Math IDE: A Platform for Creating with Math

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ABSTRACT

To inspire student engagement in middle school math, we explore the possibility of using generative AI to enhance the creativity of math learning. We present the Math IDE, a math education environment in which students learn about math concepts by building artifacts. We aimed to create a platform in which students can engage with mathematical concepts, create an artifact that embodies the math that they are learning about, and practice their high-level specification skills. In the current iteration of the Math IDE, students can create custom web pages by describing and demonstrating understanding of the math that is involved in the web page. In this short overview, we describe our process and discuss several open questions regarding the design and application of this novel method of math education.

ACM Reference Format:
Sierra Wang, John Mitchell, Nick Haber, and Chris Piech. 2024. Math IDE: A Platform for Creating with Math. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 2 (SIGCSE 2024), March 20–23, 2024, Portland, OR, USA.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3626253.3635572

1 INTRODUCTION

Empowering students with the ability to create can drive their motivation to learn [2]. We have seen this in computer science education where students are able to create artifacts as they learn how to program. Due to its ability to generate code, generative AI has the potential to bring similarly creative experiences to education in unprecedented ways. In this work, we explore how we can utilize generative AI to bring the act of creating to middle school math, and consequently, increase engagement and motivation in the subject.

2 MATH IDE

We set out to develop a platform where a student can do the following:

(1) Engage with and improve their understanding of mathematical concepts.
(2) Create an artifact that embodies the mathematical concepts that they are using.
(3) Practice their high level specification skills by working with artificial intelligence (AI) based tools.

We call this platform the Math IDE. The goal of this platform is to increase student engagement in middle school math by bringing the act of creating to math practice. Thus, the Math IDE must be an environment in which students feel the freedom to create, yet where generative AI is confined to reasonable tasks.

2.1 What can a student create with math?

The first type of project that a student can create with the Math IDE is a web page that has inputs, an output, and a run button. In the Math IDE, the student describes the inputs and the function that should be used to compute the output. The system utilizes GPT to generate a JavaScript function and a set of sample inputs reflecting the student's description. For each sample input, the student must compute the output that they expect, and compare this with the output computed by the generated function. If the outputs do not match, the student must either modify their output or assert that the generated function must be wrong (in which case, a new function must be generated). Once the student has verified all of the sample inputs, they can design the layout and background of their web page, and share it with their friends. Figure 1 shows this process.

We designed this project to meet the goals outlined in Section 2. The sample inputs are meant to improve and ensure the student's understanding of the math concepts that they are using, while still providing a creative experience. We also hope that through this project, students learn how to describe their ideas with clarity and precision, a skill that is important when using generative AI.

2.2 What is the user interface?

The user interface is inspired by programming IDEs. In a programming IDE, the student is able to run their work often and receive immediate feedback on how they are doing, and share what they build. We believe these qualities improve engagement and motivation, so we aimed to incorporate them in our interface.

We also explored numerous decisions about the feel of the interface. We spoke to multiple experts in math education and identified two distinct methodologies. The first methodology is to make our environment feel as exciting as possible. With this in mind, we designed the environment so that the student feels like they are

