DESIGNED TO FLOAT YOUR BOAT

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When we designed our new middle school (grades 7 and 8) a few years ago, we included two sections of academic exploration. Academic exploration classes last only four or five weeks, with approximately 15 class meetings. The courses give students an opportunity to experience a new subject for a short period of time.

These classes are ungraded and students present their work instead of writing a final exam.

Two faculty members, Bill of our IT department and Dan, a biology teacher, have designed and taught several interesting academic exploration classes. In one, students built a garden in a terrarium controlled by robotics, combining Arduino technology with dirt and water. The culminating project was to leave the gardens "turned-on," without human intervention, during the school's spring break. When the students and faculty returned to school two weeks later, those gardens that were living were deemed a success. The robotics tending the dead gardens, or the gardens floating in a pool of water, understandably needed a bit more work.

Another course, Introduction to Engineering, invited students to form a company, develop a product, share their work on a GitHub website they made themselves, and present their products to an audience of potential investors (guest teachers and administrators) that came to their final day of class. Unique to this class was the introduction of the agile workflow, a way of working that encouraged self-regulation, collaboration, and autonomy from teacher directives.

Taking what they learned in these classes a step further, Bill and Dan teamed up in 2017-2018 to offer 3D Nautical Design. Although the students don't know the specific terms below and the course is only an introduction, it is fair to say that they now have some experience with:

- analytical geometry;
- 3-D coordinates;
- set theory operations;
- programming basics, including blocks, functions, and variables;
- iterative design exploring the physics of buoyancy, resistance, stability, maneuverability and tracking (the ability to go straight) in water,
- workflow;
- progress tracking;
- marketing; and
- public speaking.

Sample Student logo for a design company

Here's how the class was structured, over 15 class sessions:

Students, in groups of three or four, created boat design companies. They imagined and wrote down how the company was founded, what business mission it pursued, and then designed its logo. Next students were introduced to the class workflow and how progress was measured. They used a technique called a burndown chart, enabling them to see clearly if they were on pace to finish their project.

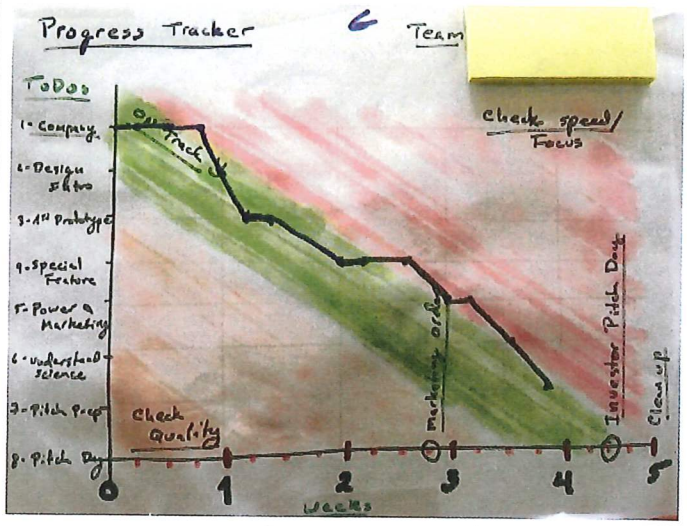
Students learned the basics of the design tools they needed to bring their company to life. Students used OpenSCAD and MakerBot software to design and print boats. They started with a hollow box, which makes a terrible boat, but is easy to design. Then they made small, iterative improvements to the boat using basic 3D geometric shapes, scaling, and set theory group differences. Each time the students changed their dimensions and printed a new boat, they ran tests in the testing pool, observing how the boat crossed the pool in calm and wavy water, with and without a crosswind.

The tests served as inputs for further modifications. Simulating boat companies through testing a variety of boat designs created many real life lessons. The students also ran into many real life problems. One of these problems occurred when printing larger boats. The MakerBot Replicator 2 tended to introduce some warp to the printed boat. The warp was an unplanned curve in the hall, which affected performance, as the students could see during testing. To solve this problem, the students began printing their boats vertically, with a flattened stern as a secure base. They removed the tendency of the printer to introduce warp, but some students were concerned, based on what they had learned from their research, that a flat stern increases drag in the water, due to the turbulence it creates. It was wonderful that the students wrestled with the trade off between technical compromises and an ideal design. Such is life.

After several iterations, students made a postcard with a photo on one side and their design skills and company information on the back. The postcard was handed to the audience on Investor Day, the last day of the class. Investors were teachers and administrators with play money they had been given to invest in their favorite boat companies. Each student group gave a short persuasive pitch, explaining why their company was a good investment.

When the students finished their pitches, it was time for snacks and for the audience to invest their money. A final teachable moment presented itself. All student groups save one went right for the snacks. The savvy group stayed behind, taking up a position at the table where the investors were placing their money in envelopes, labeled with the different boat companies. "Thank you," they said again and again, as their envelope started to fill. All teams had done their marketing, but only one team closed the sale. And that is the team that received the highest investment total.

With the completion of Investor Day, the class ended and new classes started the following Monday. Bill and Dan, however, are already talking about their next multidisciplinary course. It is sure to be a good one.



The burndown chart (a measure of progress toward the final goal) of a high functioning student group.

