Qualitative analysis of students' learning processes emerging from the trialling of a physics teaching/learning sequence

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Abstract. In this paper, we present some general aspects of two teaching-learning sequences (TLSs) that target high school students' learning in the field of surface phenomena. After introducing TLSs' theoretical framework and pedagogical approaches, we provide a research-based conceptual scheme of what we mean by "improvement of students' learning". Then, we discuss the implementation of a thematic-like analysis of qualitative data collected during the TLSs' trialling, and, after analyzing some specific aspects of learning as they emerge from qualitative data, we report some results and discuss how to study the advancement of student learning, based on the conceptual scheme provided.

Introduction

We present some general aspects of two teaching-learning sequences (TLSs) on surface phenomena in liquids trialled with high school students during the academic year 2021/2022 and give some results of the analysis of data related to students' learning. We first introduce the TLSs' theoretical framework [1], pedagogical approaches [2] and the techniques [3] used to analyze data. Then, we explore some specific sub-dimensions of learning that we found relevant to our research and show the results of a thematic-like analysis conducted on qualitative data (students' worksheets, audio recordings of students' group discussions, students' contributions during the final day brainstorming phase, notes from researchers) collected during the trialling. Through this kind of analysis, we aim to gain valuable insights into student learning processes and to contribute to the study of qualitative data collected during the trialling of pedagogical approaches in physics education.

The research

One of the purposes of our research is to investigate whether introducing different modelling scales could enhance students' understanding of surface phenomena and engagement during the pedagogical activities. Thus, we designed and trialled two TLSs, based on macroscopic and mesoscopic modelling, respectively [4], both utilizing an inquiry/investigative-based approach. We hypothesized that choosing an appropriate modelling scale could enhance the teaching-learning process. To understand which parts of each TLS can promote a significant student learning, we went in-depth with the more general issue of "promotion of students' learning" in the field of scientific disciplines. Thus, we conducted a literature review and identified some main dimensions that researchers consider when analyzing the promotion of student learning in science, i.e. the acquisition of conceptual knowledge, intellectual growth, and the development of a mindset suited to learning science [5]. In order to perform a fine-grain analysis, each of these dimensions was further broken down into sub-dimensions, which helped us study the overarching concept of promotion of learning in science. This led to the construction of a conceptual scheme that provides a framework for studying the promotion of student learning in pedagogical approaches to physical content. By carefully examining the various dimensions and sub-dimensions of learning, researchers can gain insights into the key elements contributing to significant student learning outcomes.

Methods and findings

The analysis of the qualitative data is inspired by thematic analysis methods [3]. Labelling data segments with codes, allows us to organize and analyze the data more effectively. Overall, the use of codes increases our ability to synthesize and analyze the complexities of the data, ultimately enhancing our understanding of the specific dimensions of learning. We created a code-variable correspondence table, that represents a powerful tool that helps us to understand the relationship between codes and sub-dimensions of learning, as it is addressed in this research. This table maps out which sub-dimensions, that is which aspects of learning, emerge from the data labelled with a specific code. All the choices regarding the coding process, such as the association of a given code to one or more sub-dimensions, were discussed, and agreed by the researchers involved in the study. This negotiation process ensures that the researchers reach a consensus on how to organize and interpret the data accurately and enhances the validity and reliability of the findings because it reduces the potential for subjective bias or personal interpretations.

Conclusion

The results of the analysis suggest that to deal with surface phenomena effectively, it is useful to build a TLS embedding aspects of both the approaches trialled. We observe that presenting a complex topic, as surface phenomena are, through multiple perspectives, involving students in a complex and variegated learning environment, can also lead them to achieve a deep understanding and awareness of themselves. We find that depending on the approach tested, students show an improvement related to different sub-dimensions of learning, i.e. different aspects of learning. One of the most significant results concerns the fact that mesoscopic modelling seems to provide students with effective tools for developing explanatory reasoning models, more than traditional macroscopic modelling. On the other hand, we also observed that students who followed the mesoscopic approach sometimes highlighted difficulties in correctly relating experimental results to those obtained by simulation. Therefore, we believe more time should be allocated to simulations in future didactic paths.

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