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By

David Perl - Nussbaum

מאת

דוד פרל - נוסבאום

Students' perception of a learning progression: from semi-structured inquiry activities to an open ended research project

רצף למידה בעיני התלמיד: מפעילויות חקר חצי-מובנות לפרויקט חקר פתוח

Advisor:

Prof. Edit Yerushalmi

מנחה:

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Abstract

Century long yet still ongoing calls of prominent educators and position papers (Dewey, 1910, NGSS, 2013) stress the importance of better representing the practices of inquiry in school science. Inquiry can be integrated within the framework of introductory science courses (Etkina et al., 2013), typically confined to short-term inquiry activities, or can take place in complementary frameworks such as research apprenticeships (Sadler et al., 2010), allowing students to engage in long-term project work. Frequently, because of time constraints or a radical cognitive apprenticeship approach, project work takes a "learn as we go" approach where tools & methods of inquiry are learned as needs arise during the projects. Another possible approach is "learn, then go", reducing cognitive load by introducing inquiry tools & methods in more structured settings prior to the project work. Indeed, several policy documents (AAPT lab recommendations - Kozminski et al., 2014; NGSS, 2013) recommend hierarchy of learning goals for experimental inquiry in different grade levels and courses. Does this hierarchy represent a learning progression the would pave the way to open ended inquiry projects? Would students appreciate its fruitfulness? We examined students' perspective towards this question. In particular, we examine which practices do students value in a “learn, then go" learning progression.

The context of the study is the "Research Physics" program, a three-year school subject (10th-12th grade, ~ 300h) recently introduced (2015) to the Israeli education system. The course targets interested and capable students taking in parallel the post compulsory physics course, and grants a matriculation credit. It consists of a foundation stage (~ 100 h) followed by work in pairs on a yearlong research project (~ 200 h). The design of the foundation involved structuring and problematizing scaffolds in order to develop a set of theory driven categories of inquiry practices (using various research tools, constructing an experimental system, data analysis, construction of a theoretical model, self-regulation of the inquiry process, teamwork, communication of knowledge and originality

The group administered interactive questionnaire (Henderson et al., 2007) served to collect students' reflections on the foundation stage, individually and in groups. The study participants consisted of a group of 32 ‘Research Physics’ students that

participated in the years 2016-8 in a regional class at an outreach center in the campus of a research institution (Weizmann Institute of Science). The students have already completed the foundation stage of the program and were already perusing their yearlong projects. The interactive questionnaire was instrumental in encouraging students to identify inquiry practices that they have encountered in the foundation stage and evaluate their contribution to the yearlong project.

We identified the inquiry practices that students realized that they had to cope with during the foundation stage, their correspondence to theory driven categories, and students' evaluation for the importance of these practices to their long-term projects.

High correspondence was found between students' categories and most of the theory-driven categories, in particular: a) "using various research tools"; b) "constructing an experimental system"; c) "data analysis"; d) "self-regulation of the inquiry process"; e) "teamwork" and f) "communication of knowledge". Several theory-driven categories were found to have low correspondence with the student categories: g) "constructing a theoretical model"; h) "defining and focusing research" and i) "originality".

Practices a-d were identified by students as productive to their yearlong projects, and they recommended including those in the foundation sage. For example, they explained that being introduced to a wide range of tools widened their options and allowed them to make an informed choices of suitable research tools in their projects. While the current design indeed introduced variety of tools, one implication is that future design could better explicate the pros and cons of the different tools, in response to the students' value of informed choice.

Practices e-h were perceived as superfluous. Some of these practices were perceived as non-essential in scientific research all together, in contrast to the view that the intervention aimed to develop. In particular, students viewed the practices of "teamwork", "communicating knowledge" and "constructing a theoretical model" as secondary or not intrinsic to the experimental research process.

The distinction between the categories students perceive as primary and secondary in scientific research can be explained in terms of cultural boundaries (Akkerman & Bakker, 2011) between the instructional high-school lab and the physicist lab. Certain inquiry practices, such as teamwork, communication of knowledge or constructing a theoretical model hold different and sometimes contradictive meanings across these two cultures. For example, teamwork in high school lab means collaboration among team members usually working simultaneously on the same assignment, while in a research lab it is common to find team members working on different aspects of a common problem, to form a multifaceted understanding, sharing ideas and benefiting from the different expertise of the team members.

An important implication is that acquiring teamwork practices cannot be promoted in a vertical manner - increasing the challenge by having students work on more challenging tasks together while structuring the work - allocating roles to group members (Heller et al., 1992). Instead, the design has to better portray the norms and practices of authentic research. For example, by having assessment recognize the different contributions of team members. Moreover, to facilitate boundary crossing one has to make explicit the differences between the instructional lab culture and the physicist culture.