SIGCSE 2024, March 20–23, 2024, Portland, OR, USA

ACM ISBN 979-8-4007-0424-6/24/03.
https://doi.org/10.1145/3626253.3635572

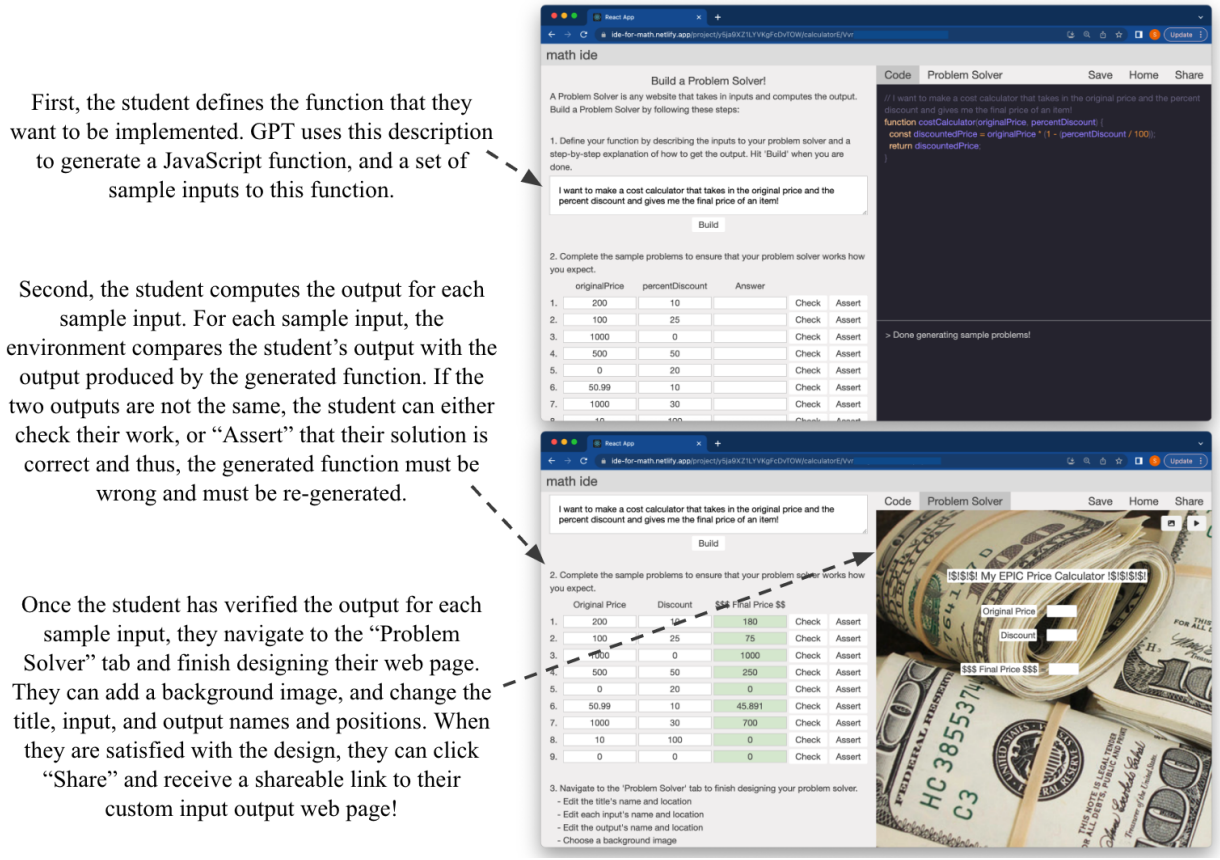

Figure 1: An experimental user interface for the Math IDE.

coding. An example of this can be seen in Figure 1, where we display the generated code in a terminal like window. The second methodology is to make the experience feel familiar so that less confident students are not overwhelmed by the new environment. We created multiple interfaces with this goal, where the language and design is as simple and familiar to the student as possible. We have not yet determined if one of these methodologies is better than the other.

2.3 What are other types of projects?

The most significant challenge in developing this platform is identifying what projects the students can build. We must be able to extrapolate the mathematical aspects of the artifact for the student to define, and then rely on GPT to generate the result reflecting the student's work. Our first type of project, the custom input/output web page, demonstrates the feasibility of this goal. We believe this type of project could be used to teach certain middle school math concepts, like percentages, decimals, and fractions. We hypothesize that other project types would be better suited for teaching other concepts. For example, a game maker where the student defines the physical aspects of the game, GPT generates it, and then the student is able to play their custom game might be better suited for teaching geometry concepts, such as angles and shapes.

2.4 How did we build it?

We built the Math IDE as a React web application. All GPT calls are made to OpenAI's Create Completions API [1]. We experimented with different LLMs, and found that text-davinci-003 is sufficient for our current needs.

3 CONCLUSION

A key remaining question lies in determining where this tool will be positioned, whether within traditional classrooms, online platforms, or a blend of both. To evaluate this tool, we need to assess how effectively it stimulates student engagement and how it impacts the overall learning outcomes of the students. There is also a need to address the security aspect, to ensure GPT is appropriately bounded in its generation. Moving forward necessitates collaborative efforts from educators and curriculum developers to transform this opportunity into an effective approach to learning mathematics.

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