Integrating Computer Science into Middle School Mathematics

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Goal:

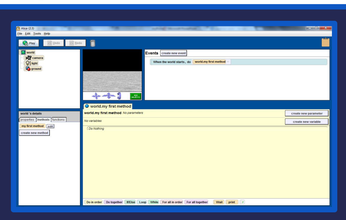
We having been researching ways to integrate computer science and computational thinking into middle school math topics using Alice. According to the Computer Science Teachers Association (CSTA), computer science education is at a "crisis" in K-12 education in the United States, and students need to gain more exposure to programming at an earlier age to solve this problem.

Implementation:

- Tutorials to build Alice worlds related to math and teach Alice programming concepts.
- Alice worlds to practice math concepts.
- Math challenge worlds.

Alice

- Alice is a virtual programming world for beginning programmers.
  - Contains a vast library of 3D objects.
  - Has computer science programming concepts such as methods, objects, loops, conditional statements, functions, and more.
  - Drag-and-drop interface
  - Useful for building games, animations, and telling stories.



Summer Workshops

Alice Teacher Workshop

- We hosted 2 teacher workshops over the summer. 25 teachers attended the beginner two-week workshop and 9 attended a week long follow-up workshop. At these workshops we:
  - Introduced the teachers to Alice.
  - Showed them some of our work and demoed other Alice worlds.
  - Taught then how to program and build worlds in Alice by going through tutorials.
  - Gave them an opportunity to create and present possible lesson plans to show how they would use Alice in their classes.

Teacher Survey

We surveyed 9 teachers about the classes that they taught, their opinions about the Common Core and CSTA standards, their views on using Alice in their classes, and new Alice tools that they would find useful.

- Their were many mixed views about the new Common Core Standards.
- None of the teachers had ever heard of the CSTA computer science standards.
- They wouldn't be able to take the time to teach students Alice.
  - Reserving laptops/computer labs for students
  - Using class time to teach students how to use Alice when they have other things to teach
  - Getting support and permission from administration

Mapping

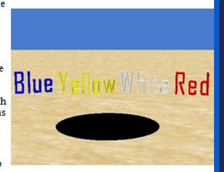
- Common Core Standards for Mathematics 5th - 12th grade

- CSTA Level 2 Standards (6th - 9th grade)

Tutorials

Math Tutorials

- Nonvisual Arrays
  - This tutorial shows how to create nonvisual arrays in Alice by using algebraic expressions.
- Nonvisual Arrays and Recursion
  - This tutorial presents how to use nonvisual arrays in Alice and also teaches the computer science concept of recursion with mathematical recursive functions (Fibonacci's sequence, Factorials, etc.)
- Probability World
  - This tutorial shows users how to create a probability game in Alice.



Alice Concept Tutorials

- Arrays
  - The purpose of this tutorial is to show how to use visual arrays in Alice.
- Astronaut-Humvee (short)
  - This is a shortened version of an introduction to Alice tutorial.
- Nonvisual Arrays
  - This tutorial shows how to create nonvisual arrays in Alice by using algebraic expressions.

Alice Concept Tutorial (cont.)

- Scene Change 2.0
  - This is the updated version of a tutorial that explains how to do scene changes in Alice.
- Nonvisual Arrays and Recursion
  - This tutorial presents how to use nonvisual arrays in Alice and also teaches the computer science concept of recursion with mathematical recursive functions (Fibonacci's sequence, Factorials, etc.)
- Visual Lists
  - This tutorial shows users how to use the ListVisualization object in Alice.

Worlds

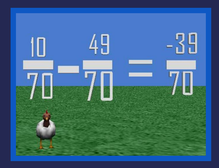
Basketball Math

- This Alice world is a basketball game that helps students practice multiplying decimals and whole numbers. The game is timed, and they receive points for each answer that they get right until the time runs out! An animation of the ball going into the goal is shown when they get a correct answer.

Fractions

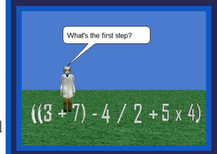
- This is an interactive Alice world that allows students to practice fraction arithmetic. Students can choose whether they want to add, subtract, multiply, or divide fractions. These problems are created randomly and the student will have the ability to reduce the problem when necessary.

Press 'A' for addition
Press 'S' for subtraction
Press 'M' for multiplication
Press 'D' for division



Order of Operations

- This world allows students to interactively practice the order of operations by clicking on the operator that should be done next in an expression. The expressions used in this world are all numeric and the students will be able to solve them at the end.



