Co-evolving Watershed Education and Programmable Media Concepts in Middle-School Classrooms: An Implementation of the Creative Thinking Spiral

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Abstract

The creative thinking spiral—imagine→create→play→share→reflect→imagine—is an important new paradigm to test, implement, and mainstream integrative learning. The spiral is particularly relevant in middle school education where students are learning important new concepts in STEM areas that usually evolve as unlinked strands. Current curriculums in elementary schools are often fragmented and students are left with an understanding of separate subjects and no way to connect them. For example, environmental education, where interlinked concepts ranging from math, science, geography, and computation have the potential to enrich integrative learning, yet a paper-and-pencil approach to learning the water cycle limits the kinds of questions that the students can ask and explore. My current research, through a targeted pilot project, takes a deliberate step to redress these gaps in K-12 education.

Keywords: Watershed, Education, Creative Thinking

1. Introduction

There is a need to train a new generation of innovators and problem solvers that can grasp complex systems and deploy computational thinking and solutions. All of this requires integrative thinking, wherein knowledge from STEM and the arts are brought together. Our goal is to use environmental education as the context (for example, hydrologic cycle, water allocation, pollution, etc.) to develop methods and models that integrate computational thinking in a meaningful way.

2. Background

Currently, the methodology of education in grades K-12 focuses largely on teaching one subject at a time throughout the school day. This leaves students with a fragmented curriculum. The vital connections between science, technology, engineering, and mathematics aren’t being made through the current educational process. The excitement behind computational learning through Scratch is the balance of traditional subjects and new programmable concepts that have the potential to connect the missing links across current curriculums.

Scratch is based off of the creative thinking spiral and replaces traditional projects with “content that is far more dynamic and interactive” (Resnick, 2007a, 2007b; Monroy-Hernandez and Resnick, 2008). To implement the creative thinking spiral it is vital to start with a pertinent topic that is being taught in K-12 classrooms. By sorting through the most important concepts in a given subject and pairing them with this paradigm within Scratch, the computational aspect can reflect back and exercise a student’s knowledge of the subject.
This paper will outline the approach being taken to implement computational learning. Research on environmental curriculums and the development of relatable programmable media manifests together in order to implement targeted workshops for middle school students.

3. Approach

“Journey of a Drop (JOAD)”, is a pilot project conducted by students at the University of Maine that integrates the concepts and knowledge of water movement in the environment with computer/multimedia programming. This approach allows students to adjust and explore environmental parameters in order to better understand their local watershed. Through controlling variables that have been created in Scratch, students can see the mathematics behind the changes that are being made. The structure of JOAD\(^1\) emerged from a collaboration with Shaleen Jain\(^2\) and students. The goal of the collaboration was to better understand the concepts of a watershed. From there, specific variables and equations were created that would affect the main educational points of the watershed project: amount of precipitation, rate of percolation, and other environmental factors, such as the number of trees and the water level were all essential to the overall learning goal of the creative thinking spiral.

In the fall of 2012, two students and two professors from the University of Maine implemented multiple workshop sessions, each being thirty-five minutes long. Each session began with a discussion and worksheet to get students informed of what they would be learning through Scratch. Questions such as “What do you think percolation means?” and “what do you think affects your watershed?” were asked prior to using the program. Each computer in the room was set up with JOAD beforehand. After the initial phase of questioning, they were allowed to experiment and explore the variety of sliders and variables that had been preprogrammed into the project. Sliders adjusted levels of trees, precipitation, and percolation in a simulation of a local watershed. In addition, variables were made to change the weather from sunny to rainy. Students explored by actively experimenting on their own. After they had tried multiple combinations of variables in order to change the environment, a second discussion was prompted. The students were asked about what happened when different sliders were moved, what combinations yielded what conditions, and what they thought could be done to change certain sliders and aspects. After a five to ten minute discussion on what they had learned from the program, they were asked to find and change the variables within the program so that the percolation rate, the number of trees, or the amount of precipitation would differ from the original. Students manipulated the program quickly and found what variables and equations related to each aspect of a watershed within Scratch “code”.

