Case Study: working with graphic representations and forces

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Abstract. The goal of the present study is to analyze how students interact with their force mental model using several external representations. We test some teaching materials based on the use of external representations that will help them to develop their intuitive mental models to the scientific ones. We have built a case study based on an interview with a sequence of problems, for the students to solve. The problems are mainly qualitative and open. Students showed difficulties to understand free body diagrams. However, when they use their own graphic representations, they become critical and reflexive regarding their own mental model.

1 Context of the research

This study is part of a PhD thesis that focuses on a semi-annual subject-matter called Didactics of Matter, Energy and Interaction (DMEI) in the Primary Education Teacher's Degree. The aim of the dissertation is to find out how mental models and external representations of forces and their interrelation can help develop new materials and practices to improve the learning of the concept of force and develop new ways of teaching it in pre-service primary science teachers training.

2 Proposal of the study and research question

The proposal of this study is one of the specific aims of the PhD and looks into how students interact with their mental model of force using several external representations. Our research questions are: (1) How external representations help preservice teachers to develop their intuitive mental model of force towards a more scientific model? (2) Is there any sequence that explicitly helps this development?

3 Conceptual background

Based on the classic literature on misconceptions on force taking into consideration the first attempts to guide the learning process to overcome them, we establish that: [1] research has evolved toward the notion of mental models [2]. Therefore, we need to focus on the modeling literature to analyze and design the students' teaching and learning process [3][4]. We complement this general framework with some recent specific studies on how to work with alternative graphic representations and forces [5].

According to the cognitive science approach, we learn how an implicit knowledge (like a mental model) could be progressively explained [6] and how this explanation could guide it to a more scientific knowledge in any domain [7]. According to the sociocultural theories, we understand scientific learning as an introduction to scientific knowledge and practices. Working with external representations (verbal and not verbal languages) is one of these practices, in such a way that we cannot understand the construction of scientific concepts without them [8]. We review relevant literature that focuses on students' external representations as tools to explore their ideas and how they could help them structure their construction of concepts and ways of

reasoning [9]. We also review literature on how cognitive and communicative conditions can contribute to the construction of scientific knowledge, concluding that the use and development of a wide range of representations has a positive effect on the student learning [10].

4 Research and design methods

We have built a case study [11] to respond to the research question. The case study is based on personal interviews that allow the description of microprocesses of progressive explicitation, with emphasis on the students' justification of their use of different types of graphic representations. A sequence of problems, mainly qualitative and open, were presented to the students to solve while their were being interviewed. For collecting exhaustive data, we have videorecorded the students' productions during the interview. All the graphic, gestural and verbal representations were coded. A written journal was used to gather all the relevant information during the data collection in the interview. The sample of the study is formed by 8 students of DMEI subject in the Teacher in Primary Education Degree. The interviews were coded and deeply described the external representations built by the students during the interview, their progress and their response to the metacognitive prompts.

5 Conclusions and implications

As expected, students developed a reflexive and critical capacity regarding their mental model when the graphic representation without instructions was introduced. On the other hand, when they were asked to repeat the representation by using free body diagram (FBD) coding, we observed how difficult it was for them to do it and to indicate on what body the forces were acting. In conclusion, in order to prepare the materials for the PhD experimental intervention we will use a new graphic representation as a bridge before the FBD to help students with the identification of forces and their action between the objects that interact.

Acknowledgements

The research was supported by ARCE 2017-UB; and by EDU2013-47593-C2-2-P (Coord. M Garcia-Milà, UB) and by EDU2015-66643-C2-1-P (Coord. C. Màrquez, UAB)

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