Integrating Computing into K-12 Education using Alice

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Introduction: Computer Science at a Crisis

A report recently conducted by the Association for Computing Machinery (ACM) and the Computer Science Teachers Association (CSTA) concluded that computer science education in our K-12 classrooms is at a crisis [1]. Policy makers at all levels are seeking "to expand the capacity and quality of science, technology, engineering and mathematics education in the U.S." because they recognize that computer science is changing the world, workforce, and, more importantly, the daily lives of our students. Yet, most states have few or no computer science education standards and few consider computer science a 'core subject'. Until the policy framework and precedent for quality computer science education is in place nationwide, educators interested in preparing students for computer science must find an alternative. A potential solution for integrating computing into the K-12 curriculum is by pairing computing concepts with the teaching of 'core' subjects. In this way "technology literacy" can be imparted to prepare students for the new technological world they live in while at the same time following the historical curriculum set by the schools. There are many tools available to facilitate this blend of traditional content with modern techniques (for example using robots or Scratch to motivate children).

Alice Programming Adventures

The focus of this research is on using the tool Alice. Alice [2] is a 3D virtual worlds programming environment that is built to introduce computer science to those with little or no experience. With Alice, students can easily create interactive stories and games (called worlds). This storytelling aspect makes Alice especially appealing to middle school girls. Teachers in all disciplines can integrate Alice into their traditional lesson plans. Traditional assignments can be modified so that students develop their own Alice worlds. Alice, in addition to bringing computer science into the K-12 classroom, can help motivate students to learn the material well because it is an exciting program to them. This project centers around developing resources to facilitate adoption of Alice in the K-12 classroom with a particular emphasis on middle school science.

The Adventures in Alice Programming [3] project aims to integrate Alice into K-12 schools with workshops that are run at various sites across the US including Duke. The workshops run with the goal of creating lesson plans over the summers with teachers who would use them in the fall. The audience is K-12 teachers, some of which are familiar with Alice and already use it in the classroom or in afterschool outreach clubs. Teachers who have completed the workshop are invited to a follow-up workshop that teaches more Alice and gives them the opportunity to share how they used Alice during the school year as well as give some direction to the future development of materials. Every few years, an Alice symposium is held where Alice developers, researchers, and users can gather and share developments on using Alice.

Future Work: Integration Into the Classroom

The next steps are to have the tutorials and projects used in the classroom by science teachers who have previously attended Alice Programming Adventures and showed interest in using Alice more extensively. The tutorials and projects should be revised based on their feedback and new projects and tutorials created tailored to their vision and traditional lesson plan. General charting objects will be developed by the CMU team and, once finished, existing tutorials should be revised to include them. Many of the science teachers from the workshops have lessons in mind that they would like to use Alice in. Further research into applications for charting in Alice will help guide what sort of lesson plans Alice best serves as a tool for. It should also be considered what other subjects can make use of this approach. For example a math class could create a probability model in Alice as well as use it to visualize data in certain lessons. Other applications for Alice in a science classroom besides in modeling and data visualization should also be further researched.

Alice Models in Middle School Science

There is a need for interactive models in the science classroom to help conceptualize objects that are either too small or too large to be practically demonstrated in the classroom. Alice's ability to easily produce interactive animations means that with the right mix of objects from Alice's library and creativity, these models can be created using Alice. We created a model of the *lac* operon, specifically focusing on showing how lactose and glucose affect transcription rate. The users are able to control the presence of both lactose and glucose (levers) which affect the probability in the code that RNA polymerase (purple sphere) will attach and transcribe the genes.
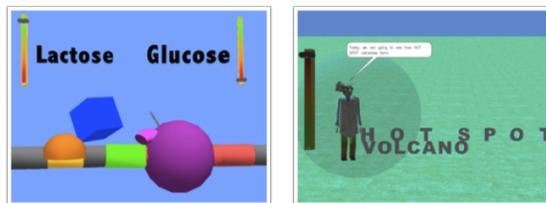

Figure 1: Alice has been used to create a variety of models for science. The *lac* operon model shows how Alice can help visualize on the molecular scale (*left*). The undersea volcano animation created by a teacher shows how Alice can be used to visualize forces that build mountains (*right*).

One challenge to producing models, especially scientific, in Alice is the need for accurate objects. There are a lack of objects in the Alice gallery that are suited for teaching science. Ordinary geometric shapes were repurposed to represent enzymes, compounds, and DNA in the *lac* opeon model. Earth science and ecosystems are well represented in the Alice library but other subjects such as genetics need objects made before teachers can easily create a model.

Charting Data in Alice

Another area where Alice use is promising for science classrooms is in working with and visualizing scientific data. Beyond teaching concrete facts, science curriculums aim to develop skills in students that will help them in understanding the scientific data. Being able to analyze data using visualizations is an important skill that Alice allows students to learn easily. We created a bar chart in Alice to aid in visualizing a collection of data. The visualization method we focused on uses rectangles that resize height to indicate value. The bars can be put together in a list to form a bar chart that animates changing values by increasing or decreasing in height.
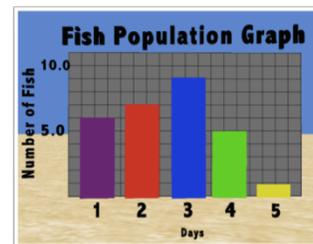

Figure 2: This world is designed to accompany a biology lab that studies how populations change if there is unnatural selection. An Alice bar chart world was developed to visualize a population of fish using data students generated from an Alice simulation. An accompanying tutorial shows teachers how to set up a similar bar chart for a given list to be used in any world.

To showcase the bar chart, we created an atmosphere world that uses two animating bars, one for temperature and one for pressure. As the scientist advances through the different layers of earth's atmosphere, students are able to learn about each layer as well as visually appreciate how temperature and pressure change.
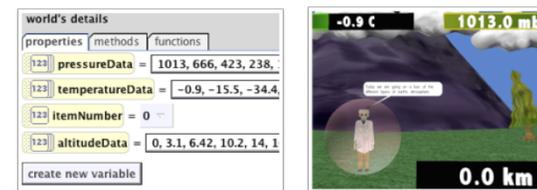

Figure 3: In the atmosphere world described above, world list variables (left) store values for pressure, temperature, and altitude at each point. These are translated into numbers and bars in the animation (*right*) with temperature on the left and pressure on the right. Altitude is presented at the bottom.

Currently, lists of data and bars are only tied together with methods we wrote in the Alice world. The final goal is for special charting objects to be built into the Alice library and take advantage of the list and array capabilities that are already built into Alice and tie the list directly to the object. Having a built-in object would mean that instructors and students could easily take any list in any world and drop in a chart visualization object to visualize data in the world.

References

[1] Wilson, Cameron, et al. Running on Empty: The Failure to Teach K-12 Computer Science in the Digital Age. [Online] Available: http://www.acm.org/runningonempty/
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[3] Susan H. Rodger, Maggie Bashford, Lana Dyck, Jenna Hayes, Liz Liang, Deborah Nelson, and Henry Qin, Enhancing K-12 Education with Alice Programming Adventures, The 15th Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE 2010), Ankara, Turkey, p.234-238, 2010. [Online] Available: http://www.cs.duke.edu/csed/rodger/papers/cse10alice.pdf