Using Multimedia to Enhance Word-Problem Instruction in First-Grade Math Classes

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Word problem-solving skills help students apply conceptual math procedures to real-life situations, and instructors need relevant methods to teach these skills so that students reap the benefits. Motivation is a key element in authentic learning, and the allure of digital may be just the motivation learners need (Malone, 1981) to tackle word problems. Results from a recent national survey of 2,000 third- through twelfth-graders revealed that children spend more than six hours of non-school time per day using media, especially “new” media such as the Internet (The Kaiser Foundation, 2010). Since children choose to spend free time consuming media, aligning teaching styles with media could be a key to capturing their attention for school subjects as well (Proserpio & Gioia, 2007). In fact, several education experts (Amhag & Jakobsson, 2009; Hughes & Daykin, 2002; Jin, 2005) have suggested that combining media design with problem solving makes students more active participants in learning, as opposed to passive recipients. The constructivist approach to learning offered through multimedia helps students take greater ownership for their learning paths, and should foster greater knowledge transfer to the real-world, which relates back to the original teaching objective of word problem-solving instruction.

This proposal outlines an approach to teaching math word problem-solving skills to first-grade students in Texas. The goal of the proposed weeklong lesson is to enhance face-to-face instruction through multimedia. The learning objectives addressed in this project are outlined in the Texas Essential Knowledge and Skills (TEKS) for Mathematics students in first grade (Texas Education Agency, n.d.).

Description of Multimedia Experience

The multimedia lesson we created is called Rowdy Robot Math Roundup. It is accessible through the Internet in two versions: 1) a Flash-enhanced website, and 2) an HTML-only version that is suitable for slower connections and such devices as the iPod Touch, which is incapable of rendering Flash files. The Flash-enhanced website includes three short videos, dynamic text, a cascading style sheet, audio sound effects, navigation controls, animation, and interactivities. The HTML-only mobile version includes three videos fed through YouTube, audio podcasts, navigation, a cascading style sheet, and HTML-based activities. Both versions include teacher resource materials to supplement the online experience, and are designed to meet the TEKS learning objectives for first-grade math students.

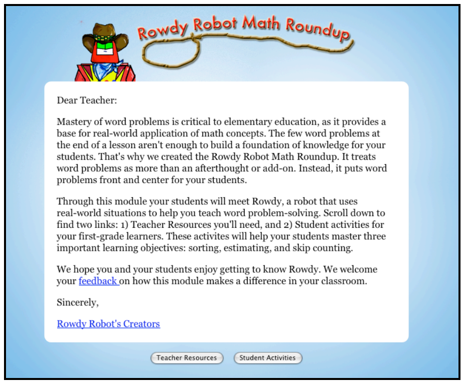
Description of the Flash-enhanced Website and HTML-only Mobile Versions, with Screenshots

The Rowdy Robot Math Roundup Flash-enhanced website and HTML-only mobile version both incorporate cascading style sheets, a logo, and robot characters that link the pages conceptually and visually. The websites were designed with two distinct paths: one for teachers and one for students. Following are descriptions of each distinct path and the reasoning behind the instructional design decision.

Teacher's Path through Rowdy Robot Math Roundup

The teacher's path begins with the index page, featuring a letter to first-grade math instructors that outlines the high-level objectives for Rowdy Robot Math Roundup (see Figure 1a for Flash-enhanced website version and Figure 1b for the HTML-only mobile version). At the bottom of the page are: a link to associated teacher resources (see Figure 2a for the Flash-enhanced website version and Figure 2b for HTML-only mobile version), and a link to the gateway to three multimedia activities for students (see Figures 4a and 4b, which serve as the student home page in the respective versions). Each version of the home page includes a mail-to:

link that gives users an easy way to provide the creators with feedback on their Rowdy Robot experience. This feedback could easily be used to update, enhance, and extend the experience.



