CS Education Re-Kindles Creativity in Public Schools

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ABSTRACT
Creativity is an important aspect of industry and education. The lack of creativity in current students has become a concern for educators. Through the process of implementing the Scalable Game Design project to teach computer science through game authoring, fostered/increased creativity occurred in public middle schools. Despite some structural limitations of the US educational system, creativity among the participating students was recognized. This paper describes a unique solution to fostering creativity while teaching game design in the limiting public school environment.

Categories and Subject Descriptors
K.3.2 Computer and Information Science Education

General Terms: Design, Experimentation, Human Factors.

Keywords: Middle School Programming, Game Design, Creativity, Computer Science Education, Scalable Game Design, Student Observation.

1. INTRODUCTION
According to popular press, the United States, as an individualistic culture, has been referred to as a creative capital. [1] But is it? Since 1990, a significant decline in the Torrence scores that measure creativity in American children, has many educators concerned. The Torrence creativity inventory (1958), is the "gold standard" in creative assessment [2]. Until 1990, the children's Torrence scores were steadily increasing. So, how can educators restore America's singular brand of creativity?

Increasing creativity in children would appear to be within the public school province. However, public schools have rarely been associated with a strong ability to foster creativity. Creativity is generally characterized as a natural human trait that is strongly developed in young kids. However, over time natural creativity can be eroded through the public school processes, due to the restrictive structure of the public school system. For instance, a forty-five minute class, two or three times a week, with 30-40 other children is the current norm in many public middle schools. Teachers have a difficult time addressing the required curriculum within this timeframe, much less inspiring creativity.

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The reality of computer education within this public school structure can be even harsher. Teachers may not have the necessary computer science background, programming tools can be inadequate [3], and curriculum materials are often missing or not well integrated into emerging standards [4]. Making computer science education based on game design feasible can require teachers to explore pedagogical and presentation trade offs, which may compromise creativity. Presentation method can have a significant effect on the facilitation of creativity. The two extreme points of control in regard to teaching presentation are direct instruction [5] and discovery learning [6]. Direct instruction is described as teacher-dictated lessons with a step-by-step presentation and no allowed deviation from the students. On the one hand this is likely to get the students to finish the games. On the other hand, there is little potential for deep learning and creativity [7].

Conversely, discovery learning provides a lot of freedom to each individual student. In its most extreme form teachers would essentially instruct students "here is the tool, now make any game you want". Generally it is believed that this model fosters creativity, but, at the same time, the lack of scaffolding [5] can result in student frustration because of their inadequate skills for making a game from scratch. This model is normally employed by after-school, Friday Computer Clubs. Students attending these clubs are typically self-selected and are usually somewhat experienced in computer technology, so the discovery model works for them. These after school computer clubs also are able to give more time to individual students and the students can spend as much time as they wish on a given project. So naturally within this scenario game-authoring software inspires creativity.

Although educators have been working to introduce more computer science into lower level public schools [3], fostering creativity with the introduction of computer science was not a priority. So even if computer science education is to be a part of public education, fostering any kind of creativity at the same time would be difficult within the current structure? The Scalable Game Design (SGD) project [3, 8] has been quite successful getting computer science education into public schools. With a quickly growing number of sites including inner city schools, remote rural schools and Native American communities in Colorado, South Dakota, Alaska and Texas, a large pool of students is currently being reached. Some schools are instructing over 900 students per year in computer science through game design. Through the SGD project structural guidelines, computational thinking tools have been created [3], middle school students have been introduced to foundational computer science concepts through game design, and student creativity has been recognized.

Generally public school teachers lean towards the direct instruction approach. The commonly held assumption is that this approach is not conducive to fostering or enhancing creativity in students. Additionally, in the current educational climate, where the focus is on standardized testing, lack of creativity can seem like an acceptable cost [5, 6, 7].

The contribution of this paper is to highlight the SGD project approach to computer science education through game design. The benefit of fostering/increasing creativity in the participating student classes is unexpected because of the current public educational structure, which limits the teacher's ability to integrate creativity into curriculum. But despite the disadvantages of this limited structure, the SGD project model through loosely structured guidelines, Agentsheets software, and the use of examples in the Scalable Game Design Arcade (SGDA), has been able to show consistent creativity within the students' games.