After all of the students had the chance to change the project in a variety of ways, the session was concluded with a final discussion about computational learning. Students were asked if they enjoyed experimenting with Scratch and if they would do it again. Supplementary pieces of the JOAD curriculum were sent home with students in the event they wanted to use Scratch on their own computers. Worksheets gave students a basis of Scratch and how to get started on making their own projects. Scratch cards were designed in conjunction with JOAD to supplement students in the case that they wanted to further experiment with the program. In addition, JOAD was uploaded to the Scratch website and students were given the link to provide the opportunity to experiment with watersheds at school or home.

4. Methodology

The ultimate goal of completing learning objectives in Scratch is to create an integrative and rewarding environment that permits both individual expression and opportunities for collaborative learning. Teaching subjects through Scratch allows students to not only learn about the subject matter at hand in a new and beneficial manner, but also the mathematics and computational aspects behind the program. By combining watershed education into the program, three methods manifest to make the active learning experience ultimately rewarding: computational, environmental, and integrative.
5. Computational

Computational learning is “a way of solving problems, designing systems, and understanding human behavior that draws on concepts fundamental to computer science” (Wing, 2006). By aligning this definition with the functionality and purpose of Scratch, it can be inferred that students can experiment with computational learning through solving the problems and designs that were created in JOAD.

Snapping together preprogrammed blocks to carry out specific functions creates Scratch projects. Project backgrounds can be narratives, art pieces, games, or a combination of all three. Students are able to explore and manifest their interests all while learning “important mathematical concepts” (Resnick, 2007a, 2007b; Monroy-Hernandez and Resnick, 2008).

Figures 1 and 2 both demonstrate the computational aspects of JOAD. Broadcasting blocks were used in order to send information to the percolation equation so that when the students adjusted the sliders, an immediate response was illustrated. “Sprites”, such as, when I receive and broadcast and wait, are snapped together in order to create the overall simulation and various functions. Each equation initially set parameters for what the program would carry out. (Figures 1 and 2 are two of the equations that students had the option to change)

![Figure 1. Percolation variable blocks](image1)

![Figure 2. Percolation equation blocks](image2)

6. Environmental

The subject matter of JOAD focuses on educating students on their local watersheds. The simulation focuses on demonstrating environmental occurrences related to watershed education. It allows students to create a variety of watershed scenarios through adjustable parameters and then visualize how each would affect the surrounding elements, such as water level and plant life (Figure 3). The simulation focused on the education of runoff water and what it means for a watershed. Students explored components of pollution through run off by means of human
interaction with the land and identified daily activities that they perform that could be contributing to watershed pollution.

7. Integrative

Educating through pilot projects like JOAD allows students to not only learn about the subject matter at hand in a new and beneficial manner, but also the mathematics and computational aspects behind the program.

The benefit of integrating computational elements with an ecology curriculum is that students will be able to learn through the discovery process. This process allows them to be the creator and educator of their own projects. When students see the schematics behind their projects, they can contextualize what elements make certain parts possible and, if changed, how it would affect the rest of the project.

The creative thinking spiral is ideally implemented when integrative learning occurs. Students have the ability to imagine, create, play, share, and reflect on their local watersheds through exploring computational aspects.

8. Conclusion

Through beginning with curriculums that are pertinent to our student’s future ecological footprint and combining it with new methods of problem solving through computational elements, we are enabling our students to excel in both areas. Students are able to expand their critical thinking and problem solving skills through programmable media and can apply those skills to explore and troubleshoot environmental situations such as watershed issues. The benefit of exposing students to a new environment of active learning is the spark that can take place when a student realizes that they can apply any situation, including ones they are interested in outside of school, to a computational environment.

During the thirty-five minute workshops in which students explored JOAD and environmental concepts, there was a spark between academics, peers, and programmable media. By the end of the session, students were demonstrating significantly more interest in the capabilities of computational learning. The concluding discussion with the students
was less facilitated by the educators and students were more involved by vocalizing their thoughts and taking away points of the pilot implementation.

Currently, contact is being made to local elementary school teachers who are looking to implement integrative learning into their curriculums. Then, current lesson plans can be transformed into a computational exercise, much like that of JOAD. Through continued work and paired learning methods throughout grade school, students would be exposed to computational elements earlier on as well as lasting impressions on the given environmental subjects being explored.

9. Acknowledgements

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10. References


11. Endnotes

1 "Journey of a Droplet", a Scratch project created by three students at the University of Maine
2 Shaleen Jain, Ph.D. Associate Professor of Civil and Environmental Engineering