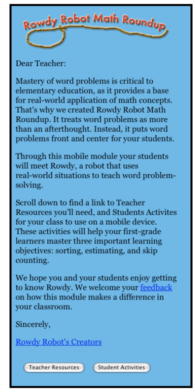


Figure 1a. Home page -- Flash-enhanced Website Version

Figure 1b. Home page – HTML-only Mobile Version

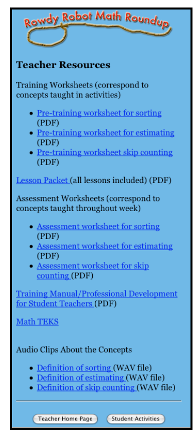


Figure 2a. Teacher Resources – Flash-enhanced Website Version

Figure 2a. Teacher Resources – HTML-only Mobile Version

Both the Flash-enhanced website and HTML-only mobile versions of the teacher resources include a link to a website containing the first-grade Math TEKS, short audio clips that use child-friendly language to explain the concepts covered in this lesson, and the following PDFs: 1) a training manual for teachers, 2) a lesson plan packet for teachers, 3) pre-training worksheets for students, and 4) assessment worksheets for students (see Figures 3a through 3d).

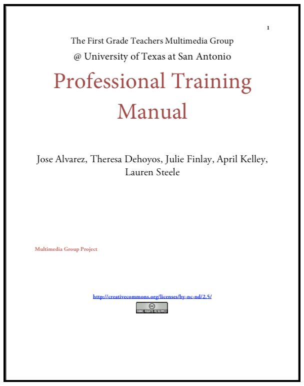


Figure 3a. Training Manual – Cover Page

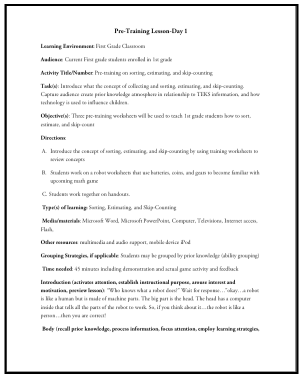


Figure 3b. Lesson Packet Sample Page

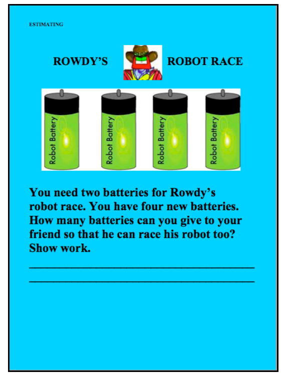


Figure 3c. Sample Pre-training Worksheet

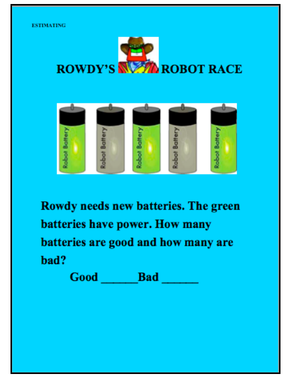


Figure 3d. Sample Assessment Worksheet

After reading though the teacher resource materials, the intended teacher's path is to click on the "Activities for Students" (see Figures 4a and 4b) link to explore the three Flash-based word-problem activities. This page will open in a new window and serve as the beginning of the student's path (see Student's Path description below). The teacher's path concept is intended to provide instructors with a comprehensive experience of the site. For more detail on the intended user experience for the instructor, please see Use Case #1 on page 12 of this paper.

Student's Path through Rowdy Robot Math Roundup

The student's path begins with the student activities home page, featuring an age-appropriate design and a guide named Rowdy Robot. In the Flash-enhanced website version (see Figure 4a), the page opens in a new browser window, leaving the teacher experience behind. This design decision was intentional to keep student users focused on the content developed for them. The teacher may consider hiding the instructor-targeted content that appears in the separate window to aid this goal. Due to technology restraints and the nature of the iPod Touch device, the HTML-only mobile version of Rowdy Robot's student home page does not open a new window (see Figure 4b).