2. METHODS

Over the course of the 2009/2010 school year the authors as members of the Scalable Game Design (SGD) Project research team, visited the participating middle school classrooms. Observations of these classrooms were written down as notes and in journal form, as well as the teacher interviews and comments. Participating classes also uploaded their self-created games to the Scalable Game Design Arcade (SGDA). Three representative classes (Abigail, Melvyn & Sheryle, all pseudonyms) were chosen for the purposes of this paper to demonstrate that despite the limitations of educational structure and observable diversity, creativity can still be fostered within a single curricular intervention model.

The three representative classrooms were chosen for their ethnic and gender diversity in comparison to each other, and because they represent different types of communities, urban, suburban and rural. Diversity within the range of technology experience of the classroom population, classroom size to student number ratio, the amount of actual classroom time, and teacher presentation method was also observed. Although the observations and comparisons for this paper are based on only three teachers, these three teachers represent most of the significant differences within the entire group of project participants. Consequently, the data from these three teachers is project representative.

Common factors for the project schools are as follows:

- All students are 6th/7th graders
- Teachers attended a week-long training before the implementation
- Frogger was the initial game taught to the students using Agentsheets software
- A trained Community College student is assigned to support the software implementation.

2.1 Creativity Dimensions in Game Design

Through the observation of the project classes and a set of the games produced by these classes, we could conceptualize the differences between these games as an indicator of creativity. The game design process allows variations along three main dimensions, where student creativity can be explored:

- **Characters:** Game characters, called agents in AgentSheets [8], are the objects of the game. In a game such as Frogger agent depictions include frogs, trucks, and alligators. Drawing these depictions can be a lot of fun for many students and even provides a sense of really making their game. Some teachers allow opportunities to change/create different agents. For instance, in a Frogger-like game the frog character may look entirely different, e.g., a monster, and not even be called a frog.
- **Levels:** Levels may vary enormously. Each game level, represented by a worksheet in AgentSheets, lays out the agents into a configuration that is likely to determine how hard the game will be. For example, a five-lane highway is much harder to cross in Frogger than a single lane highway.
- **Behavior:** The programming that students need to create determines the behavior of characters, and is by far the most complex aspect of a game. In AgentSheets the students use the rule-based Visual AgenTalk language to make behaviors with a drag and drop type interface [9].

Creativity can be expressed at all three dimensions. Despite public school limitations, within the participating schools we have many teachers using various combinations of interventions to foster creativity by dealing with ways to create characters, levels and behaviors within the parameters of the project's structural model.

2.2 Curriculum Interventions

Within this model, many curricular interventions are presented to the teachers during their training week. Each teacher can choose which ones suit their teaching style, while staying within these parameters. The required elements are that the first game taught is Frogger, Agentsheets software is used and a community college (CC) student is allowed to support the teacher in class. The different types of interventions include, but are not limited to:

- Use of online tutorial material by the teacher
- Use of online tutorial material by individual students with/without teacher direction
- Students gaining ideas from playing other student-created games on the SGDA
- Use of hand-outs for helping the students to remember all the required elements of the game and for peer review
- Integrating/separating the instruction on the agent design and programming in various and unique ways
- Specific time span allowed for the design and programming of individual agents
- Writing the required elements of the game on the board

2.3 Community College Student Support

The support of trained CC students in the participating classrooms is a unique element to this project. The students are trained to support the teachers as they teach the beginning game programming. These CC students also serve as mentors and role models for the middle school students. Each teacher may decide the kinds of roles/work they want their CC student to accomplish, as well as how often the CC student should attend. The types of roles include: 1) Basic design trouble shooting for the middle school students; 2) Various levels of paperwork, as needed; 3) Teaching implementation segments at the teacher's discretion; 4) Supporting substitute teachers; 5) Catching up absent students.

