

Connecting Computer Science and the K to 12 Classroom

DREU Final Report for Summer 2009 Experience at Duke University

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ABSTRACT

This paper describes the continued investigation started in summer 2008 into integrating the Alice 3D virtual programming environment within the K to 12 school classroom. Three one-week workshops were held in the summer of 2009 for elementary, middle school and high school educators. These workshops introduced the Alice programming environment and provided training for the novice programmer. Lesson plan ideas and information on supporting resources were also provided. Teachers were asked to share their own ideas on how Alice could be integrated into their classrooms and what objects and resources they would need in order to be more effective. Based on feed back from the teachers attending, additional resources were developed for integrating Alice into the math curriculum.

1. INTRODUCTION

There has been a significant decline in the number of students pursuing computer science degrees at North American Universities [15]. When looking at the number of minorities and women entering a computer science major, the drop is even more significant. The decline in these areas is concerning because of the rising demand for computer science and technology skills in industry [3], and the need for diversity.

Students often start making decisions about careers and university during middle school. Unfortunately, many middle school students have negative stereotypes and misconceptions about computer scientists and what they do [9]. These false

perceptions may negatively affect their decision to study computer science.

By providing positive computer programming experiences to middle and high school students we are working to increase students' awareness and interest in computer science as a career. The main tool we are using to provide these positive experiences is the programming environment called Alice.

Alice is provided as a free download by Carnegie Mellon University[2] and has been developed specifically for novice programmers. Users interact with a virtual 3D environment using basic programming skills to animate stories or create interactive games. The simple drag and drop instructions provide immediate results and removes common syntax error problems.

Adventures in Alice Programming is a specific initiative to include the Alice program into middle and high schools in a number of key locations around the U.S. including: Durham, NC, Virginia Beach, VA, San Jose, CA, Denver, CO, Charleston, SC and Oxford, MS. The Durham location has taken a unique approach by focusing on integrating Alice with a variety of subjects rather than simply in programming courses.

Skills associated with computers and technology, are considered important for all students. Rather than isolating these skills, schools are integrating them into various subjects at every grade level. The North Carolina's State Board of Education clearly states this in their teaching philosophy.

Computer/Technology Skills proficiency is not an end in itself, but lays a foundation for lifelong learning. These skills become building blocks

with which to meet the challenges of personal and professional life. To become technologically proficient, the student must develop the skills over time, through integrated activities in all content areas K-12, rather than through one specific course. [10]

Our investigation into how Alice is best incorporated into K to 12 subjects intends to encourage students to learn logical thinking and problem solving skills, and to offer an alternative perception about computer science. As a result we hope to encourage those who may be interested in pursuing computer science as a career.

2. PREVIOUS WORK

There are several teaching tools that have been developed to help novices learn computer programming. Tools like Jpie [4], Raptor [12], Lego MindStorms [6] and Logo [7] are being used based on their specific features and strengths [11]. Scratch [14] and Alice [2] have also been used in several different ways for students in K to 12 [13]. No one teaching tool is the silver bullet for introducing students to programming. These tools and others like them can be used successfully for introducing programming by leveraging their strengths and accommodating for their weaknesses.

The ability to create and animate stories in Alice is considered a strength for increasing the motivation of students to program. A version of Alice called storytelling Alice was developed to enhance these features. The resulting study found middle school girls programmed for longer amounts of time with storytelling Alice when compared to regular Alice [5]. This study has sparked the interest of those who are particularly concerned for encouraging women and minorities to pursue computer science majors.

During the summer of 2008 a three week training workshop was held at Duke University to introduce Alice to middle and high school teachers [13]. These teachers learned to program in Alice and also created lesson plans they would use for various subjects in their classrooms. These lesson plans covered a variety of subjects including math, science, language arts, social studies/history and technology/programming. Two one-week summer camps were also held for middle school students.

These students learned how to create stories, interactive games, and special effects. Alice was well received by both the teachers and the students.

3. OVERVIEW & DEMOGRAPHICS

For three weeks during the summer of 2009, one-week introductory workshops were held for K to 12 teachers at Duke University. These workshops were designed for novices who had no prior programming knowledge.

Each day of the workshop included presentations of tutorials with step by step instructions being demonstrated at the front of the classroom. Detailed written instructions and one-on-one assistance was provided during the presentations to make sure everyone was able to work through the tutorial.

Starting with an introduction tutorial each lesson reaffirmed previously learned concepts and added new ideas. On the second day a simple assignment was given which included creating a storyboard, and animating a story in Alice. Volunteers shared their storyboards and Alice worlds with the group. While time was provided during the workshop, most teachers spent the evening completing their worlds. This demonstrated the motivation the teachers experienced while learning Alice.

Throughout the week examples were shown of various Alice worlds. Several worlds were from the lesson plans created by teachers who had attended the previous summer workshop.