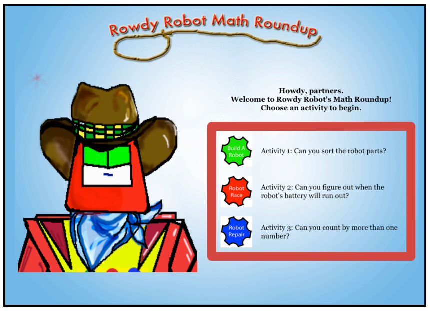


Figure 4a. Student Home Page – Flash-enhanced Website Version

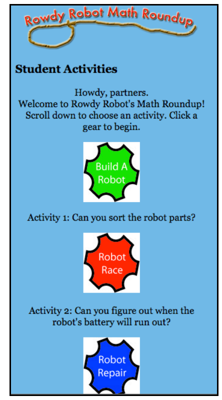


Figure 4b: Student Home page -- HTML-only Mobile Version (Note: Image truncated)

Links from the student home page take the learner to three different activities, each preceded by a short video to capture attention and prepare learners for each activity. In the Flash-enhanced website version, the videos play through the Flash interface. In the HTML-only mobile version, the video link takes the user to the YouTube Website to view the video.

To gain the optimal learning experience and incorporate the proven concept of scaffolding, learners should complete the activities in the linear succession provided. However, if using the navigation options from the student home page, users will be able to complete the activities in the order they choose. The student home page with links to all the activities should be a helpful asset to the instructor on Days 3 and 4 of the weeklong lesson, as it will facilitate the students' swift navigation to where they left off the previous day.

To reach the goal of reducing cognitive load with these activities, we incorporated the following five tenets of Mayer's Cognitive Theory of Multimedia Learning (2008): *pre-training* through face-to-face instruction and worksheets, *segmenting* through self-paced navigation, *personalization* through friendly language, *redundancy* through audio that reinforces visuals, and *spatial contiguity* through careful placement of text and visuals in close proximity on the page. In the Flash-enhanced website version, we attempted to maximize student understanding by incorporating virtual manipulatives (Moyer, Bolyard, & Spikell, 2002), or interactive digital graphics. Students working through the first activity ("Build a Robot") interact with virtual robot parts, manipulating them to solve word problems, and seeing relationships between objects as a result of their own actions. For more detail on the intended user experience for students, please see Use Case #2 and #3 starting on page 13 of this paper.

The first activity, "Build a Robot," addresses the TEKS learning objectives of collecting and sorting data, using logical reasoning to identify attributes, and using tools and technology to solve problems (Texas Education Agency, n.d.). The Flash-enhanced website version (see Figure 5a), challenges learners to sort robot parts from a bank of parts, then to click-and-drag them to corresponding spots on a robot. This requires the student to exercise sorting skills to identify colors, shapes, and numbers in order to successfully complete the activity. The HTML-only mobile version of "Build a Robot" (see Figure 5b) presents learners with a video link and static graphic, then challenges learners to identify attributes (e.g., colors and numbers) to answer multiple-choice questions using an HTML-based interface.

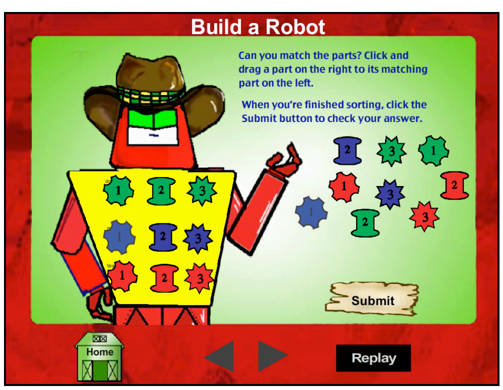


Figure 5a. Build a Robot -- Flash-enhanced Website Version

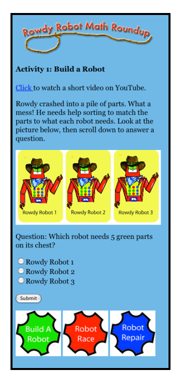


Figure 5b. Build a Robot – HTML-only Mobile Version (Note: Image truncated)

In the Flash-enhanced website version, audio acknowledgement and visual cues indicate activity progress and completion. Successful completion results in audio acknowledgement and the ability for a user to proceed to the next activity (e.g., navigation controls are enabled). In the HTML-only mobile version, successful completion leads the learner to the next activity. Unsuccessful completion in the Flash-enhanced website version prompts onscreen feedback and allows the user more chances to try to solve the problem correctly. After two unsuccessful tries, the correct solution is displayed for the student, and navigation is enabled to move on with the lesson. In the HTML-only mobile version, learners have unlimited tries to answer the two questions correctly, and when that goal is achieved, they can move on.