2.4 Classroom Descriptions

2.4.1 Abigail's Class (represents rural area)

Abigail's teaching style on the direct instruction/discovery learning continuum falls toward the direct instruction. Her class is comprised of 23-28 students, who view the Agentsheets programming lessons projected to the front of the classroom. Her classes are usually 50 minutes long. Abigail's class interventions include: 1) Students gaining ideas from playing other student-created game examples on the SGDA; 2) She teaches most of the agent depiction design first; 3) Most of the programming is taught after all the agents are designed; 4) Use of online tutorial material by the teacher when the games are uploaded to SGDA; and 5) Writing the required game elements on the blackboard for the students' reference. Abigail prefers for her CC student assistant to tutor the students who have missed portions of the lessons due to absence or other situations. During the lessons, students must pay attention to Abigail's explanations/demonstrations, but are free to experiment with their games within class time limits. When assessing the collection of the games from her class, a high degree of creativity in characters and behavior and a medium degree of creativity in levels were present.

2.4.2 Melvyn's Class (represents urban area)

Melvyn's teaching style falls into the direct instruction area. His current class has over 30 students, who are able to watch Melvyn's instruction on a Smartboard. Melvyn's students are seated closer together than Abigail's students because of space, and instruction time is less than 45 minutes after attendance-taking. Melvyn's interventions include: 1) Use of online tutorial material by the teacher; 2) Use of online tutorial material by individual students with/without teacher direction; 3) Students gaining ideas from playing other student-created game examples on the SGDA; 4) Use of hand-outs to help the students remember all the required elements of the game and for peer review; 5) Melvyn integrates the agent design with his programming instruction dependent on the class grade and time; and 6) Timed period for the design of individual agents. Melvyn prefers to have his CC student take a more active role in the teaching, such as presenting specific lesson segments and supporting substitute teachers when he is absent. Melvyn insists on a much stricter adherence to the lesson sequence and time restrictions. In the collection of the games from Melvin's class, a high degree of creativity in characters and levels and medium degree of creativity in behavior were found.

2.4.3 Sheryle's Class (represents suburban area)

Sheryle's teaching style falls more toward the discovery-learning end of the continuum, though she still maintains structure. Her classes range from 23-29 students, who learn Agentsheets from a Smartboard. Sheryle's students also have more space in their classroom and a large window. Sheryle's curricular interventions include: 1) Use of online tutorial material as the basis for her own tutorials; 2) Use of online tutorial material by individual students with/without teacher direction; 3) Students gaining ideas from playing other student-created games on the SGDA; 4) Sheryle tends to divide the agent design and the programming lessons in response to the particular class she is currently teaching; 5) Writing the required elements of the game on the Smartboard. Sheryle's teaching style could be characterized as more impromptu, because she can change the elements of the lesson to match the learning of the specific students she is teaching. Although her students usually complete the games within the same approximate time frame as the other teacher's classes.

3. FINDINGS: CREATIVE EMERGENCE

The creative process, described throughout research papers, usually has an identifiable outcome. Most of these descriptions involve an epiphany or evolution of a new thought or idea emerging from some sort of thought association. According to Herring, et al [10], creativity can be produced regularly through exposing yourself or team to visual examples. Examples can be similar to the sought-after outcome, or random artifacts with only marginal resemblance. Researchers agree that examples are one of the best ways to start the creative process [10, 11]. Observations of the project classes, show a large amount student creativity, especially in their agent and worksheet design (Figures 1 & 2).

Figure 1. Examples of the variety of "Frog" depictions created by the students

Although teacher comments and uploaded games supported this observation, the most significant commonality among the observed classes was the adherence to the project guidelines. Basically, these structured guidelines included the following protocols:

- Teaching Frogger as the first game
- Using AgentSheets software
- Uploading student games to the SGDA
- All other interventions were optional: Using SGDA as examples for inspiration was almost universal, though.

3.1 Observations: Creativity Begins

3.1.1 Abigail's Class

On the first day, the students began to play the Frogger games on SDGA. At first they just played the games without any direction. But since some of the uploaded games had errors or other problems, the students asked questions about the causes of these issues. Seeing the errors of previous students as well as the successes impressed on these students some of the intricacies of the game design process. Abigail instructed the students to write down any elements that they would want to use for their own game. The students thought about their own game design in regards to all the example games they had just played on SGDA. Eventually, the students were excitedly talking to each other about which game features they were going to use, based on the examples they had just experienced. Exposure to relevant examples is believed to lead a high degree of creativity in characters and behavior. The results of Abigail's class' game designs are shown below (Fig. 2).

