Introductory physics laboratory practical exam development: Investigation design, explanation, and argument

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Which Science Practices?

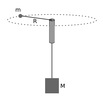
Defined by Ford (doi:10.1002/sce.20263):

	Empirical practices:
EP1	Locate information relevant to a scientific problem.
EP2	Construct a relevant/appropriate scientific question for a given problem.
EP3	Design an experiment to test a scientific question.
EP4	Apply (or know when to apply) appropriate analytical methods to examine a scientific problem.
EP5	Appraise an experimental design to identify elements and limitations and how they impact scientific findings/conclusions
EP6	Troubleshoot technical issues
EP7	Evaluate evidence and critique experimental designs
EP8	Interpret basic statistics (e.g., average and SD).
	Representative practices:
RP1	Generate a hypothesis or make a prediction based on a scientific model.
RP2	Construct an argument based on evidence.
RP3	Identify additional information needed to support an argument.
RP4	Provide alternative explanations for results that may have many causes.
RP5	Integrate and apply knowledge across sub-disciplines.
RP6	Represent data in a visual form.
RP7	Interpret visual representations of data.
RP8	Construct a Data table
RP9	Data Analysis

How Assessed?

Alignment of practices and practical items:

Practical Item	Scientific Practices Assessed
1 - Procedure	EP3, EP4, EP5
2 - Data Table	RP8
3 - Claim	RP2
4 - Plot	RP6, RP9
5 - Argument	EP5, EP8, RP2, RP5, RP9



Experimental setup

- Students work in pairs on items 1-2
- Students turn in individual write-up
- Physics context: circular motion
- Asked to relate rotational period and mass

Development process

Testing/feedback/revision process:
1. Given to 10 advanced lab students
2. Interviews with these students
3. Given to 40 Intro Physics II students
4. Interview with TA
5. Initial use: Spring 2018

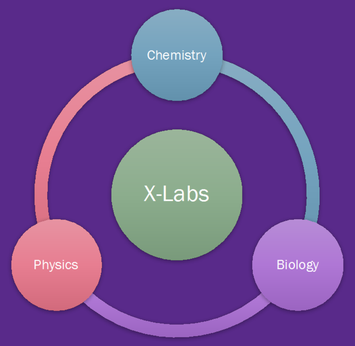
Implementation scope

				score	
Term	Students	Sections	TAs	$\bar{x}$	σ
Spring 2018	415	21	8	–	–
Fall 2018	498	26	10	82	12
Spring 2019	358	18	7	73	15

Given this widespread use, we still do not notice significant issues with cheating. (See also figures at right). ***This was a significant department concern.***

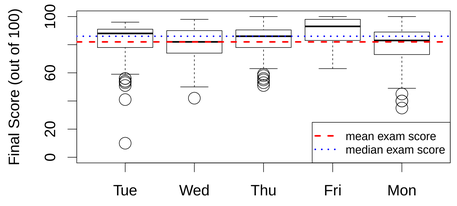
We have *developed*, *validated*, and *implemented* a practical exam to assess ***science practices*** in an introductory physics laboratory.

Take a picture to learn more



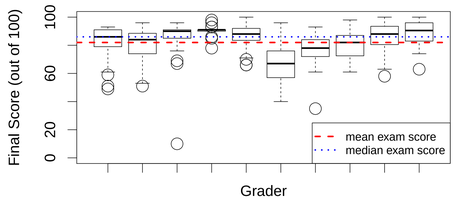
NSF
Award # 1725655

Fall 2018 results



Anova table (Friday Excluded, single grader, few sections)

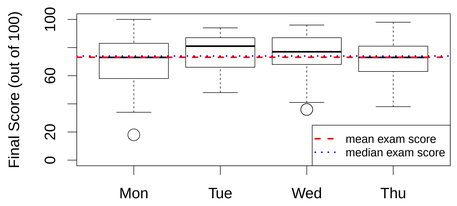
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
day	3	994	331	2.2	0.089
Residuals	462	70134	152		



Anova table

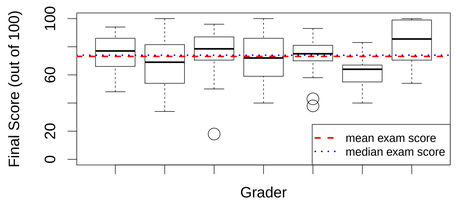
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
grader	9	22267	2474	23	$2.7e-32$
Residuals	488	53220	109		

Spring 2019 results



Anova table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
day	3	1927	642	2.9	0.035
Residuals	354	78198	221		



Anova table

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
grader	6	8028	1338	6.5	$1.6e-06$
Residuals	351	72098	205		

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