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Collaborative data collection: shifting focus on meaning making during practical work

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Abstract

In practical work focussing on conceptual development, students spend valuable in-class time on collecting data rather than making sense out of it. This provides a barrier to learning about the targeted concept. To address this problem, we developed an approach that we coin *collaborative data collection*. Using a practical on the topic *density*, we describe this approach and illustrate how the focus of practical work shifts away from mere data-collection towards meaning making. Although a single practical is described, the approach can be applied to other practicals as well.

Keywords: practical work, density, conceptual development

1. Introduction

In secondary school practical work students are often asked to carry out the experiment in teams of two. About 30 students participate in the same activity, manipulate the same equipment, in the same manner, collecting the same data [1, 2]. Although the time required to collect a large data set can be justified for some experiments, there is little time left for the more cognitively demanding tasks: interpreting the data and drawing conclusions. This while discussion and meaning making are crucial in developing conceptual knowledge through practical work and widely reported findings that students need support when interpreting the data and drawing conclusions [3–8].

Is there a different way to carry out practical work so that it entails more than collecting data? Is there a simple way to transform practical work into activities that allows the teacher

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to be available for interpreting the data, drawing conclusions, and critically evaluating what has transpired while doing the practical activity?

For practical work that focus on development of conceptual understanding of physics content we have experimented with an approach that we here coin *collaborative data collection* (CDC) where students collaboratively work on the same goal by sharing their data. This essentially reduces data-collection time and allows a focus on meaning making. We discuss this approach to practical work with a rather simple experiment on density to highlight the merits of this approach. It can, however, be applied in more advanced practicals at secondary school physics level.

2. A practical on density

In learning about density at an age of 13, a frequently used practical is determining the density of various (irregularly-shaped) objects by measuring their mass and volumes. Our previous approach was to provide students with many different objects, some with equal density, some with equal mass or volume, see figure 1. Students would spend most of the in-class time on determining the mass of each object using a balance or scales and determining the volumes using the immersion method. A worksheet was provided to help them in developing or enhancing the concept of density by exploring the direct proportional relationship between mass and volume of 'related' objects. This required them to work with the data, first producing a graph and second interpreting it using scaffolding questions. The unexperienced students needed a lot of time to draw the graph. Little time was left to look for patterns, discuss what these patterns imply, and, e.g. use the graph to predict an object's mass given its material and volume. Students often finished the worksheet at home. We thus could not help on the spot with analysing the graph, understanding and fully appreciating the concept of density.

Figure 1. Students would normally spent much time on measuring the mass and volume of each object, where here only a subset of the collection is given.

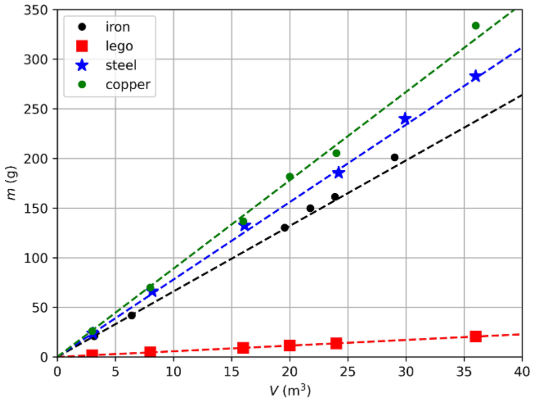

Figure 2. A typical graph produced in this practical with CDC approach. Features of this graph, and what can be inferred from these are discussed centrally.

3. CDC for understanding density

In our CDC version, each student team is given only a subset of the available materials. Students are still familiarized with the instruments and methods, though three or four measurements probably suffice to do so. Once finished, they share their data with the teacher who processes the data and produces the graph of the combined measurements. Each student has thus access to the visual representation of the whole dataset that they normally had to produce themselves, see figure 2. Moreover, as some teams have the same object, they confirm each other's measurements.

As less time is spent on data-collection more time can be devoted to the process of meaning making. A typical class discussion where the teacher scaffold the meaning-making is shown below.

Teacher:	What do you notice in this graph?
Student:	Some points are on the same line.
Teacher:	And…?
Student:	These lines seem to go through the origin

[teacher draws the lines].

Teacher:	What does it mean when measurements are on the same straight line and the line goes through the origin?
Smart student:	That their ratio is the same.
Teacher:	And what does *that* tell you?
Student:	…
Teacher:	If a measurement is on the same line and that line goes through the origin, then there is a direct proportional relationship between mass and volume. Thus, if the mass doubles, the volume doubles too, but their ratio remains the same. The ratio between mass and volume is called the *density*. The density is a material property.
Student:	What do you mean by material property?
Teacher:	If the material is the same, than the density is the same. A material property is thus a feature that all objects made of the same material share, independent of the amount of material we have. So, if we assume that this (points to line) is iron and we would have an iron object with a mass of 5 g, what would be its volume?

[discussion ensues where the teacher highlights properties of the graphs]

4. Rebuttal

But should our students not learn how to make a graph themselves, learn how to analyse their data and learn how to draw informative conclusions that are supported by their data and so on? These are indeed valuable learning goals that we target in our education. However, as Hodson [9] clearly describes: learning science, learning about science and doing science are different goals and require different learning methods. As the CDC approach presented here focuses on learning about density ('learning science'), other important learning goals can (and should) be addressed in other activities. Otherwise, some students surely become cognitive overloaded [10]. The data, however, remain available to the teacher and can be reused in the next lessons.

5. Conclusion

A simple approach to practical work is described which redirects the focus of students away from data-collection and towards interpreting the data. Although a single practical is described in detail, we use the CDC approach in other practicals as well. For instance in exploring Ohm's law where student teams obtain different resistors and some are given. One can think of revising practicals based upon this simple idea of collecting and sharing the data as a scientific consortium.

Data availability statement

No new data were created or analysed in this study.

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Freek Pols was a physics teacher for ten years and is now the first year physics lab course coordinator at the faculty of Applied Physics, Delft University of Technology. His research focusses on practical work in physics and teaching scientific inquiry at both secondary school and academic level.

Patrick Diepenbroek has been a teacher for 17 years now. Currently, he teaches physics. As an Extended-Essay coordinator, one of his interests is teaching students how to conduct research, and the support the students need while conducting research. He recently received a PhD grant for research into classroom dialogue and how this influences the teaching and learning process.