Developing a Definition of Function Through Engaging with the Vending Machine Applet

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Literature

- Definition of function often used in schools is the Dirichlet-Bourbaki function: a mathematical relationship such that each element in the domain corresponds to exactly one element in the range.
- There is an extensive body of research on students' understanding of function and much of that reports that there is difficulty identifying functions and distinguishing them from non-functions. (e.g., Carlson et al., 2003)
- Curriculum often emphasizes procedures and algebraic expressions when studying functions. (e.g., Carlson and Oehrtman, 2005)
- Research shows that students have difficulty showing different representations of functions and different context for functions. (Cooney et al., 2010)
- Cooney, Beckman, and Lloyd (2014) identified three essential understandings to the concepts of function. (Cooney et al., 2010)
- Research shows function machines show promise, but some students still struggle determining what is and what is not a function.
- Carlson et al., 2003 that there is difficulty identifying functions and understanding of function and much of that reports on students' function behaviors.
- Dirichlet Definition of function often used in schools is the function as a rule which assigns to each element of the domain exactly one element of the range.

Framework

- Cognitive root quotations anchoring concept which the learner finds easy to comprehend, yet forms a basis on which theory may be built. (Tall et al., 2000, p. 497)
- A function machine is an example of a cognitive root. A typical example would be "Guess My Rule." Research shows function machines show promise, but some students still struggle determining what is and what is not a function.
- Instead of a "Guess My Rule" machine, we used a vending machine as a cognitive root.

Data Collection

- 15 seventh grade classrooms in the Southeastern United States across four different teachers.
- Students worked in pairs on the vending machine task.
- A total of 72 pairs of students completed the task.
- Worksheets, screen recordings, definitions, and audio were collected for each pair.
- For each screencast, we created a narrative that included a chronological record of the students’ engagement with the applet that included a transcript, as well.

Research Question

RQ1: How do middle school students engage with the vending machine applet?

RQ2: What aspects did middle school students include in their definition of function after engaging with the vending machine applet?

Results

- Incorrect Attention to Output – 19%
- Object – 43%
- Relationship – 0%
- Neither Relationship or Object – 58%
- Attention to Output – 70%

Narratives Change in Understanding

- Change of Color 45%
- Non-Matching Input and Output 29%
- Two Can 9%
- Machine Use 12%

Vending Machine Applet

- GeoGebra Book consisting of 8 pages. Each page consists of 2 vending machines.
- Each vending machine contains four buttons, Red Cola, Diet Blue, Silver Mist, and Green Dew.

Analysis

- For each type of data, a codebook was developed.
- All data was coded by three researchers.
- Disagreements were discussed and discrepancies were resolved.
- Definitions
- We coded each definition for focus and attention to output.
- Worksheets
- Each machine was coded for whether it was listed as a function or not a function as well as the students' language of justification.
- Narratives
- We coded for moments where students had a change in understanding and what triggered their change.

Implications

- Students are able to use this novel representation of a function to develop their own definition of a function.
- 89% of the definitions attended to the univalence requirement.
- Through this activity alone, students did not develop an understanding that a function is a relationship.
- Most often, the change of understanding occurred when the students saw the changing of the output can color.
- This change of understanding often triggered the understanding that the output and input did not have to match, but the output remained constant.
- Students also developed their understanding by how they interacted with the applet.