Introduction

Learning Exchange is an after-school program run by Brown University students. It is designed to excite Providence middle-school students about solving problems from the classroom and the real world through project based learning. We want to create a community of young people who are excited about their ideas and have the confidence and skills to implement them. In Spring 2014 we addressed this with classes for computer game programming and for engineering and design.

The goals of the program are as follows:

1. To **build mentoring relationships** between students at Brown and in Providence.
2. To **engage students in creating projects** and learning skills of which they are proud.
3. To **connect analytical and mathematical thinking** to these projects in order to make math more relevant to students.

This spring, the program ran 2 sections with around 30 total students and 5 teachers.

Program Structure

This Spring, we were able to run both Design and CS programs at DelSesto Middle School, but were unable to coordinate the logistics for programs at Nathanael Greene. The programs met twice weekly for one-hour classes, and the semester lasted for 10 weeks.

New instructors applied through an online survey and were interviewed in person. We advertised the job through Brown Morning Mail and advertised at the Spring activities fair.

Curricula

Computer Programming

Introduction

Computer science (CS) is a rapidly evolving field that allows students to express their creativity through the development of software. In addition, producing games and animations also requires students to practice logical reasoning as they work through the control flow of their program to understand how they can make it work.

This was our sixth semester of Computer Science through Learning Exchange. Over the years the program has grown and the curriculum has changed to better engage students and strike the right balance between developing skills and having fun.

- Early on, we placed a strong emphasis was placed on teaching math concepts and then structuring programming projects around those concepts. Students often lost interest in this approach, and it did not put sufficient emphasis on learning programming concepts necessary for completing their projects.
- In our second year we implemented an entirely project-based curriculum, and taught math as it came up. Math was present in many projects as we expected, but integration was poor as we placed a stronger emphasis on teaching programming concepts.

This semester, we developed a series of worksheets to aid teaching, especially given our staffing constraints. Students are provided with their own flash drives to use during class, which they take home at the end of the semester. This improves the organization of the class and also gives students more ownership of their projects.

Environment and Class Structure

The students progressed through six worksheets over the course of the semester. These introduced basic scratch programming concepts in the form of simple games for them to implement, so even as they were learning the material they could still be engaged in producing something of value. Though most students required the entire semester to complete the series, a few students managed to progress to making their own games (usually extending the functionality of one of their previous worksheet projects).

DelSesto sets the enrollment of its AfterZone classes, and so there were around 15 students (more than we had laptops). While the students were sometimes open to working in pairs, often one student would fall into simply watching while the other did the majority of the work. At the end of the semester, students presented their favorite projects at DelSesto's end of AfterZone celebration.

Reflections

The use of worksheets greatly reduced the amount of time teachers had to spend actively controlling students and keeping them on task, relative to how hard it was when they were each working on their own different idea for a game.

We noticed a fairly large discrepancy in performance between the 7th and 8th graders in the class and the 6th graders. Whereas most of the former managed to complete most or all of the worksheets by the end, the younger students struggled with staying focused and patient enough to guide themselves through the worksheets. All students were very responsive when they received personal attention, however, so with more staff available, the worksheets should still be effective for younger students as well.

Engineering and Design

Introduction

Over the past 200 years, tremendous feats of engineering have found a presence in corners of our everyday lives; whether we look to the simple truss bridge or to the mighty fighter jet, we find that there are practical applications for physics and mathematics that amaze and inspire us to build more of them. Engineering skills, specifically the use of physics rules to create a device that performs a function efficiently and reliably, are helpful in many careers today. Thus, the goal for an educational program in engineering is to leverage the inspiring power of man's engineering marvels to cultivate critical thinking skills, the ability to work in groups, and the mathematics and physics aptitude necessary to succeed in engineering, design, and life.

In previous semesters, the engineering and design curriculum was largely focused towards simple planning exercises (such as properly organizing to create a movie), and away from concepts in mathematics and physics, as a great inclusion of the latter could impose a higher barrier for entry into the program. The first goals of Learning Exchange engineering and design are to teach problem solving skills that can be applied to any problem and to introduce basic math and physics concepts such that there are is no prerequisite knowledge. The second goal is to then provide the students the opportunity to engage these concepts and problem solving skills in relevant, fun collaborative projects such that they are challenged to think critically and they learn unique applications of their classroom learning.

