Coding activities facilitate positive physics learning opportunities.

Introduction

Computation is an integral tool used in the field of physics, making it crucial to teach to our undergraduates. Additionally, many benefits of including computational physics in the curriculum have been identified, such as: [1]

- Computational thinking skills
- Making connections
- Sensemaking
- Visualizing diverse problems
- Transferrable skills

It is no surprise that introducing computation into the physics curriculum benefits students, but we wanted to know:

How do computational exercises impact physics learning?

Methods

In a second-year electricity and magnetism course, students engaged in an activity to develop their understanding of curl and divergence by numerically computing vector derivatives of a 2D vector field. From the student perspective, the series of events was as follows:

Pre-Quiz → **Guided Tutorial** → **Computational Activity** → **Post-Quiz**

After the data was collected, the method for analysis was to compare the pre- and post-quizzes for each student and quantify any learning gains or losses made for each vector derivative. Then, learning gains were categorized based on how the student coded the vector derivative (i.e., correctly, incorrectly, not at all). The pre- and post-quizzes were further analyzed for changes in approach to the vector derivative problems.

Analysis & Results

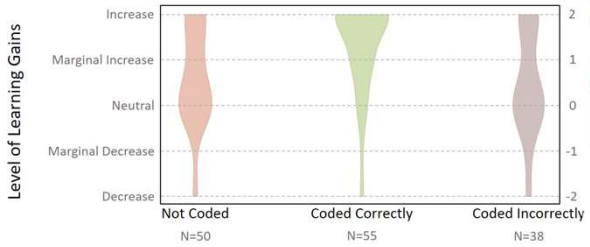

Figure 1. A violin plot depicting the distribution of learning gains based on the coding category the vector derivative falls within for the computational physics activity

Parameter	Model
N	143
Model significance	**
Parameter	**Coeff.**
Intercept	0.380 ± 0.154 *
Coding (0=Not Coded)	
Coded Correctly	0.638 ± 0.211 **
Coded Incorrectly	0.067 ± 0.234

'***' p<0.001, '**' p<0.01, '*' p<0.05, ' ' p>0.05

Table 1. Results of linear regression testing difference between coding engagement types

1. Coding the vector derivative correctly relates to a higher increase in understanding than not coding it
2. There is no difference between coding the vector derivative incorrectly or not at all

→ The computational activity **increased understanding** without being detrimental when done incorrectly

3. Approach to vector derivatives shifted from more qualitative and incorrect to more quantitative and correct
4. Students demonstrated a more correct understanding of all tools used to solve vector derivatives

→ The computational activity helped develop a more **correct and holistic understanding**

	Tools for Justification				
	Drawing	Changes in density or magnitude	Changes in direction	Math or symbolic	Other
Pre-Quiz					
Used correctly	6	14	42	8	11
Used incorrectly	2	31	58	14	24
Post-Quiz					
Used correctly	8	22	43	52	14
Used incorrectly	8	20	38	17	18
Post - Pre Score †	-4	+19	+21	+41	+9

† Scored +1 for correct, -1 for incorrect; compare pre-/post-quiz scores

Table 2. Categorization of vector derivative submissions on pre- and post-quizzes based on the tools used for justification and whether they were used correctly

References

[1] Sand, O.P., et. al. "How computation can facilitate sensemaking about physics: A case study" 2018 PERC Proceedings; https://doi.org/10.1119/perc.2018.pr.Sand

Victoria Arbour, Owen Butler, Martin Williams, **Michael Massa** | University of Guelph Physics Department