Infrared Thermal Imaging – Teacher's Friend when Facing Students' Misconceptions

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Abstract. Among ca. 500 Czech high school students, a research was conducted to identify their most serious difficulties in the field of thermal phenomena. Using a TCE test, phase transitions, thermal conductivity and perceiving heat as a property of a body were found out to be the topics richest in misconceptions. On the basis of these results, the set of thermal imaging hands-on experiments was designed to face these misconceptions by visualizing appropriate physics situations. All the experiments are being used and verified continuously by high school students visiting the Interactive Physics Laboratory established by our university.

1 Introduction

Thermodynamics is considered conceptually a very rich area that uses many terms that are familiar from everyday life but have different meaning in physics [1]. This language gap together with our experience concerning everyday thermal phenomena is responsible for constructing a system of naive beliefs that is often in conflict with scientifically correct explanations (e.g. [2]). Many previous studies, including the author's one, uncovered topics where students show conceptual misunderstandings in the field of thermal phenomena [3, 4].

However, in the last few years, more and more physics teachers can offer their students a powerful tool to enter the world of thermal processes, which have so far remained hidden to our eyes. Thermal imaging cameras are fascinating devices opening the world of small temperature changes and providing a unique chance to visualize even those processes which could help students to deepen their understanding [5, 6]. For this reason, the need arises for appropriately designed physics school thermal imaging experiments, mainly those performed by students themselves. In the form of three sequences, this contribution offers inspiration for ca. 15 thermal imaging experiments, which are based on the identified misconceptions.

2 The research on misconceptions related to thermal phenomena

Using a translated TCE test [7], the quantitative conceptually-oriented research was conducted among Czech students. The sample consisted of almost 500 high-school students aged between 16 and 18. The results showed that the most problematic parts of thermodynamics for students are phase transitions, thermal conductivity and the general perception of heat as energy hidden inside the matter. These misconceptions first appeared in the pre-test and remained the most important also in the post-test, some of them slightly reduced, but other even slightly strengthened [8].

The really most serious difficulties in understanding were discovered in the field of phase transitions; above all, refusing the fact that temperature does not change during melting, freezing and boiling represents the strongest identified misconception, and one that is very resistant to change. Similarly, temperature changes during evaporative cooling appeared to be a problem for respondents.

The concept of heat as energy contained in matter is similarly strong, during the instruction even slightly strengthened. On the other hand, the misconception, which is often mentioned in literature, i. e. the existence of both "hot heat" and "cold heat", is in the Czech environment – probably due to language specifics – only minor or effectively eliminated during instruction.

Fig. 1 Students using a thermal imaging camera in the Interactive Physics Laboratory

Generally speaking, the increase of average students' score between the pre-test (46 %) and the post-test (58 %) was statistically significant, but it resulted in normalized gain of $g = 0.23$ which implies only low effectiveness of instruction that students had undergone. The retention study conducted two years after the post-test on the sample involving ca. 50 % of the initial participants showed that since the post-test, changes in students' results have not been statistically significant – any strong misconceptions have neither arisen nor disappeared.

3 Experiments inspired by misconceptions

On the basis of the above mentioned misconceptions, three sequences of thermal imaging experiments were prepared – the first and most extensive one focuses on phase transitions (dominantly evaporation and condensation), the other on thermal conductivity (metals vs. insulators) and ways how to change internal energy (heat vs. performing work).

All the sequences follow the POE (*predict – observe – explain*) scheme and accent the concrete situations contained in the TCE test. Each sequence starts with trivial experiments and continuously escalates to tasks that are more complicated; the difficulty is designed to be appropriate for high-school students but the author's experience shows that some parts of sequences are easy to use also with younger pupils. In the poster contribution, the sequences design as well as students' worksheets will be presented.

All the experiments are regularly performed by students who visit the Interactive Physics Laboratory [9] that provides high-school students and their teachers a space for conducting physics experiments, which could be hardly carried out in the classroom because of their time or equipment demands. This repeated use of sequences enables their gradual improvements.

References

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