The second activity, “Robot Race,” addresses the TEKS learning objectives of pattern identification, time measurement, and estimation (Texas Education Agency, n.d.). In the Flash-enhanced website version (see Figure 6a), a learner-paced video and animation set the stage for a multiple choice word problem interactivity that challenges the learner to exercise estimation skills. The HTML-only mobile version (see Figure 6b) presents learners with a video link and static graphic, then poses a question about estimation, using an HTML-based interface.

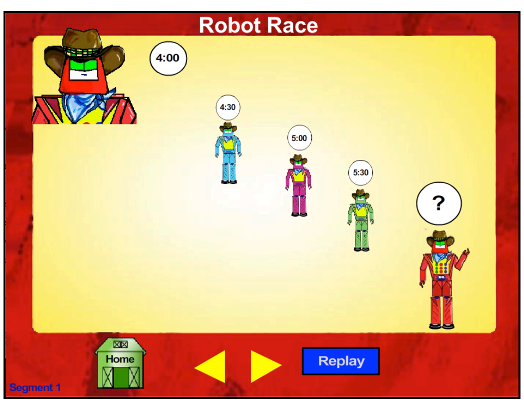


Figure 6a. Robot Race – Flash-enhanced Website Version

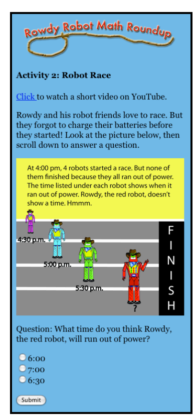


Figure 6b. Robot Race – HTML-only Mobile Version (Note: Image truncated)

As with the “Build a Robot” activity, in the Flash-enhanced website version, audio acknowledgement and visual cues indicate activity progress and completion. Successful completion results in audio acknowledgement and the ability for a user to proceed to the next activity (e.g., navigation controls are enabled). In the mobile version, successful completion leads the learner to the next activity. Unsuccessful completion in the Flash-enhanced website version prompts onscreen feedback and allows the user more chances to try to solve the problem correctly. After two unsuccessful tries, the correct solution is displayed for the student, and the navigation is enabled to move on with the lesson. In the HTML-only mobile version, learners have unlimited tries to answer correctly, and when that goal is achieved, they can move on.

The third activity, “Robot Repair,” addresses the TEKS learning objectives of patterns and algebraic thinking (as evidenced in skip counting), coin identification and value, and identifying math in everyday situations (Texas Education Agency, n.d.). The Flash-enhanced website version of “Robot Repair” (see Figure 7a) starts with a learner-paced video and animation, then presents the word problem in two parts, with the learner using the answer in the first question to solve the second one. The HTML-only mobile version (see Figure 7b) presents learners with a video link and static graphic, then poses questions that require the student to exercise skip-counting skills, using an HTML-based interface.

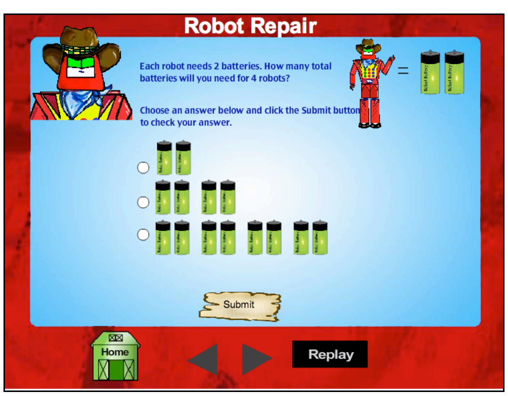


Figure 7a. Robot Repair –
Flash-enhanced Website Version

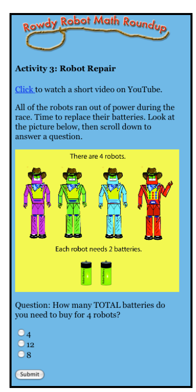


Figure 7b. Robot Repair –
HTML-only Mobile version (Note: image truncated)