3.1.2 Melvyn's Class

Melvyn takes role at the beginning of every class as required. Often this task takes a lot of class time. Melvyn keeps a tight rein on his class because there is never enough time to finish the lessons. He demonstrates the techniques of agent design for Frogger on his Smartboard. Because of time constraints (only 45 min.), a timer is used to keep his students on task when designing or programming each agent. Right before his class ended, Melvyn displayed all the frogs that all the students had designed during that class, on the

Smartboard. The students pointed out their specific frog to the other students, comparing them with the other frogs on the board. This generated increased enthusiasm and motivation for better agent quality. Melvyn's students were limited to a specific amount of time to design and program their agents, but still produced a high degree of creativity in characters and levels. His students' uploaded games are below (Fig. 2).

3.1.3 Sheryle's Class

Sheryle's teaching style is more flexible than most of our teacher-participants. She puts examples on her Smartboard and then circulates throughout her classroom, commenting on her students' work, and giving suggestions and help where needed. She regularly encourages her students to show each other their ongoing game designs for inspiration. The collection of the games from Sheryle's class shows high degrees of creativity in characters, levels, and behavior. During one of her classes, we saw her divide the agent design and the programming into two separate lessons, while during another observation of a different class, she instructed the class in the programming as each agent was designed. Sheryle says she believes in altering the protocols for each class based on the class time and abilities of her students. Sheryle's students' game designs are shown below (Fig. 2).

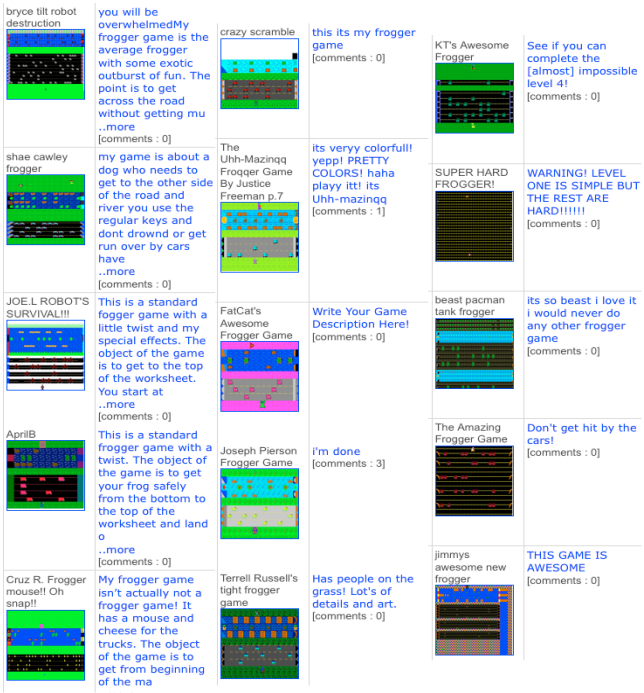

Figure 2. Screenshots and Descriptions of Frogger games collected from Abigail's (Two Left Columns), Melvyn's (Two Middle Columns), and Sheryle's class (Two Right Columns).

3.2 Teacher Comments

Throughout the classroom observations, some of the teachers made unsolicited comments about recognizing creativity during their project classes (*quotes in italics*). Others sent emails with descriptions of their student creativity. Some are listed below.

"I definitely witnessed more creativity within the confines of the project than I had seen through other projects."

Initially this creativity took the shape as outlandish and colorful agent depictions. Students used their ability to design their own agents by making strange-looking frogs or other animals in the frog's place. They also created these agents in a rainbow of colors the original green frog would never recognize (email).

"After creating their basic Frogger game (Level 1), they went on to create additional levels with their own creative ideas which included unique characters, varied street directions & mystifying surprises along the Frog's path home."

I can't believe the unique game levels and versions from the students. Although these game versions were based on the Frogger game, only someone who knew the actual coding would be able to detect this similarity (email).

"They for sure want to change the agents to be their own styles, like soccer feet pushing soccer balls into goals rather than the normal Sokoban design with destinations … or dogs running across the street to avoid dog catchers for Frogger."

As the teachers so aptly describe, their students are having a creativity field-day, throughout the game authoring classes.

