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Analysis of Capillarity Phenomenon Models in Primary and Secondary Education in Spain: A Case Study on the Design, Implementation, and Analysis of an Inquiry-Based Teaching Sequence

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Abstract : This study focuses on improving the understanding of the capillarity phenomenon among Primary and Secondary Education students. Despite being a common concept in daily life and covered in various subjects, students' comprehension remains limited. This work explores inquiry-based teaching methods to build a conceptual foundation of capillarity by examining the forces involved. The study adopts an inquiry-based teaching approach supported by research emphasizing the importance of modeling in science education. Scientific modeling aids students in applying knowledge across varied contexts and developing systemic thinking, allowing them to construct scientific models applicable to everyday situations. This methodology fosters the development of scientific competencies such as observation, hypothesis formulation, and communication. The research was structured as a case study with activities designed for Spanish Primary and Secondary Education students aged 9 to 13. The process included curriculum analysis, the design of an activity sequence, and its implementation in classrooms. Implementation began with questions that students needed to resolve using available materials, encouraging observation, experimentation, and the re-contextualization of activities to everyday phenomena where capillarity is observed. Data collection tools included audio and video recordings of the sessions, which were transcribed and analyzed alongside the students' written work. Students' drawings on capillarity were also collected and categorized. Qualitative analyses of the activities showed that, through inquiry, students managed to construct various models of capillarity, reflecting an improved understanding of the phenomenon. Initial activities allowed students to express prior ideas and formulate hypotheses, which were then refined and expanded in subsequent sessions. The generalization and use of graphical representations of their ideas on capillarity, analyzed alongside their written work, enabled the categorization of capillarity models: Intuitive Model: A visual and straightforward representation without explanations of how or why it occurs. Simple symbolic elements, such as arrows to indicate water rising, are used without detailed or causal understanding. It reflects an initial, immediate perception of the phenomenon, interpreted as something that happens "on its own" without delving into the microscopic level. Explanatory Intuitive Model: Students begin to incorporate causal explanations, though still limited and without complete scientific accuracy. They represent the role of materials and use basic terms such as 'absorption' or 'attraction' to describe the rise of water. This model shows a more complex understanding where the phenomenon is not only observed but also partially explained in terms of interaction, though without microscopic detail. School Scientific Model: This model reflects a more advanced and detailed understanding. Students represent the phenomenon using specific scientific concepts like 'surface tension,' cohesion,' and 'adhesion,' including structured explanations connecting microscopic and macroscopic levels. At this level, students model the phenomenon as a coherent system, demonstrating how various forces or properties interact in the capillarity process, with representations on a microscopic level. The study demonstrated that the capillarity phenomenon can be effectively approached in class through the experimental observation of everyday phenomena, explained through guided inquiry learning. The methodology facilitated students' construction of capillarity models and served to analyze an interaction phenomenon of different forces occurring at the microscopic level.

Keywords : capillarity, inquiry-based learning, scientific modeling, primary and secondary education, conceptual understanding, Drawing analysis.
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