As with the “Build a Robot” and “Robot Race” activities, in the Flash-enhanced website version, audio acknowledgement and visual cues indicate activity progress and completion. Successful completion results in audio acknowledgement and the ability for a user to proceed to the next activity (e.g., navigation controls are enabled). In the HTML-only mobile version, successful completion leads the learner to the next activity. Unsuccessful completion in the Flash-enhanced website version prompts onscreen feedback and allows the user more chances to try to solve the problems correctly. After two unsuccessful tries, the correct solution is displayed for the student, and the navigation is enabled to move on with the lesson. In the HTML-only mobile version, learners have unlimited tries to answer correctly, and when that goal is achieved, they can move on.

Literature Review

On the surface, solving word problems successfully may seem to require that math students know only how to search for key words in the problem, translate those words into mathematical symbols and formulas, and then apply those formulas. However, this direct translation is merely a structural extraction method, likely to produce short-term success at best (Jonassen, 2003). The aim of word-problem instruction should be to give students real-world application of mathematical formulas, and to make students understand math concepts at a deeper level, balancing procedural and conceptual knowledge attainment (Stylianou & Shapiro, 2002). Students will not achieve long-term learning objectives unless they comprehend word problems at a conceptual level. Complementary use of multimedia in instruction could aid that desired level of understanding, especially when the multimedia materials have been developed by a skillful instructional designer who understands learning theory and uses technology to make learning more meaningful (Moallem, 2003). In addition, an informal approach to teaching math may help students who have difficulty learning in a more traditional or formal setting (Wedege, 1999). And finally, considering that students are motivated to use computer-based technology in their free time (The Kaiser Foundation, 2010), adapting the same technology to achieve learning goals such as word problems is worthy of deeper experimentation. Rowdy Robot Math Roundup takes all these factors into consideration.

Deeper learning in math occurs when instruction includes a variety of grounding representations or metaphors that build on a learner's existing knowledge and everyday experiences (Land, 2000). Visual representations play an important role in that engagement for math instruction (Sedig, 2008). Interactive computer-based learning is most successful when it employs this same approach (Moreno & Mayer, 1999). That is why Rowdy Robot Math Roundup builds on a first-grade student's emerging computer literacy, and uses visual representations within the word problems to which students can relate (e.g., building a robot with available parts like they might do with a robot toy, guessing who will progress in a race, and buying and replacing dead batteries). We argue that both the Flash-enhanced website and HTML-only mobile versions of Rowdy Robot Math Roundup will be effective because they were built with learning goals and objectives in mind, while striving for high levels of usability and interactivity for the intended audience (Góméz & Mateos, 2004). Based on Mayer's Cognitive Theory of Multimedia Learning, this website's interdependent use of words and pictures should engage learners through dual sensory inputs, increasing the chance to foster deeper, more authentic learning (Mayer, 2008).

Adding sample word problems to the end of a lesson that addresses a single concept may be an obstacle to deeper learning. This instructional approach allows students to merely mimic the formulas used in the top-of-mind instruction they have received, potentially without fully understanding the conceptual relationship of the problem's elements (Weber-Russell & LeBlanc, 2004). This approach is not mentally demanding and may lead to formulaic direct translation from words to symbols without fostering deeper learning. To address this obstacle, Rowdy Robot Math Roundup is a single instructional unit focused on word problems themselves, and covering multiple math concepts instead of replicating just one in word-problem form. We believe this approach will address the issue of solving word problems to promote understanding and application of concepts to real-life experience.

Description of use cases

Use Case #1: First-grade Math Instructor's User Experience of Rowdy Robot Math Roundup

Before committing to using the Rowdy Robot multimedia lesson, the instructor should read through all the materials provided through the URL, determine if the lesson will help meet the learning goals of the particular classroom, and assess whether the equipment requirements can be met. Using this module requires at least one Flash-enabled computer with Internet access and/or an iPod Touch. If deemed a good fit for the classroom, the instructor should plan to devote one full week of math class time to teaching word problem-solving skills using the Rowdy Robot lesson. That week should accommodate both online and offline activities, as this module is intended to complement face-to-face instruction.

