The Simplicity-Completeness Issue In Physics Explanations

Discussing The Rainbow With Student Teachers

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Abstract. This study explores the extent to which student teachers (STs) of physics can detect consequential gaps in a given explanation (RQ1), and the extent to which they sacrifice simplicity for completeness when designing an explanation for a given audience (RQ2). A very limited explanation of the primary rainbow ("one ray") was discussed with 33 STs, using two successive questionnaires. The STs were often unaware that the "one ray" explanation was logically invalid (RQ1), and the dilemma between simplicity and completeness often remained unresolved after this invalidity was pinpointed (RQ2). The implications for teacher preparation are finally discussed.

1 Introduction

'How do teachers decide what to teach, how to represent it?' ([1] p. 8). To articulate the strengths and weaknesses of an explanatory text, it has been proposed [2] to use grids based on explicit criteria. The present study focuses on the criteria of completeness and simplicity, that may seem *a priori* incompatible. The study investigates the extent to which student teachers (*ST*s) detect consequential gaps in a given explanation, and how this influences their decision-making process. The chosen topic was limited to the case of the primary rainbow.

2 Rationale, and research questions

Choosing an explanation to teach a topic can be understood as a two-step process: a critical analysis of current explanations and a decision based on the perceived benefits and risks of each candidate explanation [3]. It is common to observe a conflict between completeness and simplicity. In the present study, the participating *ST*s were invited to detect gaps in an explanation of the primary rainbow, with one of these gaps rendering the explanation logically invalid. The two research questions are: (RQ1) To what extent do *ST*s recognise the gaps in this incomplete explanation?; (RQ2) Do participants see a need for a more coherent and less simple explanation - in this case, for first-year university students - and why?

3 Experimental design

33 student teachers were presented with an explanation of the rainbow that took into account only one particular incidence of a solar ray on a drop ("one-beam" explanation). Such

an explanation is logically invalid since another incident ray - for example, a diametrical ray - would cause a different deflection. *Quest. 1* first explored additional explanations that *ST*s thought first-year university students would need in addition to the "one ray" explanation. *Quest. 2* begins by explaining that the specific incidence considered in the "one ray" explanation corresponds to a maximum brightness of the reflected ray. Participants were then asked what value they placed on this additional explanation to ensure a good understanding of the rainbow in the target audience.

4 Main results and discussion

Only one participant (out of 33) explicitly pointed out the logical incompleteness of the “one ray” explanation,. This clearly indicates that the issue of logical incompleteness is hardly detected in this group. The value of completing the “one ray” explanation as proposed in *Quest. 2* was declared important by nearly all *STs*, but several hints suggest that the simplicity-coherence dilemma was not easily resolved. This research indicates that *ST*s would benefit greatly from explicit consideration of the interrelated issues of simplicity, coherence, and completeness of an explanation.

References

[1] L.S. Shulman, Those who understand: Knowledge growth in teaching, *Educational researcher*, **15***(2)* (1986) 4-14.

[2] L.Viennot and N. Décamp, *Developing Critical Thinking in Physics The Apprenticeship of Critique*,) (Berlin: Springer) (2020)

[3] L. Viennot Incomplete Explanations in Physics Teaching Discussing The Rainbow With Students Teachers, *Eur.J. Phys.* (2021) ⟨10.1088/1361-6404/ac1500⟩