

An Assessment Rubric for Future Teachers Ability to Design Experiments

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Ioannis Lefkos, University of Macedonia, Greece

Abstract. Designing an experiment is a challenging task for most learners. In this work, we are proposing the use of a rubric for the assessment of future Teachers' ability to design experiments. The rubric comprises 6 dimensions and 3 levels of success of the learners' designs and is facilitated by giving a paper & pencil task and a specially designed worksheet. Results from a pilot study revealed that using the rubric we were able to identify the learners' difficulties. This kind of task and assessment scheme can easily be applied to a variety of educational conditions.

1 Designing experiments

Laboratory work and students' engagement in inquiry practices are highly appreciated in science education as a means of promoting students learning [1]. Experimental work is a central component of inquiry-based approaches and the inquiry learning cycle [2]. However, the process itself of engaging students in experimentation is not universally defined, and a variety of ways of describing it have been proposed most of them proposing a three stages process. The first of the stages is usually called "design" and is the preparatory phase where one properly designs an experiment in order to answer a research question [3].

Designing an experiment is probably the most challenging stage in experimentation [4] and various difficulties have been identified in learners of all ages, ranging from primary school to university students [5]. We considered it to be a scientific "ability" since reflection and critical processes have to be employed by the learners [6]. Research on the ability to design experiments at the university level is mostly focused on Engineering or Science majors [6,7], but assessing and developing this ability of future Primary School Teachers (PST) is also important [8] in order to promote their engagement in similar tasks with their students.

Concerning the assessment of the ability to design experiments, there is a variety of proposed methodologies like rubrics, pen & paper tasks, questionnaires, or interviews. From the aforementioned, rubrics can also be used as a scaffold for the development of the ability to design experiments [6] and this is the approach used in this work.

2 Assessing the dimensions of designing experiments –a pilot study

Designing an experiment comprises a set of sub-abilities or "dimensions". Adopting a modified version of a scheme used elsewhere [9], in this work we propose using 6 dimensions and 3 levels of success, thus defining a 6 x 3 rubric for assessing future PST ability to design experiments. Dimensions assessed in this rubric are: (i) Hypothesis formulation, (ii) Criterion of hypothesis verification, (iii) Dependent & independent variable identification, (iv) Control of variables strategy implementation, (v) Necessary materials & devices indication, (vi) Experimentation & data collection process description. Each one of the aforementioned dimensions is assigned 3 levels of success and awarded 1 to 3 points respectively. The total score of each learner can be calculated by summing the points from all dimensions (max 6x3=18). A specially constructed worksheet is used for prompting learners' answers in each dimension. This worksheet works both as a scaffold for learners' designs and at the same time facilitates the assessment of the design of experiments.

As an example, the levels of success for the dimension of hypothesis formulation are displayed in Table 1. Since the original scheme [9] was proposed for younger learners, these levels were adjusted to better fit the PST levels of success, enhancing the rubric's granularity, using a content analysis approach on their answers. In a pilot study the designs of experiment of 35 future PST, were assessed at the beginning of the semester. Using this rubric, we were able to probe their difficulties in some dimensions, like the hypothesis formulation or the manipulation of variables, as also reported elsewhere [5].

Table 1 The levels of success for the Hypothesis formulation

Success Level Dimension: Hypothesis formulation Points

Level-1 Learner formulates a hypothesis based on alternative conceptions or incorrect assumptions 1

Level-2 Learner formulates a hypothesis based on scientifically accepted assumptions 2

Level-3 Learner formulates a hypothesis based on scientifically accepted assumptions, also using scientific

terminology 3

3 Conclusion

Designing an experiment is an important stage in experimentation and future PST should be trained to acquire this ability. In this work, we have proposed a rubric for the assessment of the ability to design experiments in 6 dimensions, to be applied using a specially constructed worksheet for a paper & pencil task. Using this scheme we were able to identify difficulties in some dimensions. This kind of task and assessment scheme can be used for monitoring the development of the learners' ability to design experiments. Moreover, it can easily be implemented even in large audiences, in f2f or distance education, since no laboratory equipment is used.

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Author: LEFKOS, Ioannis (University of Macedonia, Greece)

Presenter: LEFKOS, Ioannis (University of Macedonia, Greece)

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