Challenges

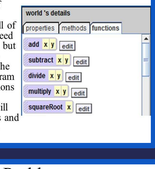
Boat Race Challenges

- This Alice world is a boat game where the player must drive a boat through 10 arches and it presents several challenges to the user:
1. Fill in the *average* function to find the average time the boat travelled between each arch.
2. Fill in the *average* function to calculate the total speed of the boat (distance over time).
3. Complete the *average* function to calculate the average distance between each arch, since they arches are randomly placed each game.
4. And finally, fill in the *win* method so that after each game, Alice prompts the user if they want to play again. Then, the *average* function should be completed to return the average time it took the player to race through the course per game.

Calculator Challenge

1. Starting Functions Challenge

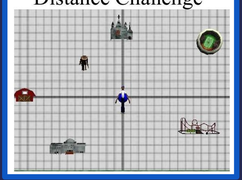
- Functions are chunks of code that return a value when they are called. All of the functions that you need have already been built, but right now they don't do anything except return the value 1. Finish the program by filling in these functions using Alice built-in functions so that they will return the correct values and make the calculator run correctly!



Other Challenge Ideas

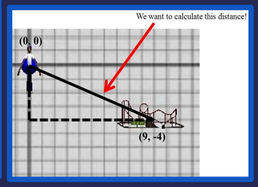
- Use loops to implement the exponent challenge, rather than the "a raised to the b power" function.
- Pretend that multiplication does not exist. Use loops and addition to create the same affects of multiplying two numbers together.
- Make a function to calculate the factorial of a number. (6 factorial = 6! = 6*5*4*3*2*1)
- Build a +/- button to easily switch between positive and negative numbers.
- Create other buttons to go with all of the Alice's advanced math functions (cos, sin, tan, ln, …) and add them to your calculator.

Distance Challenge



Problem

- It's Jimmy's first time in a new city, and we need to help him find his way around! He knows where he is located in the center at (0, 0) to start, and he also knows the coordinates of each place he wants to visit. Your job will be to fill in the distance function, to calculate the distance from Jimmy to his destination. You can move around the city by clicking on the different places of interest that you want to visit.
- 1 unit = 1 meter



Oak Grove Middle School

On November 30, 2012 we taught three 6th grade classes throughout the day. In each class, we:

- Showed demos of Alice
- Went through the shortened Astronaut-Humvee tutorial with the students and they built their own Alice world.
- Had them try out some of the math Alice worlds (Fractions or Order of Operation)

In general, we found that the students were really excited and enjoyed using Alice!

SIGCSE

March 6-9, 2013

- We presented a poster on Integrating Computer Science into Middle School Mathematics using Alice.

- We ran a workshop called "Experimenting With and Integrating Alice 2.3 into Many Disciplines" with Steve Cooper, Wanda Dann, and Jacobo Carrasquel, during which we displayed some of our Alice math materials.

Alice Activity Day

Activity Day Schedule
March 23, 2013 (Morning and Afternoon)

- Gave the students a pre-survey to see their attitudes about computer science, test their previous knowledge of Alice, and get demographic information.
- Showed demos of previously made Alice worlds.
- Had the students build their own world to tell a story about a character on an island (similar to the short Astronaut-Humvee).
- Gave the students free time to add to the island world or build a new one.
- Demoed some examples of worlds and projects for school subjects.
- Had the students try some of the math Alice worlds (Order of Operations and Fractions) to practice math concepts.
- Had the students complete the basic Calculator Challenge.
- If there was extra time, the students had free time to work on their worlds or play around with demo worlds we provided on their computers.
- Gave the students a post-survey to see what their opinion was of Alice and if it could be useful in their classes, see if they learned about Alice coding, and see if Alice changed their attitudes about computer science.

Demographics

- 26 total students (14 in the morning and 12 in the afternoon)
- 1 student chose not to complete the survey
- 13 females and 12 males
- 9 Caucasian, 1 American Indian, 1 White/American Indian, 3 African American, 1 Turkish, 6 Asian, 2 Multi-Racial, 2 did not respond.
- All students were 11 or 12
- We asked the students if they knew their career interests: 5 doctors, 3 veterinarians, 2 lawyers, 1 law enforcement agent, 6 scientists/engineers, 5 responded other, 6 were undecided, 1 equestrian, 1 video game designer, 1 robotics, 1 graphic designer, and 1 crazy cat lady.

Results

- Overall, there was a general increase in interest in computer science.
- The number of students who "Strongly Agreed" with liking to use computer science to solve problems increased from 3 to 8 and nobody answered negatively after using Alice compared to 5 who "Disagreed" before.
- Significant increase in the interest for using computer science in a future career. The average response went from "Disagree" (2.88) to "Agree" (3.217).
- 14 students "Strongly Agreed" with voluntarily taking additional computer science classes after using Alice and only 8 did in the pre-survey.
- Many students suggested Alice should be used for projects and activities in their classes.
- Students found the Calculator Challenge to be confusing.