Environment and Class Structure

The curriculum was based upon a design process with six stages:

1. Investigate
2. Brainstorm
3. Develop
4. Prototype
5. Refine
6. Build

The process was introduced at the beginning of the class and each stage was explained. Then the projects built upon the students understanding of the process, along with some specific knowledge for the project. At the end of each project, there would be some sort of friendly competition among the students' implementations. Surprisingly, the motivation of the students to challenge their friends in these competitions led to uniquely high levels of student-teacher engagement throughout the semester.

The class was structured with a number of projects that were designed to increase in difficulty and challenge the students to effectively use the design process when making projects for vastly different goals and conditions. The students at Del Sesto were initially slightly discouraged by having to learn the physics behind each project in a classroom setting, however the teachers managed to conduct fun, interactive sessions such that when the time came for the challenge of the project, the students were brewing with ideas for their own designs.

Paper Airplanes

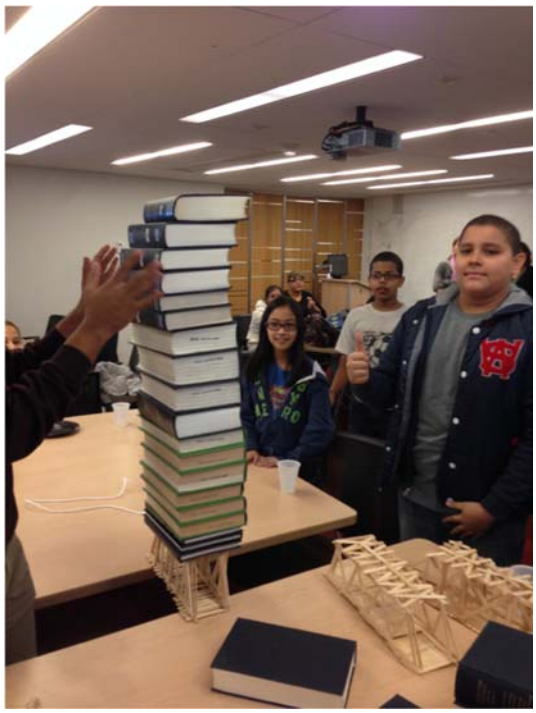
Students had the opportunity to define what they considered to be success and then to design the best paper airplanes according to their metrics for success. They were given a sample of paper airplane designs based off of well-known fighter jets, and challenged to think about the reasons for including certain features, for example the "delta wing". This project has a significant "investigate" portion, emphasized the idea of iterative design, and introduced the idea of setting metrics for success, as the final competitions tested distance and accuracy of flight.

Egg Drop

Students were taught the physics intuition behind falling objects, and Newton's laws in correlation to the forces acting when an object falls through the air and hits the ground. Then they were given a restricted list of materials and tasked with designing a device to hold an egg such that the egg shouldn't shatter if dropped from a 10-foot height. Since each student had only one egg to work with, this task imposed a significant planning requirement and emphasized thorough and skillful execution.

Bridge Building

As the culmination of the semester students were asked to build a bridge out of popsicle sticks and hot glue that could hold the maximum amount of weight. Students were walked through the designs of various types of bridges that exist around the world ("truss", "arch", "suspension"), and required to justifying the physical features of their personal designs before building. This project required focus on all of the stages of the design process and the bridges.



Student made bridges

The Future of Engineering and Design

The engineering and design curriculum continued to be successful this semester at DelSesto. We will continue the pattern of using classroom math and physics learning in fun applications, and potentially attempt to take on more ambitious projects.

Future Goals

Going forward, we continue to look for ways to improve students' motivation and learning. In many ways we have made great progress in making our program enjoyable and engaging for all students. We feel comfortable with our two offered programs, and so our focus now is on expansion to reach out to more Providence schools.

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