Paper 4: Identifying Evidence of Student Engagement in CT via Automated Response Analysis

Subject/Problem

A main argument for the integration of CT into science classrooms is that of *authenticity*– that science should engage students in real science, which is becoming increasingly computationally dependent. While many efforts have been made to design new curricula to incorporate authentic learning experiences by integrating CT into STEM classrooms, little work has been done in using student data to identify examples of engagement in authentic CT science practices (Grover et al., 2014; Swanson et al., 2019; Arastoopour Irgens et al., 2020; Tang et al., 2020). How can we find evidence of students engaging in authentic scientific practice in CT infused classrooms? In this paper, we discuss an automated coding process that identifies evidence of student engagement in CT practices.

Design and Procedure

We base our analysis on the Computational Thinking in Mathematics and Science Practices Taxonomy (Weintrop et al., 2016), which consists of twenty-two specific practices that are divided into four categories: data, modeling and simulation, computational problem solving, and systems thinking. For this analysis, we exclusively focus on the first category, data practices, in order to prototype our computational methods.

We use response data from 51 students who participated in a two-week CT integrated biology unit focused on experimental design. In the unit, students interact with both physical and computational models, while answering multiple-choice and free-response questions on an online platform. We limited our corpus to the 84 free-response questions that students responded to over the course of the curriculum, resulting in a corpus of 4436 responses. To identify student responses that included evidence of students engaging in data practices, we used the taxonomy to derive what a main key – sub-key search structure. The program then searches student responses for instances of the the main key, in the case of data practices was simply 'data,' and also a number of sub-keys are a stemmed verb derived from the taxonomy (e.g."collect" would allow finding "collection", "collecting", "collected", etc.). The sub-keys we used in this analysis are collect*, creat*, manipulat*, analy*, visuali*. These are then computationally searched for in each of the responses.

Analysis and Findings

Using this strategy, we identified 187 responses that contained the main key and at least one sub-key for data practices. To verify our autocoder, four human coders coded a randomized subset of 50 responses in the corpus to identify evidence of a data practice: any responses that indicate students' engagement in collecting, creating, manipulating, analyzing or visualizing data with an explicit or implicit involvement of a computational tool, plus responses that mention automated ways related to data handling. Average Cohen's Kappa across coders, was 0.717, which indicates moderately high agreement.

Table 1. Sample responses identified by the autocoder.

By using those tools you are able to gather your data very quickly and have all the mean and standard deviations in front of you ready to go. The data collecting process is much faster

and you can prove your experiment right or wrong very fast as well.
I used google sheets to collect and organize my data. By doing this, I was able to calculate different values such as mean, std. deviation, std. error and chi square. When all my data was collected, I was able to make a graph to visually show my findings.
By creating a larger sample size of 50 subjects, I am making the data more accurate. After 1000 ticks, you can see how the moist environment is preferred by the subjects. 41 subjects entered the moist chamber and 9 entered the dry chamber.
The data is recorded quickly and completely accurately; there is absolutely no room for human error in the computationally automated data collected tool

Contributions

This type of automated response identification is a first step in understanding students' engagement in authentic CT science practices in the classroom to better understand how our designs evoke student engagement in CT. Our automated coding process is generalizable in order to enable future work in identifying evidence of other CT practice engagement. Additionally, we plan to apply the autocoder to the question texts. This question coding, paired with the coding of the responses, could be utilized to identify particular question archetypes that might effectively trigger student responses that include evidence of CT engagement. Finally, because the process is automated, such analysis can be completed on-the-fly, meaning teachers could flag student responses that contain rich CT engagement and use them as in-class discussion points. Alternatively, teachers could use the autocoder as a first pass to identify possibly rich student responses to assess for CT proficiency.