Towards inquiry: Redesign of a first year physics lab course

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Abstract. Recently, calls for a shift in focus for physics lab courses have been made. It is recommended for introductory lab courses to aim at teaching students how to plan, conduct and evaluate a rigorous experimental physics inquiry. However, transforming lab courses is a difficult task. I elaborate on the road I have been walking the past three years in redesigning our first year physics lab course. The theoretical framework on which the design is based is elaborated, and subsequently show how the ideas are operationalized in a lab course for ~ 250 students.

Introduction

It has often been reported that lab courses and activities, are inefficient and ineffective [1, 2]. There are striking similarities between our former course and issues reported in literature, such as unrealistically trying to achieve multiple goals within a single activity [2, 3]. As this ineffectiveness was also recognized at our university [4], the first year physics lab course (FYPLC – 168h, ±270 students) has recently been redesigned using the three broad goals:

1) to increase students' motivation to do experimental work,
2) to advance the lab course to 21st century standards and insights,
3) to enable students to engage in basic experimental physics inquiry independently.

The latter goal aligns with recent calls for a shift in focus for lab courses [5] towards learning how to plan, conduct and evaluate a rigorous experimental physics inquiry. However, transforming a lab course towards attaining this goal is a tall order, especially since we do not seem to understand how this learning goal can be attained effectively. Moreover, there are not many reports on transforming lab courses. Therefore, the central question addressed here is:

How can we transform a physics lab course towards teaching experimental physics inquiry?

Methodology & Results

An Educational Design Research approach [6] has been used to redesign the FYPLC. Based upon the preliminary experiences with the course, recommendations from various scholars, the three broad aims for the course and the *Procedural and Conceptual Knowledge in Science* (PACKS) model (figure 1) [7] a new structure for the course and its content is developed.

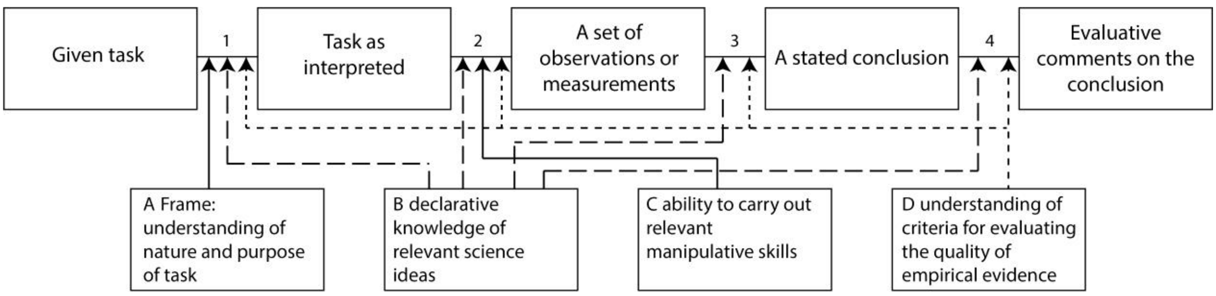

Figure 1. The PACKS model links the various types of knowledge and their influence in each step of an inquiry. In the renewal of the course, the model has been used to guide pedagogical decisions.

As successfully engaging in inquiry requires a substantial amount of conceptual and procedural knowledge and expertise, acquired by making decisions, try, fail, evaluate and repeat, the course constitutes three phases, see table 1. The *introductory phase* focusses on the basic procedural and conceptual knowledge such as gathering, processing and presenting data. Seven self-explanatory Jupyter Notebooks introduce students to Python, data- and error-analysis. Students apply the acquired knowledge in an introductory experiment in which they determine the relation between the force between two magnets and their mutual distance. As students have difficulties with reporting results, much time is given to analyse results and present these in a convincing way.

The *practice phase* focuses on getting familiar with frequently used equipment and measurement techniques. Students carry out three 'recipe-style' experiments. These experiments familiarizes them with spectroscopy and electronics circuits and measurement methods.

In the *application phase* students apply their acquired knowledge by planning their own inquiry. Students first pick from a list a topic of their interest. A small theoretical introduction and an experimental setup is provided. Students then pose their own research question and conceive their own experiment.

Table 1 The outline of the FYPLC

Phase	Content	hours	Assessment	PACKS
Introduction	Programming and data-analysis in python	40	Test	B & D
	Determining the relation between force and distance of two magnets	24	Results & conclusion	A & D
Practice	Determining the Boltzmann constant using the (V,I)-characteristic of a diode using DMMs	12	Paper	C
	Determining RC-characteristics using an oscilloscope	8	Labjournal	C
	Determining the spectral lines of Na or Hg using spectroscopy	12	Report	C
	Determining g with an accuracy of 0.1%.	12	Abstract	D
Application	Self-conceived experiment	40	Paper	A-D

Conclusions

We conclude that we have successfully transformed the FYPLC using literature on teaching scientific inquiry. Our course prepares students for more complex and independent experiments. More details on the process, the challenges, the gained insights will be elaborated in the presentation.

References

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