The programming concepts presented in the tutorials included: methods, properties, functions, variables, parameters, user input, random numbers, if/else, while, loops, events. Some of the enhancement concepts presented include: camera control, lighting, scene changes, vehicles, texture maps, sound, transparency, importing and exporting, changing color.

A total of 100 teachers attended these workshops and were mainly from North Carolina. Other locations included: Alabama, Florida, Indiana, New York, Ohio, South Carolina and Virginia. Close to half of the teachers worked with high school students (grade 9 to 12). One third were middle school teachers (grade 6 to 8) and the others worked with elementary school (K to grade 5), or students of all grades.

Teachers who were interested in developing formal lesson plans for integrating Alice into their classrooms were asked to indicate what lesson plans they would like to create. Elementary teachers focused mainly on language arts, mathematics, science and social studies lessons. Middle school teachers touched on almost all of the subject areas including: language arts, business, technology, math, earth science, biology, chemistry, foreign language, and art. Many of their lesson plans focused on math and sciences. High school teachers were even more evenly spread over the various subjects and provided ideas for lessons in math, language arts, history, programming, earth science, business, social studies, biology, chemistry, art, physics, foreign language, economics, dance, art history, and geography. Teachers also indicated their interest in using Alice with gifted students and those with various physical and mental disabilities. This diverse response indicates the flexibility of Alice as a tool that can be used in the classroom for many subjects and with many students.

It was a little surprising that teachers concentrated on Alice as a tool they could use to create their own teaching material rather than a way for students to use to directly create their own worlds. Only around 30% of teachers who provided lesson ideas directly stated or strongly implied that students would be doing the programming. This may be an indication of the teachers' comfort level with using Alice. As one participant in the workshop explained she would not want to teach her students how to use Alice if she did not know how to do it herself.

Teachers also requested additional 3D Alice objects they would like to have access to. There are currently over 750 3D objects in Alice including characters, animals, props, vehicles, backgrounds, and shapes. Teachers at the workshops requested over 300 additional objects for use in their curriculum. Many of these objects were general props, backgrounds and animals that could be useful in multiple subjects. Other objects were more subject specific.

There were requests for famous people, places and buildings that would be helpful for language arts, history, music, art and sciences. Buildings teachers requested include: U.S. government buildings, significant architectural buildings and monuments, historically significant structures of settlers and Native Americans. Famous characters that were requested include: U.S. presidents and politicians, artists, scientists, philosophers, musicians, mythological

characters, writers, popular fictional children's literature characters and heroes.

Teachers also requested learning based objects and environments that would be helpful for math, physics, biology, earth science, history, social studies, geography, chemistry, technology, art, and music. Specific environments included: ancient worlds, art studio, business office, computer lab, science lab, ecosystems, and famous land forms. Subject specific objects included: 3-D prisms, human anatomy, animal anatomy, biological cells, DNA molecule, chromosome with genes, Bunsen burner, balance, beaker, conical flask, petri dish, pipettes, test tube, coordinate plane, electric circuit parts, various chemical molecules, fraction tiles, interactive calculator, maps, magnets, levers, pulleys, screws, phases of the moon, protractor, ruler, artist tools, computer equipment, business equipment, plants at various growing stages, and various scientific rock forms.

It is unclear if teachers would have provided additional lesson plan ideas if the objects were already included in the Alice libraries. However, the specific nature of the objects and the direct relationship with the subjects being taught suggests that many teachers had considered ideas when they requested the objects.

4. MATH

Based on the important relationship between computer science and math, I focused on how Alice can be integrated into the math curriculum. This project focused on three different ways Alice can be used: interactive games, completing a template world and animated stories.

Integrating Alice through an interactive game requires the teacher to create or find a world that provides reinforcement for the concepts that are being introduced in the classroom. One of the teachers at the workshop requested an interactive game that would reinforce the place value concept. Building on this idea, a rounding world was developed which requires the player to identify the place value and round the number to that place value.

The interactive game has three levels of play: level one practices rounding from tens to hundreds, level two practices rounding from hundreds to hundred thousands, and level three practices rounding from thousands to hundred millions.

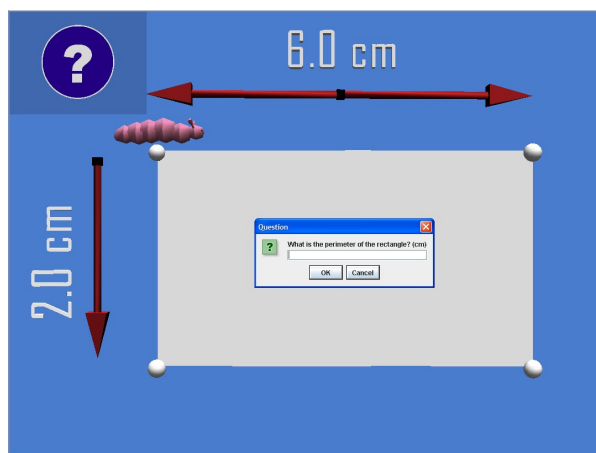


Once the player has selected the level of play the game begins. A random number is generated and is displayed on the screen. A husky dog enters and asks the player to click on a specific place value. This place value is randomly determined. If the player selects the wrong place value the husky will repeat the instructions until it is answered correctly. When the correct place value is selected an arrow slider moves to that position. The player is then asked to determine what should happen to that number during rounding. This is done by either clicking on the arrow if the number should go up or on the circle if the number should stay the same. If the incorrect answer is selected the lower place value number is animated and gives a hint to the player. Once the correct decision is made the number animates as it rounds to the nearest place value and a point is added to the score.

