally available and accessible to the classroom: extrapolations from district assessments, TMFM templates available in the district and known to the students, and a small number of classroom laptops (5) loaded with the appropriate software.

With this in mind, we also wish to discuss the limitations of the instruments available for this study. Increasingly, teachers are asked to make data driven decisions as they plan instruction. In this case, the testing instruments (snapshot tests and the district benchmark tests) were in a multiple choice format and did not ask the students to explain how they derived the answer. Although state and local standards require students to communicate using grade level appropriate mathematical terminology, the assessment instruments do not measure this requirement. The use of the TMFM rubrics and observation measures provided data to support student increases in the ability to communicate mathematical thinking and demonstrate conceptual understanding, but these measures were specific to the project and not widely used in the district. This study provides insights into gaps between what teachers see and experience in day to day indicators of student progress and the standardized tests that serve as the students' and teachers' official score keepers. The technology integration aspect of the study, using podcasts, produced artifacts of student work that provided evidence of achievement and can serve as a valid and accurate indicator of student success. It is our hope that more authentic measures such as these can serve to eventually expand the very narrow definitions of learning and achievement currently in operation.

More importantly, this study helps to establish a beginning evidence base that seeks to examine for whom technology integration is most useful. As indicated, the higher achieving students began and ended the project with high scores. The students in the middle, and those with identifiable special needs appeared to benefit the most from these activities. The lowest achieving students were still struggling, but most were making progress. Further research could investigate results of using class-wide technology integration to increase mathematical discourse on the achievement of disaggregated groups of students, which was beyond the scope of this study.

When designing the technology integration aspect of this study, it was important for us to remember that a problem-based task should guide the use of the technology, not the other way around (Porter, 2010). Accordingly, the technology we used became an integrated element of the project and served as an appropriate vehicle to motivate and inspire students to regard their work in mathematics as meaningful and helpful to themselves and other students. The podcast seemed to contribute to the students' self-confidence as they mastered new tools and used socially connected technologies to learn concepts in the mathematics curriculum. Podcasting was the "carrot" that took students on a journey to demonstrate conceptual understanding, explain a solution

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beyond just the answer, develop a deeper understanding of the content, and see that knowing the content and the ability to communicate that knowledge are one and the same (Brozo & Puckett, 2009). Nevertheless, the results indicate that for most students it was still easier to get the right answer than it was to describe how to obtain it using appropriate mathematical vocabulary. As noted by Stigler and Hiebert (1999), communicating mathematics thinking is more rigorous a task than finding a solution.

Finally, using current technologies in teaching mathematics specifically, and in classroom instruction more generally, is still a new phenomenon for most elementary and middle school students. As educators and action researchers, we strongly believe that effective technology use leads to higher levels of student achievement, motivation, and engagement in the learning process. And although technology integration is encouraged by a multitude of researchers and organizations, few studies test its use on achievement in mathematics (Edyburn, Fennema-Jansen, Hariharan, & Smith, 2005; Franklin & Peng, 2008). Continuing advances in computers, hand-held devices, and web-based software could increase research interest in this area.

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