Project-based learning for Honors College students

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Calculus-based physics for Honors College is different from the regular classes because of the required immersive experience. Each student, or group of a maximum of three students, must pick up a project for the end-of-semester report and presentation. Since the campus closed before they completed their projects, we moved to a hybrid approach with some experiments carried out by the instructor and others based on simulations. To ensure equitable effort, the entire team had to coordinate both on writing the final report and on recording a VoiceThread video with their presentation for the entire class. All presentations were discussed and evaluated by the entire class during a zoom conference.
COURSE PHILOSOPHY

“Honors 158 Lab complements the corresponding lecture of the second part of a one-year introductory course in physics for students with broad interests. In addition to running standard labs, students will be completing projects on course-related topics with the objective of providing a research-oriented experience. Laboratory three hours per week.”
Specific Honors Learning Outcome - Foundations of Knowledge and Methods of Inquiry

1. Demonstrate the ability to create and communicate analytic arguments supported by evidence.
2. Analyze and synthesize information within and/or across disciplines.
3. Design and implement a major research project that reflects a high level of proficiency in methods of inquiry and ways of thinking.
Lab Research Project:

“During the semester, you will be required to design and carry out an experiment of some aspect of physics from this semester’s topics. After consulting with your instructor you must decide on your topic by March 12. A detailed outline is due by March 26. The oral presentations will be on April 16. Written reports on your projects are due on April 20.”

Projects are typically selected by the students and drive them to investigate, do research, and construct their own solutions.
Advantages:
- Foster active learning
- Students work in groups, communicate and engage
- Integrates content area
- Enhances long term memory
- Improve problem solving skills
- Provides relevance

Steps:
1. Identify a problem/topic
2. Develop a plan to solve it
3. Implement the plan in finding a solution
4. Evaluate the implementation and make a presentation
Spring 2018-sample project onsite

“THE PREVALENCE OF RADIATION IN EVERYDAY LIFE”

1. Recorded data related to alpha, beta and gamma radiation in the lab using the Nuclear lab station detector
2. Using a digital Vernier radiation monitor students measured radiation on campus, different location across the city, car, historic houses, dormitory.
3. Other application of radiation "How radiation affect flight space travel"?
How We Measured Radiation in the Lab

- Used a Spectech ST150 Nuclear Lab Station
- Measured radiation at different distances
- Measured radiation at different voltages
- Inserted different objects to be used as shielding
- Paper, cloth, leaf, wood, plastic, aluminium, lead
- Background radiation: 3 cpm at 520 V
How We Measured Radiation Outside the Lab

- Vernier Digital Radiation Monitor
- Voltage: 9 V
- Set device to 5 minutes and allow to count
- Counter measured gamma radiation for 5 minutes
- Each count is a particle hitting the counter
- Background radiation
- Differences in radiation measures vs location
### Data

<table>
<thead>
<tr>
<th>Location</th>
<th>Count</th>
<th>CPM</th>
<th>Location</th>
<th>Count</th>
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<td>New Car</td>
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### 5. Outside Radiation
Applications

**Fighter Jets**

- Original testing grounds for spaceflight technology
- Radiation experienced by rocket pilots
- 3 mSv annually
- Changes in genetic expression
- LDR and hormesis
- Lead glass
- Stealth technology
Spacecrafts

- No atmosphere or magnetosphere in space
- Can’t build out of lead
- Weight
- Design
- Packing
- Material, thickness
- Hydrogenated BNNT’s
Sample project # 2

Spring 2020-sample project remote setting:
Alpha and Beta Decay simulation
Simulations:
● https://phet.colorado.edu/en/simulation/alpha-decay
● https://phet.colorado.edu/en/simulation/beta-decay
Simulations

Alpha Decay

- Alpha Decay
- Half Life
- Radiation

New! Java via Cheerp: Check to see if a browser-compatible version exists

ABOUT
FOR TEACHERS
TRANSLATIONS
RELATED SIMULATIONS
SOFTWARE REQUIREMENTS
CREDITS
Results

Constant Starting Atoms (Alpha)

- 0.5s half-life
- 0.75s half-life
- 1s half-life
Results

Constant Half-life (Alpha)

- 10 atoms:
- 40 atoms:
- 80 atoms:
Results

Constant Starting Atoms (Beta)

- 50 atoms, 5 year half life
- 50 atoms, 7.5 year half life
- 50 atoms, 10 year half life
Results

Energy graphs
Schroedinger’s Cat

- Thought experiment
- Single Hydrogen-3 atom
- 12.32 years half-life
- 100 runs
MATLAB Code

```
global bern timesVect1 proportionsVector1 countsVector;
opts = optimset ('DerivativeCheck', 'off', 'Display', 'off', 'TolX', 1e-6, 'TolFun', 1e-6, 'Diagnostics', ...
    'off', 'MaxIter', 200, 'LargeScale', 'off');
bern = 99;
timesVect1 = (1/200)*[2, 19, 43, 74, 103, 172, 205, 340, 449, 662, 762, 863, 1151];
countsVector = [98, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 1];
proportionsVector1 = (1/bern)*[99, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, 1];
starting_estimatedParam1 = rand(2, 1);
lower_param1 = (-1)*ones(2, 1);
upper_param1 = 2*ones(2, 1);
while 1
    [estimatedParam1, likely2, exited2] = fmincon ('halfLife_mle', starting_estimatedParam1, [], [], [], [], lower_param1, upper_param1, [], opts);
```

Code inspired by:

Conclusions

- Students involved in the PBL they report being enthusiastic, enjoy working with others.
- Students have a better understanding of the subject matter.