In designing the interactive game several features were considered. To provide player motivation a score was included, encouraging feedback by the husky, and hints when the wrong answer is selected. Accessibility issues for those who are color blind was also considered when choosing the color for the number groups.

A second way to include Alice in the math classroom is to promote student involvement in programming. A geometry world was created with two versions: one version as an interactive game, the other is an unfinished template.

The interactive game asks the user to type in answers of area and perimeter for a square, rectangle or circle. The teacher has the ability to modify the program by choosing the shapes and to include various dimensions. The caterpillar animates the perimeter and area as the user enters the correct answer.



For the student involvement version, the world is not completely finished. The student needs to complete the program by calculating the area or perimeter. This would be accomplished by using the programming and mathematics functions built into Alice. When the students have completed this part of the program they can check their answer by clicking play. The animation will then let them know if the calculation provided the correct answer. The teacher can set up the template world with any number of questions for the area and perimeter of a square, rectangle or circle.

The final way this project considered using Alice in the math classroom was the animation of mathematic concepts. To do this an example on improper fractions was selected out of McKellar's book "Math Doesn't Suck: how to survive middle school math without losing your mind or breaking a nail" [8]. The contextual story along with the mathematical concept was animated.

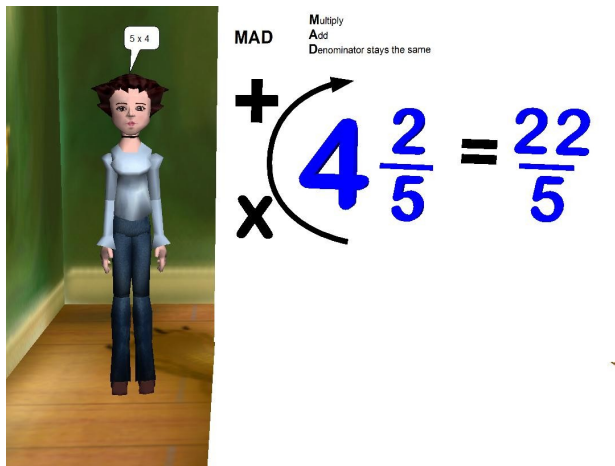
In this world the story produces a scenario that requires the character to solve a math problem. The concept considered in this story is converting a number into an improper fraction.

The story begins with a character talking to the viewer about a pizza party she is going to have. There are 5 pizzas on the table when the character leaves to welcome a party guest. While she is gone the viewer watches the dog jump on the chair and eat some of the pizza.



The character has been informed that there are only $4 \frac{2}{5}$ pizzas left. She decides to use the MAD method (multiply, add, denominator stays the same) to calculate an improper fraction and figure out how many pieces of pizza are left.

The MAD method is then animated while the character explains the steps being taken. Each number and operation moves into place to show the multiplication, addition and denominator steps. A short review of the calculation is repeated and the character determines how many pieces of pizza are left. The narrative ends with a bit of a twist as the basketball team arrives and more pizza is needed.



Each of these Alice worlds gives an example of how Alice can be used in the math classroom. A teacher who wants to include one of these examples in their math lesson can simply use it as is, or modify the world to suit their specific needs. Access to these example worlds and other tutorials are made available on the Adventures in Alice programming website [1].

5. SUMMARY

Alice can be used as a tool in the K to 12 classroom. The 3D programming environment is flexible and can be used in lessons for many different subjects at various grade levels.

During one-week workshops elementary, middle school and high school teachers were trained as novice programmers in the Alice program. These teachers were motivated to use Alice in their classrooms through interactive games, quizzes and storytelling. Feedback on lesson plans they intended to create included various subjects: math, language arts, history, programming, earth science, business, social studies, biology, chemistry, art, physics, foreign language, economics, dance, art history, and geography.

Providing a greater variety of resources for teachers including additional 3D objects, and example lesson plans for multiple subjects may support the use of Alice in their classrooms.

The focus for this project was to create several Alice resources for the math classroom. An interactive game, template program and animated story were developed. The interactive game reinforces math rounding skills. The template program gives the opportunity for students to practice their math and some programming skills. And the animated story takes a math concept and demonstrates it visually.

It is our intention that these resources developed for K to 12 teachers will inspire other ideas to help all students as they learn logical thinking, problem solving skills and have positive computer science experiences. And through these experiences, students who are considering careers and university choices will be encouraged to pursue computer science further.

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