Creating a Computational Playground in High School Physics

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OSPREY PHYSICS TEACHING INITIATIVE
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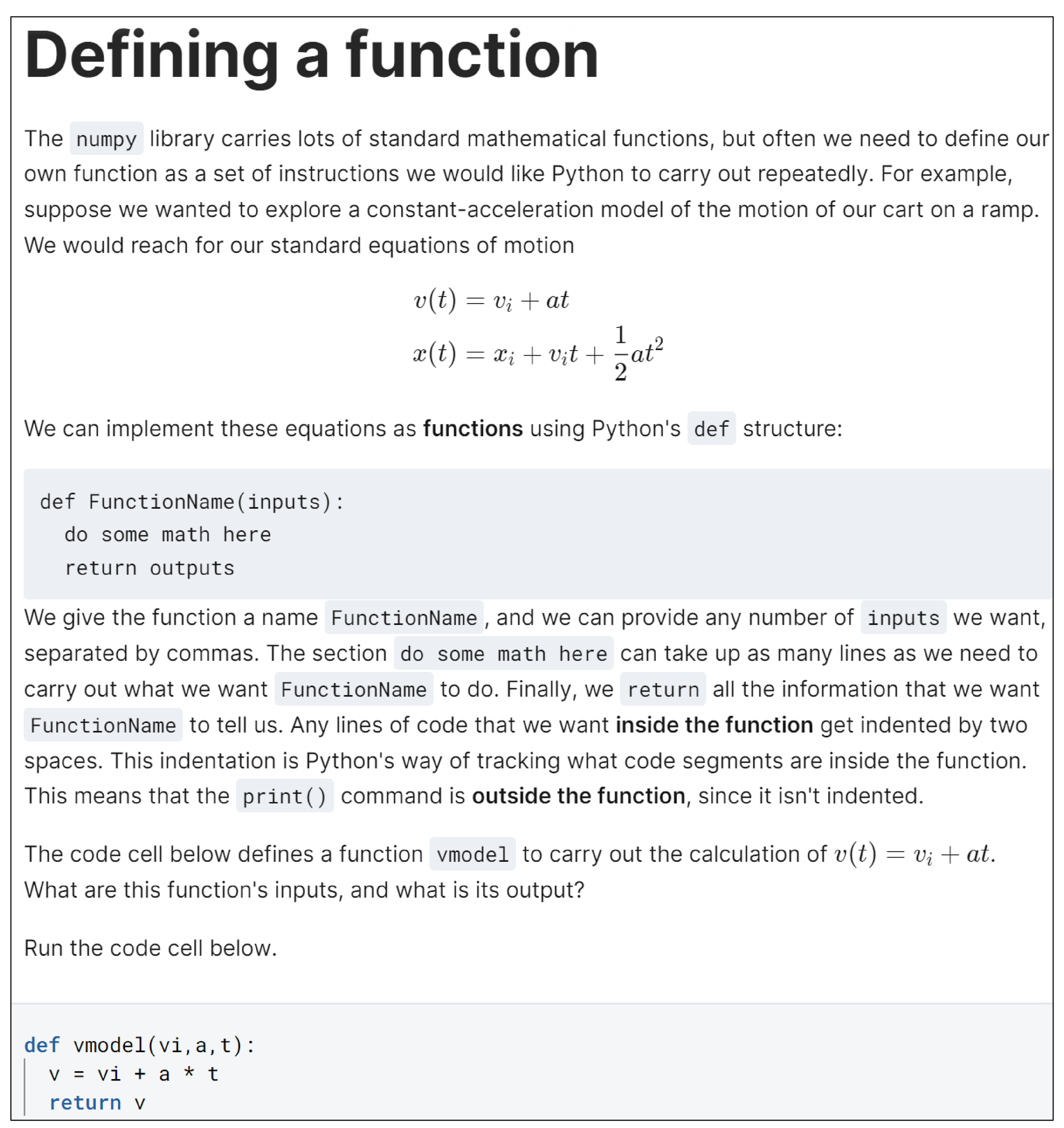
WHAT IS COMPUTATIONAL THINKING?
The interdisciplinary practice of using computers to solve problems and to understand STEM-related concepts.

WHY COMPUTATION IN HIGH SCHOOL PHYSICS[1]?
- Provide a more complete picture of physics.
- Add another representation to the student's toolkit.
- Introduce challenges that develop valuable skills.
- Prompt sense-making to increase the intellectual diversity of learning physics.
- Reinforce curriculum learning objectives.

PROFESSIONAL DEVELOPMENT FRAMEWORK
We offered online asynchronous modules and monthly feedback (Figures 1 & 2) using Jupyter notebooks[2].

