An introduction to the Assessment Rubric for Physics Inquiry

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Abstract. Assessment and feedback are essential in learning to engage in physics inquiry. However, assessment regularly focusses only on the quality of the presentation of the results rather than the adequacy of the decisions made during the investigation and students' ability to justify these. To acknowledge both aspects of inquiry, we developed and validated the Assessment Rubrics for Physics Inquiry using so-called Understandings of Evidence: insights and views that an experimental researcher relies on in constructing and evaluating scientific evidence. In the presentation we elaborate on the construction, validation and implementation of the rubric.

Teaching Quantitative Physics Inquiry

When planning, conducting and evaluating a physics inquiry, an experimental physicist relies on various insights which help in making decisions that are seen as adequate by peers. These insights ought to be developed in students to enable them to engage successfully in *quantitative physics inquiry* (QPI), the inquiries in which a quantitative relation between two variables is to be established. In attaining this learning goal, assessment and feedback is key [1]. However, an often neglected aspect of assessment is the quality of students' choices and students' ability to justify the adequacy of these [2]. There is thus a need for assessment criteria to determine the degree to which students developed the insights required to engage, independently, in QPI [3]. To that purpose we constructed the Assessment Rubric for Physics Inquiry (APRI) [4]. Using the research question '*What does successfully engaging in QPI entails, and how can we asses it?*' we review the development and validation of ARPI. We elaborate in this presentation on the need for objective assessment, the theoretical framework, the validation process and the implementation of the rubric in the field.

Theoretical background

The premise of this study is that an inquiry comes down to the building of a scientifically cogent argument where each decision and action undertaken is substantiated [5]. Teaching scientific inquiry than revolves around the question: '*What is the best next step in producing a convincing answer to the research question?*'. In Millar's [6] *Procedural and Conceptual Knowledge in Science* (PACKS) Model, figure 1, knowledge type **D** relates to what the best next step entails. Aspects of knowledge type **D** are the Concepts of Evidence (CoE), concepts that underpin the collection, analysis and interpretation of data [7]. Related CoE can be grouped into sentences from which 'Understandings of Evidence' (UoE) – insights and views that an experimental researcher relies on in constructing and evaluating scientific evidence – can be derived. These UoE are the backbone for the construction of ARPI.

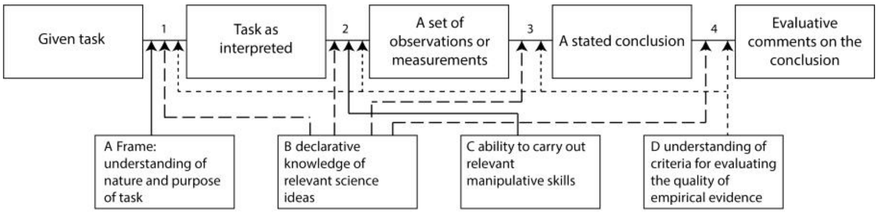

Figure 1. Millar's [6] PACKS model – with a focus on type D knowledge – is used as a framework for constructing ARPI.

Method & Results

The augmented and adapted Delphi study [8] to construct and validate ARPI consisted of five rounds. Using literature on teaching scientific inquiry, we developed a preliminary set of UoE. Per UoE, descriptors for three levels of attainment were specified, see figure 2. These UoE and descriptors constitute an early version of ARPI. This version was scrutinized by various content experts, adapted where required and subsequently tested in the field. Based on these two rounds, a revised version of ARPI was presented to the same experts to establish ARPI's content and construct validity. In the final round, the ecological validity of the instrument was further established by consulting external experts (teachers of lab courses). The result is a rubric that constitutes of 19 UoE divided over six phases of inquiry, with five attainment levels. The rubric has acquired both content and construct validity and the results suggest that ARPI has a high degree of ecological validity as all experts considered ARPI of added value and feasible to use to score open inquiry.

The researcher understands that:	**This understanding is demonstrated by:**	**Attainment levels**		
		4.	**2**	**0**
Measured values will show inherent variation and the reliability of data must be optimised, requiring repeated measurements.	Considering the number of repeated readings in terms of the required accuracy and/or available instruments and their sensitivity, adjusting the choice when needed.	Substantiates the required number of repeated measurements based on the spread in the data and the required reliability. Considers collecting alternative, additional data and collects these if appropriate.	Repeats measurements a fixed but sufficient number of times without substantiation in terms of the quality of the dataset. Considers collecting additional data only in retrospect, as a recommendation.	Collects too few repeated measurements without substantiation or consideration of the quality of the dataset. Does not consider collecting further data at any stage.

Figure 2. ARPI consist of 19 UoE, and descriptors for the lowest, middle and highest attainment level. Intermediate levels are assigned when the lower level is outperformed but the higher level not fully reached.

Conclusion

We consider ARPI a useful assessment tool as the UoE can be interpreted as the learning goals for activities that aim at enabling students to engage in inquiry. It has been shown to be useful in research as it allows to monitor students' progression of engaging in QPI [9, 10].

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