Development of a teaching concept on the subject of “sound propagation” based on a transmitter-receiver-model

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Abstract. One of the most important senses of the human body is the sense of hearing. In Austrian schools ‚hearing' and related physical concepts (sound generation and propagation) are already part of the physics curriculum in 6th grade (age 11-12). However, for this target group, evidence-based teaching concepts covering research findings on learning difficulties and student concepts are not available. Therefore, we are developing such a new teaching concept on sound propagation and hearing. After the development of the first version of this concept, we conducted teachings experiments and refined the teaching concept.

Introduction

In Austria, a reform of the National curriculum for lower secondary schools brought many changes for teaching physics in school. For example, some physical concepts related to the process of hearing are now addressed in the 6th grade - which is the first year of physics in secondary school. This holds many challenges, because due to the curriculum these concepts should not be built on the particle and wave model [1]. But this also opens new chances: The curriculum promotes a phenomenological approach to acoustics and the use of a transmitter-receiver model [2] to explain the physical processes underlying hearing and sound propagation. However, there is yet no evidence-based teaching concept for this new curriculum which considers known learning difficulties and student concepts. To contribute to closing this gap between research and practice, we developed a new teaching concept in alignment with the Austrian curriculum as part of a master thesis. In order to refine the first version of the teaching concept, we take a closer look at students' learning processes and aim to answer the following questions: To what extent does the developed teaching concept support learning processes in the field of acoustics, in particular sound generation and sound propagation (according to a transmitter-receiver model)?

Theoretical framework and research

Based on the model of educational reconstruction [3], we selected, among others, the key ideas that 1) sound is transmitted, when an object is moving, 2) this movement transfers to the propagation medium, leading to propagating compressions and rarefaction within the medium which can be referred to as a sound wave and 3) when sound waves - i.e. compressions and rarefactions - hit a sound receiver, something starts to move at the sound receiver.
Student conceptions and learning difficulties about ‚hearing' and sound propagation are well-known in physics education research. These include, for example, the student conception that a sound can be elicited [4] or that sounds fly through the air and are something material [5]. In current school books or learning materials, sound is often visualized by a function or a particle model. Especially for young students in their first year of formal instruction in physics these abstract approaches can contribute to a reinforcement of student conceptions and learning difficulties [5]. Therefore, the representation of sound propagation poses the biggest challenge. Since - as described above - it can already be difficult for students to realize what sound is and, above all, that sound is not a material thing, the question arises which form of representation counteracts these student conceptions and still adequately represents the process. To avoid known student conception, we decided to use typographical simulations which we based on the idea of

illustrations used by Wiener [6] for the structure of atoms. Our simulations show the compression and rarefaction in the propagation medium using the word "Luft" (German word for air).

Methods and Findings

We conducted teaching experiments with a first version of the teaching concepts with seven grade-6 students. We split the teaching concepts in seven parts - each part comprising one or two key ideas. These parts were presented to the individual students in a teacher-learner setting. After each part a short interview in three steps followed: First, the students were asked, how plausible the physical concepts are and what was not plausible (acceptance). Second, they were asked to describe the concepts in their own words (paraphrase) and third, sometimes they had to apply the concepts in a similar context (transfer). We analyzed the teaching experiments using qualitative content analysis according to Kuckartz [7]. We used a deductive category system with scaling categories. The results of the teaching experiments show that six out of seven students accept the central physical concept unreserved. However, some students had difficulties to paraphrase the idea of sound propagation as well as concepts built on sound propagation (table 1).

Table 1: Evaluation of paraphrase tasks from the first interviews

Student	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Part 1 Transmitter-receiver-model	Successful	Successful	Successful	Successful	Successful	Successful	Successful
Part 2: Sound transmitter	Successful	Successful	Successful	Successful	Successful	Successful	Poor
Part 3: Sound propagation 1	Successful	Successful	Satisfactory	Satisfactory	Successful	Successful	Successful
Part 4: Sound propagation 2	Successful	Successful	Successful	Satisfactory	Satisfactory	Successful	Satisfactory
Part 5: Sound receiver	Successful	Successful	Successful	Satisfactory	Successful	Satisfactory	Satisfactory
Part 6: Speaking (example 1)	Successful	Successful	Successful	Successful	Satisfactory	Successful	Poor
Part 7: Dolphins (example 2)	Successful	Successful	Successful	Satisfactory	Satisfactory	Satisfactory	Not evaluated

Legend
- Successful paraphrase
- Satisfactory paraphrase
- Poor paraphrase
- Not evaluated

Conclusion and further procedure

Based on the results of the teaching experiments, the part of the teaching concept on sound propagation was revised and new analogies (e.g. slinky) were combined with typographical illustrations. Currently, we are conducting further teaching experiments with the refined version of the teaching concepts. The results will be presented on a poster.

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