Before the week begins, the instructor should read through the lesson plans and make enough copies of the pre-training and assessment worksheets for all the students in the class. The teacher may choose to group students or have them work individually, depending on equipment availability, learning styles, and other factors particular to the classroom of learners. Using the lesson plan packet provided, the teacher can develop a customized lesson plan, based on the specific needs of the students. The first day of the week should focus on face-to-face pre-training instruction, including an explanation of word problems, word and function equivalencies, and completion of age-appropriate word-problem worksheets provided for students to solve alone or with peers. Three days of instructions using the Flash-enhanced website or HTML-only mobile version of the website should follow. The last day of the lesson should be devoted to assessment. Each day the teacher can assess student comprehension of the lessons through completion of online activities. The worksheets can also be used as homework.

The following two use cases address actual instruction of the lesson in the classroom, depending on the equipment.

Use Case #2: User Experience of Rowdy Robot Math Roundup in a Classroom with Multiple Computers or Mobile Devices

In a classroom with multiple computers or mobile devices, the instructor should assess if there are enough for each student to have his or her own online experience, or if students should be paired or grouped so that they share a computer or mobile device. The instructor should make this decision based partly on the equipment, but also through consideration of the learning styles of the students. In some classrooms with ample equipment, an instructor may decide to pair up some students and let others work independently. Days 2 through 4 should focus on use of the online module so that students start translating the concepts to real-life examples demonstrated through virtual manipulatives. The teacher should arrange beforehand with the school's technology specialist to make sure all the equipment is functional so that each student's learning experience potential is maximized.

Use Case #3: User Experience of Rowdy Robot Math Roundup in a Classroom with One Computer

In a classroom with a single computer, Day 1 should be devoted to face-to-face instructional pre-training. As with Use Case #2, Days 2 through 4 should incorporate use of a projector so that all students can “walk” though the online lessons as a group. The teacher should arrange beforehand with the school’s technology specialist to connect a projector to the classroom computer to make this experience possible.

If a projector is not available, the teacher may consider assigning the students to small groups and arranging the classroom into stations that feature activities related to the lesson. The groups could circulate among stations during the class period, spending just enough time at each station so that all are visited in the given class period. A sample configuration might be:

Station 1: Offline, complete pre-training worksheet as a group.

Station 2: Online, complete one Flash activity as a group.

Station 3: Offline, complete assessment worksheet as a group.

Additional offline activities that promote the same learning concepts as Rowdy Robot may be developed for a classroom that lacks equipment. One such hands-on activity might be using different-colored blocks or shapes to exercise sorting skills. The instructor may also consider having the students create their own word problems and challenge classmates to solve them.

Accessibility

If Rowdy Robot were to be used in an actual classroom today, a teacher would access the website on a computer capable of translating Flash programming through the URL: http://students.coehd.utsa.edu/group1/Final/web/index.html. To access the HTML-only mobile version, a teacher would use an Internet browsing-capable device and navigate to: http://students.coehd.utsa.edu/group1/Final/mobile/index.html. As described in the Use Case #1, the teacher should read through the whole site, including all the teacher resources to determine usability in the particular classroom. If the latest version of Flash is not installed on the computers the teacher plans to use to teach this activity, the teacher should contact the school's technology specialist to update the equipment, or plan to use the HTML-only version of Rowdy Robot Math Roundup, located at http://students.coehd.utsa.edu/group1/Final/mobile/index.html.

Summary and Conclusions

We propose the implementation of Rowdy Robot Math Roundup to assist instructors teaching their first-grade math students the concepts of sorting, estimating, and skip-counting. Its intended effectiveness in increasing a student's understanding of solving real-world word-problems with the use of these concepts relies on a framework of evidence-based research. In addition, its use of diverse multimedia is a manifestation of concepts learned at the University of Texas at San Antonio's College of Education and Human Development master's degree plan for Instructional Technology, making Rowdy Robot Math Roundup an engaging, interactive, and fun activity for young learners to experience. As a next step, we would relish the opportunity to test Rowdy Robot Math Roundup in a real classroom to test its effectiveness and improve the lesson based on feedback.

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