Integrating numerical modeling into an introductory physics lab

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Introduction

Computational Component in Mechanics Lab Course

Computational Component in E&M Lab Course
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Computational Component in E&M Lab Course
Goal of Presentation

• Share with the audience the process of instructional design
• Describe the main components of the lab course
• Share interview results of student attitudes towards the course
MOTIVATION

1. Identify broad goals
2. Consult with experts/literature
3. Refine broad goals
4. Identify broader goals

Process of Instructional Changes
Identify broad goals

Consult with experts/literature

Refine broad goals

Identify broader goals

Form a diverse team

Refine final goals and design desired changes

Allocate roles & tasks to team members

Identify internal support system

MOTIVATION

PREPARATION & DESIGN

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Develop desired instructional changes
Pilot test (uncontrolled environment)
Evaluate & Revise
Create a resource online library for students

Pilot test (controlled environment)
Evaluate & Revise

Implement changes for two years
Evaluate & Revise
Create a resource online library for TAs

Process of Instructional Changes
MOTIVATION
PREPARATION & DESIGN
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IMPLEMENTATION & EVALUATION
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Create a resource online library for students

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Evaluate sustainability

Implement changes for two years

Evaluate & Revise

Create a resource online library for TAs

Process of Instructional Changes

MOTIVATION

PREPARATION & DESIGN

DEVELOPMENT

IMPLEMENTATION & EVALUATION

SUSTAINABILITY
<table>
<thead>
<tr>
<th>PROJECT</th>
<th>LAB</th>
<th>SITUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematics</td>
<td>1 (Expt. &amp; Model)</td>
<td>$\alpha = \text{const.}$</td>
</tr>
<tr>
<td></td>
<td>2 (Expt. &amp; Model)</td>
<td>$\alpha = a(t)$</td>
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<td></td>
<td>3 (Report)</td>
<td>Synthesis</td>
</tr>
<tr>
<td>Dynamics</td>
<td>1 (Expt. &amp; Model)</td>
<td>$\Sigma F = \text{const.}$</td>
</tr>
<tr>
<td></td>
<td>2 (Expt. &amp; Model)</td>
<td>$\Sigma F = \Sigma F(t)$</td>
</tr>
<tr>
<td></td>
<td>3 (Report)</td>
<td>Synthesis</td>
</tr>
<tr>
<td>Energy and momentum</td>
<td>1 (Expt. only)</td>
<td>Collision</td>
</tr>
<tr>
<td></td>
<td>2 (Model only)</td>
<td>Collision</td>
</tr>
<tr>
<td></td>
<td>3 (Report)</td>
<td>Synthesis</td>
</tr>
<tr>
<td>Oscillations - Torque</td>
<td>1 (Expt. &amp; Model)</td>
<td>Free</td>
</tr>
<tr>
<td></td>
<td>2 (Expt. &amp; Model)</td>
<td>Damped</td>
</tr>
<tr>
<td></td>
<td>3 (Report)</td>
<td>Synthesis</td>
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</table>
EXAMPLE: PROJECT 2 – LAB 1

EXPERIMENT

- Classic situation of a cart \( (m_c) \) attached to a hanging mass \( (m_h) \) through a sting.

- Photogates record the crossing time and speed of the cart.

- Collect kinematic measurements for \( m_{h1}, m_{h2}, m_{h3}, \) and \( m_{h4} \).
EXAMPLE: PROJECT 2 – LAB 1

MODEL

- Simple analytical model
- Students use an instructional video to develop their first model.

HIGH SCAFFOLDING
EXAMPLE: PROJECT 2 – LAB 2

EXPERIMENT

Lab Structure and Content
EXAMPLE: PROJECT 2 – LAB 2

MODEL

- Extended model
- Students use their first model (lab 1) to help them develop the second model of this project (lab 2).
- Use fit parameters to find out the mass loss rate.

LOWER SCAFFOLDING
ASSESSING THE QUALITY OF THE LABORATORY COURSE

STUDENT GROUP VIDEO ANALYSIS (ENGAGEMENT & LEARNING)

STUDENT INTERVIEWS (ATTITUDES)
ASSESSING THE QUALITY OF THE LABORATORY COURSE

STUDENT GROUP VIDEO ANALYSIS (ENGAGEMENT & LEARNING)

STUDENT INTERVIEWS (ATTITUDES)
INTERVIEWS

- 18 students participated in the 15-min interviews through 3 consecutive semesters
- The interviews were audio and video recorded

THEMATIC ANALYSIS

MODELING

Geoffrey

Chris

Anthony
I liked that part [modeling]. It let us analytically find it out ourselves and then use the computational model to check whether our stuff [data] align. And if it didn't, we were `oh, why it didn't?' I know that in the last [project], we messed up the frequency with the period, and our answers in the computational model were completely different. We looked back at it; we were liked `oh, yeah, that makes a lot of sense.' We used the model to figure it out. I kind of liked it.

"Modeling as a means to “check” the experiment"

- Geoffrey
I've just never used computers in that way. [...] And especially with the modeling, with the experiment's extent, you could only get so much data from it, but then once you made the model, you can extrapolate beyond that point. And so I thought that was cool to be able to see like, `Oh no, it will continue this rate of change.' Even though we had a track that was a meter and a half long.

- Chris
Modeling as a research tool

Computational modeling will help me in the future because it takes away the experiments now. It can often go wrong, but yes, it is a lot safer; you can take out factors that can make a difference in a physics experiment. [...] But the computational model is gonna make everything a lot quicker. You can do a lot more things, that's the only way I can see it.

- Anthony
The integration of computational aspects into a course is a challenging and time-consuming process.

The success of the course revision requires multiple people involved and design of structured activities.

The assessment of student attitudes towards course redesign is mostly on the positive side.

Most of the interviewed students identified the numerical components as the most beneficial aspects of the course.

Initial data from video data assessment suggest high student group engagement.
https://doi.org/10.1119/10.0003899