

"I learned how all the math we have been doing works."

The effect of RAFT hands-on activities on student learning, engagement, and 21st century skills

Submitted by

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Executive Summary

Since 1995, Resource Area for Teaching (RAFT®) has deployed an innovative, award-winning model for making hands-on activities affordable and accessible to educators. In spring 2011, Rockman et al (REA), an independent educational research, evaluation, and consulting firm in San Francisco, conducted a study of the impact of two RAFT hands-on mathematics activities on student learning, engagement, and 21st century skills. The primary purpose of this evaluation was to provide quantitative evidence of the effect of RAFT hands-on activities on students' knowledge and engagement. Secondary purposes were to observe teachers' implementation of RAFT hands-on activities and receive feedback about activity engagement directly from students. Study participants included English language learners, special needs populations and students from a broad spectrum of socioeconomic statuses. Key findings are:

- **Learning.** Students improved their ability to solve or set up word problems after engaging in the RAFT hands-on activities.
- **Engagement.** Students responded positively to the RAFT activities, labeling them as fun, interesting ways to learn and solve problems.
- **21st century skills.** Classroom observations and student surveys revealed the additional benefits of the RAFT activities, such as the development of teamwork, a key 21st century skill.

Students' written comments about the activity included:

- **[I learned]** *how all the math we have been doing works*
- *That if each of you has a job on that team, you will succeed*
- *I learned how to make a problem from things in real life and how to solve them*

Data Collection and Methodology

This study involved 17 4th – 6th grade teachers who taught a total of 458 students in 23 classes. Fourth grade teachers taught Frack Jack©, a RAFT hands-on activity that teaches fraction concepts within a card game. Sixth grade teachers taught Salmon You Can Count On©, an activity that uses proportions to predict the total population of "salmon" (i.e., plastic chips) from the distribution found in "captured" samples. These kits are representative of all of RAFT's hands-on activities.

For both activities, teachers administered a brief pre-quiz prior to the activity and then administered a post-quiz one or two days after the activity. The quizzes each contained five multiple choice and short answer questions in which students had to identify fractions or proportions, set up or solve word problems, and perform calculations. REA and RAFT staff also observed nine classes using a structured protocol. Observers looked for evidence of students' application of mathematical knowledge, engagement, and collaboration (an important 21st century skill), as well as details about teachers' implementation of the activities.

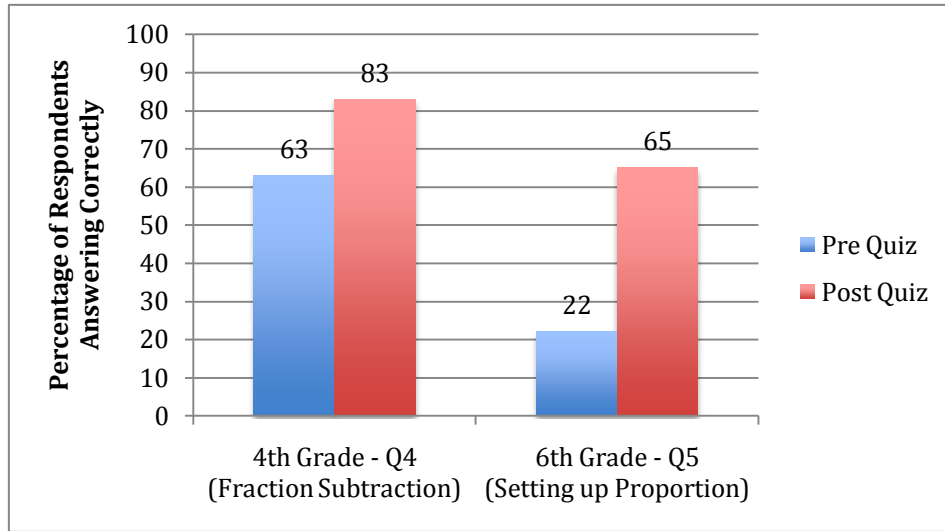
Key Findings

- 1. Learning. Students improved their ability to solve or set up word problems after engaging in the RAFT hands-on activities. Specifically, students correctly answered questions about subtracting fractions and setting up proportions more often on the post-activity quiz than on the pre-quiz. Classroom observations link these learning gains to the work students did during the hands-on activities.**

In general, students came into the hands-on activity with prior knowledge about fractions and proportions, and came out better able to apply that knowledge to new problems. Most students (73-85%) correctly answered two pre-quiz items that measured their understanding of basic math concepts. For instance on the pre-quiz, most 4th grade students could already select the smallest fraction from a list of choices, while 6th grade students could construct a ratio using information from a data table.

