

A review of studies on students' difficulties about the nature of sound and its properties.

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Abstract. Sound is a common phenomenon in our lives, a key concept in physics and present in most curricula. Despite this, even university students show difficulties understanding sound. It is relevant to identify these difficulties, because they can inform efficient strategies for teaching and learning. We present the results from a systematic literature review regarding three concepts: a) the nature of sound; b) sound's propagation; c) the sound wave model. The revision shows that there is not a clear learning progression about the nature of sound since Primary up to University education.

Introduction and aims.

Sound is a common phenomenon that we experience every day and plays an important role in understanding physical phenomena that are relevant to students. Moreover, sound understood as a wave phenomenon, contributes to the understanding of classical and modern physics [1]. In fact, sound properties and sound effects are typically covered in all stages of Education Science curricula [2]. Despite its common presence in the science curriculum, and its ubiquity as a physical phenomenon, students display numerous difficulties regarding this concept [1]. In the context of our long-term research, which deals with the design and evaluation of a teaching/learning sequence (TLS) about sound for pre-service primary teachers, it is specially relevant to conduct a systematic revision about learning difficulties on the concept of sound. In fact, it is known that many of the difficulties observed in Elementary and Secondary students are common to those encountered in pre-service and in-service Primary teachers [3]. In this paper, we will focus on revising the available published research about the understanding of sound. Particularly, we will focus on research that analyses students' difficulties in understanding: a) the nature of sound, b) sound's propagation; c) the sound wave model.

Methods

The method employed in this work has been a systematic review, because it is an objective, rigorous and efficient tool that allows the revision of the available scientific literature about a particular topic or research question and the synthesis of the empirical evidence about that topic [4]. In order to select the papers that would comprise this study's sample, we established four selection criteria: (1) *The type of document*. Only research papers were taken into

account; (2) *The publication date*. Only those papers published between 1990 and 2017 were selected; (3) *The paper's title, abstract and keywords*. Those papers that included the term “sound” and that belonged to the area of Science Education; (4) *The paper's topic and coverage*. Papers that showed difficulties with respect to i) the nature of sound; ii) sound's propagation; iii) the sound wave model; (5) *The educational stages*. Papers that examined difficulties in Primary, Secondary and Higher Education. Regarding the latter, we targeted pre-service Primary and Secondary Teacher Education.

Results

The revision comprised a total of 66 research articles and all of them inquired about students' ideas about the nature of sound. These investigations show that most of the primary and secondary students (6 to 16 year old) attribute the properties and behaviours of material substances to sound [5,6]. For example, one research with 6 to 10 year old children showed that the youngest pupils tended to think that sound can not pass through material barriers unless there are holes on them [7]. Consequently, the older students that did not attribute material properties (10-20% in [7]) tended to perceive sound as “no regular matter”, although their reasoning is not consistent for different sound phenomena. Another result arose from the systematic review is that all the examined investigations showed that students do not understand sound as a wave, and in consequence, they cannot understand properties such as tone and intensity [8]. A third result derived from this revision is that only a 12 % of the papers dealt with pre-service teachers' understanding of sound.

Discussion and conclusions

The systematic revision allows drawing important implications for educators and curriculum designers about the teaching and learning of sound. Without understanding the vibrating nature of sound and the propagation of such vibration it is difficult to teach sound as a physical concept and incorporate efficiently the wave model [8]. This implies that there is not a clear learning progression regarding the concept of sound from Primary up to Higher Education. The implications derived from this revision will inform and support the design of a TLS on the nature of sound for pre-service Primary teachers.

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