3.3 SGDA Game Comparisons

When looking through all the Frogger games created by the project's participating middle school students, the variety of worksheet forms and agent color is apparent (Figure 1). The game agents and worksheets represent an outcome from the students' efforts to design something original within the designated parameters. In other words, the students played the games on SGDA, built on or expanded the previous students' designs to construct a unique and identifiable outcome, i.e. their own Frogger game. These new games are creative extrapolations of the Frogger examples the students originally played on SGDA, The project implementation structure seemed to increase the teacher's capability for fostering creativity in the students, in spite of the requirements normally placed on the average public school teacher. Some of these are listed below.

- Limited Class-time (less than an hour for a lesson)
- Role-Taking requirements (Class-time required)
- Increased disciplinary burden in the classroom (More class-time required)
- Compulsory curriculum with little flexibility for creativity
- Changing class periods & class frequency (no consistency)
- Increasing class size without restriction

So, given these difficulties and others currently placed on public school teachers, the expected range of creativity within the student participants was not expected to be as high as that expected from an after-school Computer Club [3, 4]. But since the student games uncharacteristically demonstrated creativity similar to Computer Club members, it was hypothesized that the project structure's elements could intrinsically foster creativity. So, the following sections further describe these possible elements that appear to have contributed to or fostered this outcome.

3.3.1 Creative Agent Depictions

Using Agentsheets software offers design flexibility for agents and worksheets that encourage creativity from the beginning of the learning process. Often other software parameters require the use of pre-designed agents. Within the project implementation structure, students are offered multiple examples of agent design and programming options from SGDA. The agent design skill is relatively simple to learn, so students are afforded the opportunity to

create exactly what they envision, to the extent of their learned ability (Figure 1). So, the uploaded games show a reasonably accurate representation of the students' creative abilities (Fig. 2).

3.3.2 Examples: Inspiring Creativity

Most project teachers chose to have their students play the games on SGDA before formal instruction. This intervention was usually viewed as a motivational tool to engender interest and encourage familiarity with a specific game, rather than a means of promoting creativity. But the teachers recognized a creative increase in their students' abilities in comparison to other creative project lessons.

Other ways that examples tend to be used in the SGD project to promote creativity are through peer-to-peer instruction and CC student mentoring. In both cases, a student is shown an example of the correct process and given the opportunity to ask questions before attempting the procedure on their own. From this process, students learn to see each other as creative resources.

4. CONCLUSIONS/DISCUSSION

Evidence presented in this paper suggests that the implementation structure of the SGD project has had a substantial role in increasing/fostering creativity within the participating schools. This structure, designed to promote interest in computer science (CS) through the design of games, using Agentsheets software, the multiple uses of examples (SGDA) and the subsequent uploading of these games to SGDA, resulted in a secondary effect of cultivating creativity. Since the participating schools offer a diverse student group (multiple locales, ethnicity, technology expertise, and class size), the SGD project structure constitutes the common factor in this equation. So, the authors believe that the characteristics of the SGD structure for introducing computer science to middle school students, which integrates the creative flexibility of Agentsheets, and teacher training and support, with the collaborative sharing and example resources of SGDA can be integrated to increase observed creativity while promoting CS.

SGDA is not unique in its function as a creative resource. But, the integral part it plays within the SGD project structure, coupled with the flexibility of the Agentsheets software, provides the students with a unique experience that appears to foster creativity. Throughout our observations, the students demonstrated creativity in the design of the game agents consistently. The teachers commented on this creativity within the project module. The indications from separate sources (uploaded games, observations, teacher comments) would tend to validate the SGD project structure and its guidelines as described, as a contributing to significant factor in promoting creativity.

5. FUTURE RESEARCH

Currently, the most obvious creative examples are represented by the agent depictions and worksheets. But all games must have programming and how creative the students have been with their programming is an aspect the authors hope to address in a future paper. As a relatively new curriculum, it will be interesting to track how the creativity aspect is affected as teachers continue to repeat the SGD lessons.

More investigation is warranted on the collection of student comments in comparison to, or supporting those of the teachers and the exploration of the elements within the SGD structure for use in other subject areas (geography, chemistry, etc.) for promoting creativity. Both could be valuable research areas.

The direct instruction/ discovery-learning continuum is another valuable research area. Public opinion holds that a freer discovery-learning approach is more conducive to fostering creativity, but most participating teachers favored a more scaffolded approach. Further research could help clarify this issue.

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