After the RAFT hands-on activity, students made gains in three of the five items on which they had not scored highly before. Students improved the most on questions requiring them to apply their math knowledge to complex problems: subtracting a fraction from a single whole object (4th grade) and setting up proportion problems (6th grade) (Figure A).

Figure A: 4th and 6th Grade Pre and Post Quiz Results
(4th Grade, 155 students; 6th Grade, 258 students)



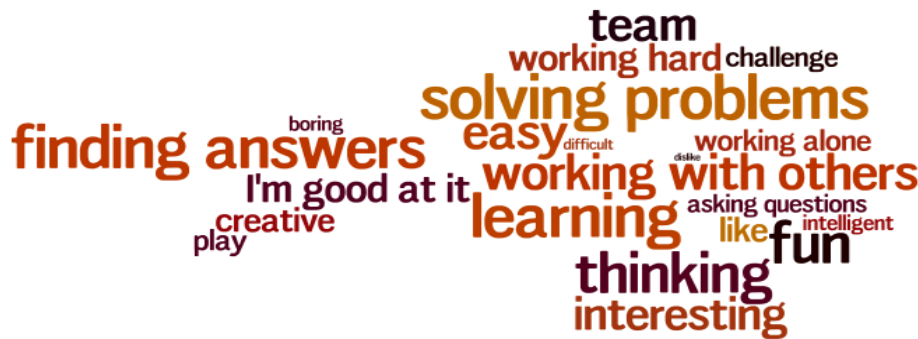
Students' quiz performance followed logically from their observed behavior during their RAFT hands-on activity. In both the 4th and 6th grade activities, students applied mathematics skills by solving problems with hands-on materials. During Salmon You Can Count On, for example, students repeatedly set up and solved proportions to estimate the population of a group from a smaller sample. In Frack Jack, they had to put together fractions to make a whole circle without going 'bust'. These experiences appear to have led directly to improvements on the post-quiz. The pattern of quiz responses also suggests that the activities were well-designed to expand the teachers' existing curriculum and build on students' math skills.

2. Engagement. Students responded very positively to the RAFT activities, labeling them as fun, interesting ways to learn and solve problems.

Students not only had the chance to apply their math skills in the RAFT activities, but did so in a stimulating environment. On the post quiz, students read a list of 21 words and circled the ones that they felt best described the activity they had just done. This list included positive descriptors such as 'fun' and 'creative,' negative words such as 'boring' and 'dislike,' and skills such as 'solving problems' and 'working with others.'

The results were overwhelmingly positive for both the 4th and 6th grade groups. 'Fun' was the number one descriptor for the 4th graders, followed by 'learning' and 'I'm good at it' in a tight race for second. Negatives such as 'boring' and 'dislike' were at the bottom of the list. The vast majority of students used only positive words to describe their activity (92% of 4th graders and 80% of 6th graders). For 6th graders, 'solving problems,' 'learning,' and 'finding answers' were all in a clump at the top of the list, followed by 'fun' and 'thinking' in second. Again, the more negative descriptors fell towards the bottom of the list (Figures B and C).

Figures B and C: 4th grade hands-on activity descriptions (155 students), 6th grade hands-on activity descriptions (258 students)



Furthermore, when asked what they learned from the activities, students most commonly mentioned the mathematical skills they learned or improved as a result of the activity. Students took this opportunity to comment on how ‘fun’ or ‘cool’ the activity was. Some also talked about teamwork, with several comparing working in a team favorably to working alone. Students also commented positively on the fact that the activity was hands-on. Specific student comments included¹:

- *I learned that eyeballing isn't easy as touching when you estimate.*
- *I learned a fun way of doing math that involves teamwork.*
- *I learned proportions, rates, ratios, graphing, & more it was a cool way of doing things*
- *That sometimes everything has math.*
- *how all the math we have been doing works*
- *I think I learned and helped me understand the lesson better.*
- *I learned that hands on activity make learning fun.*
- *I learned that lerning isent all about siting in a desk with a paper and a pencil*
- *I learned how to cross multiply and I understand fractions more.*

¹ All quotations are transcribed as they appeared in the student surveys. They preserve students' grammar, spelling, and ideas as authentically as possible.