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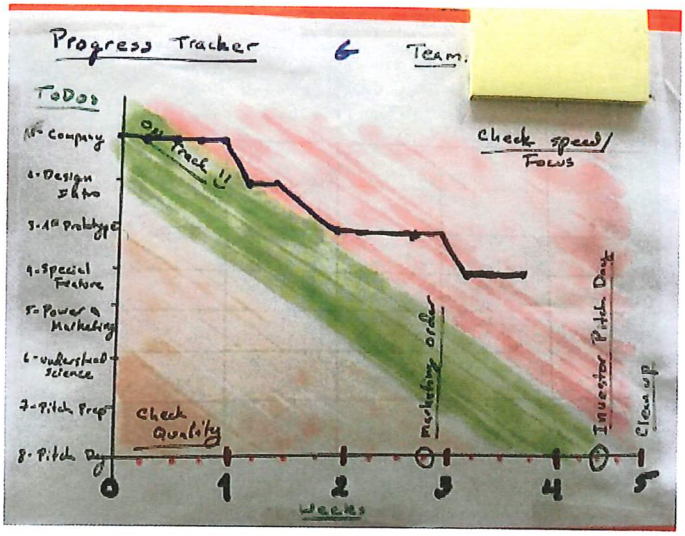
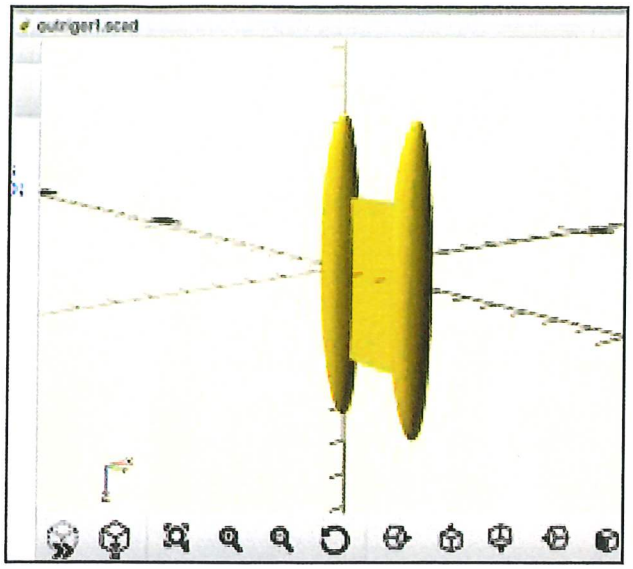
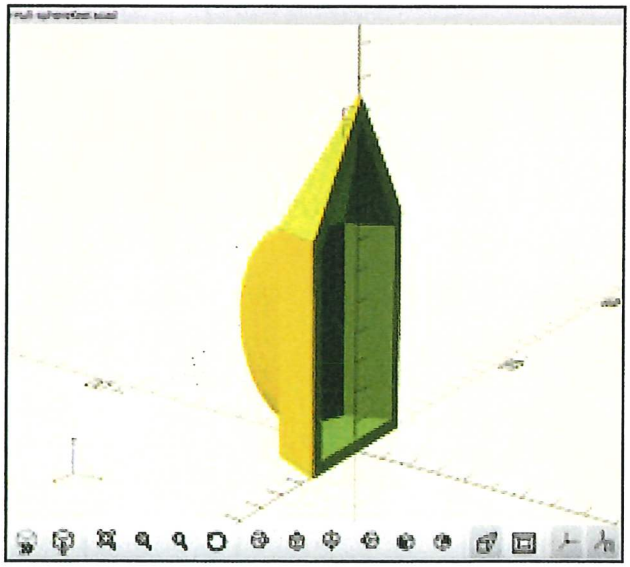


A burndown chart of a group that struggled to work together.



Sample boat by a student, showing the use of geometric shapes (cubes & spheres) and geometric algebra manipulated with translation, as well as scaling and set theory operations (union and difference).



Sample boat by the a teacher, demonstrating modules (reusing code) and variables to resize the boat at will for different design needs. This also demonstrates the concept of faces, used to create additional shapes (in this case a hull with 2 points of stability).

About the authors

Bill Tihen works in IT as the school's Systems Engineer and Coder. He enjoys exploring new ideas using Lean Start-Up methodology, particularly when he can share them with middle school students in short, creative classes. Bill has also worked as an Electrical Engineer, Robotics Engineer, Research Engineer, Environmental Educator, and as an Outward Bound Instructor. He enjoys technologies involving Arduino, OpenSCAD, R, Python, and Elixir. btihen@las.ch

Dan Patton is a science teacher with an interest in adding authenticity to the curriculum through interdisciplinary "real world" projects. As a member of the STEAM special interest group with ECIS, Dan and others have been been experimenting with STEM and citizen science projects to engage students in projects that have benefits and constraints beyond the classroom. Dan is relatively new to computer programming, but sees its power and has worked with Bill to learn Arduino and OpenSCAD. His next challenge is Python, which students will use to solve analysis problems with citizen science data. dpatton@las.ch

Paul Magnuson is the director of the middle school and the school's educational research department, which supports the exploration of innovative teaching and learning. He has been a member of the ECIS special interest group for Research Engaged Schools since its creation eight years ago. pmagnuson@las.ch