Towards A Human-in-the-Loop LLM Approach to Collaborative Discourse Analysis

Supplementary Materials

C2STEM Learning Environment

This document contains supplementary information about the C2STEM learning environment and is provided to the reader for reference. The authors assume the reader is familiar with the manuscript.

The C2STEM learning environment targets STEM+C learning through computational modeling tasks where students construct and debug models of scientific phenomena [2]. Students learn kinematics by building computational models of the 1- and 2-D motion of objects. C2STEM combines block-based programming with customized domain modeling blocks to support the development and integration of science and computing knowledge as students create partial or complete models that simulate behaviors governed by scientific principles.

In the *Truck Task* depicted in Figure 1, students use their knowledge of kinematic equations to model the motion of a truck that starts from rest, accelerates to a speed limit, cruises at that speed, then decelerates to come to a stop at a stop sign. Within this task, students must identify and initialize the physics variables that guide this behavior; update these variables according to the kinematics laws that guide the relationships between position, velocity, acceleration, and time; and construct conditional statements to capture the behavior of the truck in the different phases of its motion. For example, students have to create conditional statements that model behavior changes from accelerating to cruising and then cruising to decelerating and stopping. Students have to leverage their understanding of the relationship between velocity and acceleration (e.g., that an acceleration value of 0 will cause the truck's velocity to stay constant) and translate this knowledge into computational form to build the correct model.

The C2STEM environment supports students' problem-solving by allowing students to execute their model and visually assess the motion of the objects in their model. Students can monitor how variables change as the simulation runs using variable inspection, graphing, and table tools (shown in Figure 1). Students' *Environment Actions* are categorized utilizing a hierarchical task-oriented structure adapted from previous work [1] as: (1) *BUILD*, where students add new blocks to the executable model; (2) *ADJUST*, where students adjust blocks in the executable model by either moving them, editing them or their parameters, or removing them; (3) *DRAFT*, where students add, remove, or modify blocks that are not connected to the executable model (this is akin to commenting code); (4)*EXECUTE*, where students run the full executable model or a set of blocks; and (5) *VISUALIZE*, where students use the variable inspection, graphing, or table tools [1].

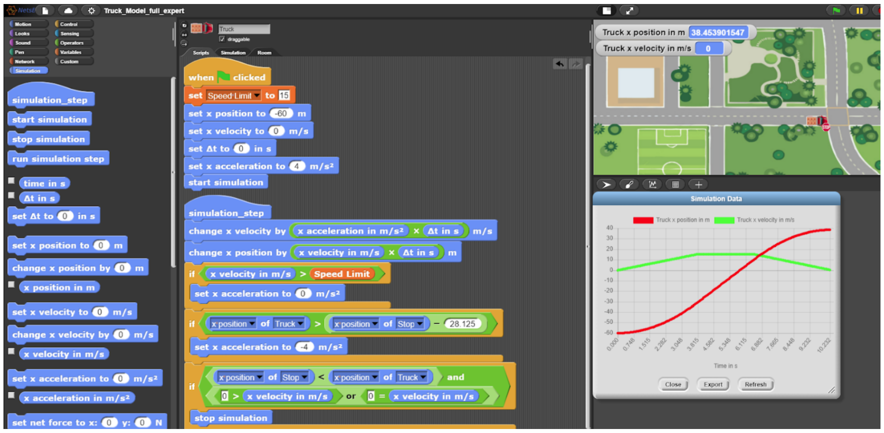

Fig. 1. C2STEM truck task. [3]

To track students' activities in the environment, abstract syntax trees (ASTs) are used to encode students' Environment Actions into *Task Context* categories: (1) *variable initialization*, (2) *variable updating* at each simulation step, (3) *conditional statements*, and (4) *variable updating* within these conditional constructs [3]. Like previous research [3], we use this categorization to divide students' model-building work into distinct segments to contextualize students' conversations. We include both the Environment Actions and Task Context categories in the prompt (see the *Method Application Details* portion of the supplementary materials). Additionally, we provide the prompt with the different environment variables and their corresponding values. This includes *acceleration* (maximum acceleration and deceleration of 4 m/s and -4 m/s, respectively), *delta_t* (the change in time for each simulation step; a constant set to 0.1), *velocity* (the speed limit is 15 m/s), the initial position of the truck (-60), and the position of the stop sign (38.16).

References

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2. Hutchins, N.M., Biswas, G., Maróti, M., Lédeczi, Á., Grover, S., et al.: C2stem: A system for synergistic learning of physics and computational thinking. Journal of Science Education and Technology **29**, 83–100 (2020)
3. Snyder, C., Hutchins, N.M., Cohn, C., Fonteles, J.H., Biswas, G.: Analyzing students collaborative problem-solving behaviors in synergistic stem+c learning. In: Proceedings of the 14th Learning Analytics and Knowledge Conference (2024)