When asked if they would like to do additional hands-on activities like the RAFT activity, the majority of students answered affirmatively, with 98% of fourth graders and 91% of sixth graders selecting “yes” or “maybe” (Figures D and E).

Figure D: 4th Grade: “Would you like to do more hands-on activities like this?” (149 students)

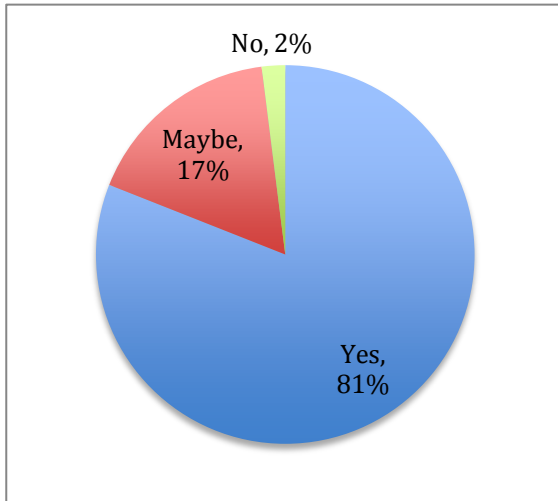
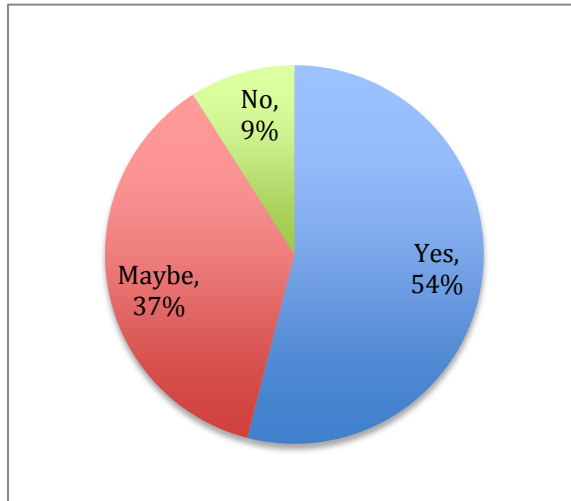


Figure E: 6th Grade: “Would you like to do more hands-on activities like this?” (248 students)



3. 21st century skills. Classroom observations and student surveys revealed the additional benefits of the RAFT activities, such as the development of teamwork, a key 21st century skill.

During the activities, students had to work together to solve problems and experienced the highs and occasional lows of being part of a team. In one Frack Jack classroom for example, students encouraged each other in choosing whether to continue adding pieces to their circles. In a mix of Spanish and English, students teased each other with comments such as, “you’re gonna get busted” and revealed their continued learning and experimentation with comments such as “oh I never knew that!” Students in this classroom showed outstanding teamwork and interpersonal reinforcement, while relying on their spatial reasoning to determine fractional equivalents.

Additionally, more than half of the 4th graders mentioned creativity and working with others – key components of 21st century skills - as phrases that described their activity. For 6th graders, ‘solving problems’ and ‘working with others’ were prominent selections. Student comments included:

- *I learned that I work better in group then by my self because it makes it funer and easy.*
- *That if each of you has a job on that team, you will succeed*
- *I learned how to make a problem from things in real life and how to solve them*

Conclusion

Rockman et al's evaluation of two RAFT hands-on activities demonstrates the ways in which a single, hour-long activity can have an immediate, discernable impact on students' learning, engagement, and 21st century skills. Not only did students enthusiastically embrace the opportunity to do hands-on work, they generally managed to stay on task, share responsibilities with their teammates, encourage one another, and develop mathematics skills in the process.

Our evaluation also documented numerous ways in which the quality of activity implementation influenced students' success. The most successful teachers scaffolded the RAFT hands-on activities for their students, whether by providing a "word wall" of mathematics vocabulary, closely monitoring group behavior, or even bringing in a whole salmon to illustrate exactly what the small plastic chips in the activity were meant to represent. We encourage further thought as to how best to leverage and share those promising implementation strategies so that all teachers – even those who may be less experienced with hands-on activities – can get the highest return on investment from RAFT's hands-on activity kits.