Investigating alignment between learning objectives, question prompts, and rubric criteria in a second-semester introductory physics lab.

Carrie Menke, Jarrod Cortez
UC Merced

Intro

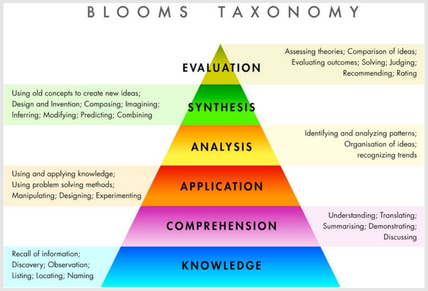
The UC Merced Physics department redesigned the Introductory Physics I and II laboratory courses to align with the American Association of Physics Teachers' (AAPT's) recommendations[1], which emphasize experimental thinking and skills over principles covered in lectures. The courses adopted the recommended learning objectives (CLOs). Each lab manual includes specific learning objectives as well (LOs). To support our mission as a research university, students are trained in keeping a lab notebook, which is also how assessment of various learning objectives are assessed.

In spring 2022 the descriptive rubric was shifted from a descriptive rubric to a check-list that directly references our lab notebook guide. An additional to the lab notebook requirements was a section for students to explain how they knew they had achieved the specific LO's in each lab.

We used with Bloom's taxonomy[2] to analyze alignment between the CLOs, LOs for 4 lab manuals, prompts within those manuals and the lab notebook checklist rubric for the Introductory Physics II course.

Methods

We compared CLOs to the rubric criteria, LOs for 4 labs, and the prompts in those labs. We analyzed the active verbs in learning objectives and question prompts associated with the cognitive processes of Bloom's Taxonomy.



Results

- The checklist rubric increased alignment between the LOs, lab manual prompts and the rubric criteria.
- The specific LOs emphasize application and analysis in Bloom's taxonomy.
- The lab notebook checklist rubric allows assessment of each CLO and spans the cognitive processes dimension of Bloom's taxonomy.

References

1. Kozminski, J., Lewandowski, H., Beverly, N., Lindaas, S., Deardorff, D., Reagan, A., ... & Zwickl, B. M. (2014). AAPT recommendations for the undergraduate physics laboratory curriculum. *American Association of Physics Teachers*, *29*.
2. Armstrong, P. (2010). Bloom's Taxonomy. Vanderbilt University Center for Teaching. Retrieved [July 20, 2022] from https://cft.vanderbilt.edu/guides-sub-pages/blooms-taxonomy/.

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Shifting to a checklist rubric increased alignment between assignment learning objectives, assignment prompts, and the rubric criteria in a 2nd-semester introductory physics lab.

Alignment Tables

Course Learning Outcome (CLOs)	Bloom's Taxonomy: Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Construct Knowledge (K)		X	X	X		X
Model (M)	X	X			X	
Design Experiments (D)					X	X
Develop Technical and Practical Laboratory Skills (T)		X	X			
Analyzing and Visualizing Data (A)			X	X		X
Communicate Physics (C)		X				

Rubric Criteria Groups	K	M	D	T	A	C
Notebook maintenance						
Objectives, Purpose, & Predictions	X	X				
Experimental Plan/Procedure	X		X			
Carrying out the Experiment	X			X	X	X
Complete Data Analysis	X				X	
Data Interpretation	X	X			X	X
Achievement of learning objectives	Lab-specific					
Lab reflections: experimental skills (& misunderstandings)				X		

LO's Phyphox III	Bloom's Taxonomy: Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	CLO
Numerically **calculate** the first derivative from discrete data points.				X			A
Numerically **calculate** the second derivative from discrete data points.				X			A
Conceptually and mathematically **analyze** the relationships for acceleration, jerk, and snap.				X			A, C

Lab Manual Prompts Phyphox III	Bloom's Taxonomy: Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation	CLO
Use "Acceleration without g" to **collect** acceleration data…			X				D, T
Numerically **calculate** the second derivative from discrete data points.				X			A
Do the necessary **calculations** to create plots…				X		X	A
Comment on how the charts **compare** to your annotated screenshot of the phyphox data as well the motion associated with the data.				X		X	A

Lab Notebook Guide

Notebook Rubric