**Abstract**

Recently, the National Research Council’s framework for next generation science standards highlighted “computational thinking” as one of its “fundamental practices.” Students taking a physics course that employed the Arizona State University’s Modeling Instruction curricula were taught to construct computational models of physical systems. Student computational thinking was assessed using a proctored programming assignment, written essay, and a series of think-aloud interviews, where the students produced and discussed a computational model of a baseball in motion via high-level programming environment (VPython). Roughly a third of the students in the study were successful in completing the programming assignment. Student success on this assessment was tied to how students synthesized their knowledge of physics and computation. On the essay and interview assessments, students displayed unique views of the relationship between force and motion; those who spoke of this relationship in causal (rather than observational) terms tended to have more success in the programming exercise.

**Motivation**

Computational Thinking

**How?**

Python

**Timeline**

FALL 2011

**Visual**

**Assessments of Computational Thinking**

**Proctored Assignment**

- Model the motion of a baseball immediately after it was hit.
- Students were given a grading case on Earth.
- They were then given a practice case on the moon.

**Success rate**

<table>
<thead>
<tr>
<th>Correct results and animation</th>
<th>Produced animation, but incorrect results</th>
<th>No animation</th>
</tr>
</thead>
<tbody>
<tr>
<td>31%</td>
<td>25%</td>
<td>44%</td>
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**Essay Question**

- Investigated whether students success was predicated on reproducing an algorithm or did successful students make deeper connections between physics and the computational algorithm.
- Students broke down into three sometimes overlapping views: force-causal, kinematic-observational, and iterative.
- Students who were force-causal were exclusively iterative.

**Think-aloud Interview**

- 5 students were given the original scaffolded code from proctored assignment on paper and asked to fill in the missing code in a think-aloud environment.
- Students were asked questions about how they define a force, and how forces, motion, and the integration loop were related.
- 3 students presented a force-causal and iterative-local views on the essay question.
- 1 student presented a primarily iterative-local view on the essay and during the interview.
- Students who presented force-causal and iterative views were able to explain their programs more effectively both programmatically and physically.

**Summary and Conclusion**

- 9th grade students were taught to use computational modeling and computational thinking during their forces instruction in a Modeling Instruction physics classroom.
- About one third of the students were completely successful in completing a computation assignment.
- Student success on the proctored assignment was closely tied to how students synthesize knowledge of physics (force and motion) and computation (iterative processes).
- Students who described iterative processes but had not yet connected the concepts of force and motion were unable to create precise computational models.

**References**