Figure 1 Sample Jupyter Activity



Defining a function

The `numpy` library carries lots of standard mathematical functions, but often we need to define our own function as a set of instructions we would like Python to carry out repeatedly. For example, suppose we wanted to explore a constant-acceleration model of the motion of our cart on a ramp. We would reach for our standard equations of motion

$$v(t) = v_i + at$$
$$x(t) = x_i + v_i t + \frac{1}{2}at^2$$

We can implement these equations as **functions** using Python's `def` structure:

```
def FunctionName(inputs):
  do some math here
  return outputs
```

We give the function a name `FunctionName`, and we can provide any number of `inputs` we want, separated by commas. The section `do some math here` can take up as many lines as we need to carry out what we want `FunctionName` to do. Finally, we `return` all the information that we want `FunctionName` to tell us. Any lines of code that we want **inside the function** get indented by two spaces. This indentation is Python's way of tracking what code segments are inside the function. This means that the `print()` command is **outside the function**, since it isn't indented.

The code cell below defines a function `vmodel` to carry out the calculation of $v(t) = v_i + at$. What are this function's inputs, and what is its output?

Run the code cell below.

```
def vmodel(vi,a,t):
  v = vi + a * t
  return v
```

References
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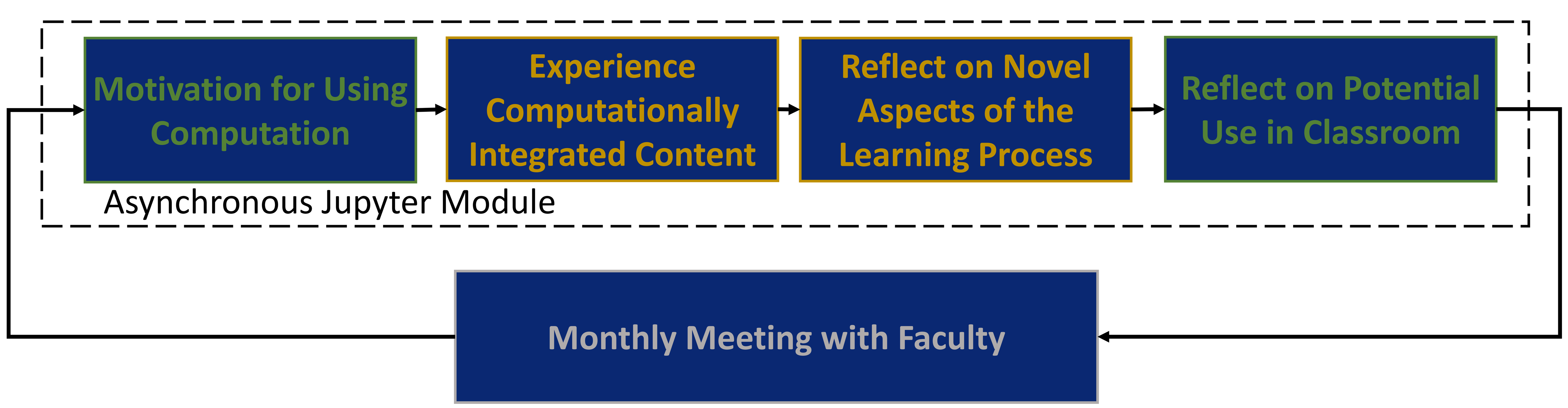
Online professional development can prepare high school physics teachers to integrate computation in their classrooms. We observed teachers making sense of computation using a learner frame and a mediator frame[3-8].

Scan to learn more

Learner Frame: Focuses on what teachers are learning about computation, what piques their own curiosity, and what they feel they can accomplish.
Mediator Frame: Focuses on what teachers believe about what their students would accomplish with computation, what their students are curious about, and how they would use computation to develop their ideal classroom environment.



FINDINGS & DISCUSSION
We interviewed 3 teachers who completed the PD program. Their experiences as learners prepared them to mediate computational experiences for their students.

What they enjoy learning.
"I found every time we've had discussions, I get excited, and I end up at the end of the meeting going and doing some research of my own of using the materials."

"Teaching the Physics 1 stuff is kind of nice but it's nice to actually get back into doing the things I loved doing at college."

How they learn.
"I think structure is important. If you can make it like a playground. I'm imagining a video game, where it's not quite the most intuitive thing but you are playing around, you're tweaking with numbers, you're coming to conclusions. You can restart and try again."

Beliefs about their students.
"The computational activities give them that little breath of fresh air so it's not always just the mechanics curriculum."

"I found [the modules] very interesting and very intriguing… The curious ones, are going to feel the same way."

"I'm not sure how many of my students would be inquisitive enough to just jump in."

Beliefs about what their classroom should be like.
"[Computation] gives [the students] a little bit of independence and a little bit of autonomy."

"That gets everyone more comfortable to try out crazy things."

"The buzz is what you want in the classroom."

NEXT STEPS
These teachers' assumptions that the most curious students would appreciate computation warrants further investigation as we strive to make physics more accessible. These findings inform future PD iterations and continuing support for teachers. We will assess the conceptual affordances of computation in future classroom integration.

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