Central University of Technology, Free State

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Southern African Association for Research in Mathematics, Science and Technology Education

BOOK OF ABSTRACTS
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25th Annual Meeting of the Southern African Association for Research in Mathematics, Science & Technology Education (SAARMSTE)


Hosted by

Central University of Technology – Free State

Theme: Research to learn and teach for diversity in Mathematics, Science and Technology Education

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Designed and Printed by:

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STIMULATING AND SUPPORTING INQUIRY-BASED SCIENCE LEARNING WITH INFRARED CAMERAS IN SOUTH AFRICA

Introduction and Aim

Research shows that inquiry experiences can provide students with meaningful opportunities to develop science concepts (Edelson et al., 1999). There is a directive in the South African Curriculum and Assessment Policy Statement (CAPS, Department of Basic Education, 2011) that teaching should include inquiry-based approaches, where learning is guided by students’ own questions and curiosity. In practice, South African researchers such as Ramnarain (2016) have found that teachers and students from previously disadvantaged backgrounds find it challenging to adapt to inquiry-based learning. In this regard, the current ongoing study concerns stimulating and supporting inquiry-based learning activities in Physical Science. Herein, thermal science is a meaningful point of departure since it is a central component of most international science curricula, and transcends many core concepts in physics, chemistry and biology, such as heat, energy, and climate change.

The South African National Curriculum for Grade 7-9 Natural Sciences promotes the understanding of thermal phenomena. For example, the curriculum includes concepts such as heat transfer processes (e.g. radiation and conduction), energy transfers, and insulation. Albeit so, it is a very challenging and abstract area of science for students to understand. This is partly due to the fact that many central terms used in its discourse such as heat, are known from their use in everyday life, but mean something completely different in science. In addition, there are few possibilities to actually see and physically manipulate thermal phenomena, which make thermal concepts that more difficult to visualize and learn. As one solution to overcoming this conceptual obstacle, the recent advent of hand-held infrared (IR) camera technology allows students to directly observe thermal phenomena that are otherwise invisible and notoriously challenging to teach and learn, such as heat conduction through metals, temperature increases due to friction, and energy transfers in object collisions (see Fig. 1).
Figure 1. Photographs and thermographs showing heat conduction through metal and the insulating properties of wood displayed by the camera (left); IR camera image of temperature increase due to friction from rubbing an eraser on a table (middle); Image and accompanying IR camera inset visualizing the otherwise unobservable temperature increase due to collision between a metal ball and asphalt (right).

Our previous work in a Swedish context has concerned the development of a set of practical activities for teaching thermal science using hand-held IR cameras in physics. These activities are aimed at stimulating student inquiry and have been designed for teaching at different educational levels in Sweden including grades 4, 7, and 10 (Authors, 2015a, 2015b, 2014). Over the last year, the authors have initiated a binational collaboration between South Africa and Sweden, with the overall aim to investigate the use of thermal cameras in inquiry-based teaching activities in 7-8-grade physical science South African classroom contexts.

Method

To date, three preliminary video-recorded classroom interventions have been conducted in grade 7-8 physical science contexts with 38, 10 and 5 learners (13-14 years-old), respectively, in Khayelitsha township in the Western Cape. A hand-held FLIR C2 IR camera (see Fig. 1., left) was used to conduct predict-observe-explain (POE) (White & Gunstone, 1992) classroom laboratory tasks that, inter alia, included: pouring hot water into a ceramic mug and a plastic cup and measuring the temperature of the objects, making thumb/hand-contact with a piece of wood and a sheet-metal utility knife, and measuring their temperature before and during contact (Fig. 1, left). The aim was for students to observe any differences in heat flow through a thermal conductor and insulator, respectively, and to confront the alternative conception that our human sense of touch is an accurate thermometer. Video-recorded data from the sessions was transcribed and analysed qualitatively. Analysis was informed by diSessa’s (2014) microgenetic learning analysis and Geertz’ (1973) thick description approaches to observing student interaction, so as to interpret and investigate students’ exchanges and their exposed conceptual understanding about thermal phenomena.

Preliminary Results and Discussion

Our initial results have been encouraging, with the POE approach revealed as an effective means for stimulating science inquiry around thermal concepts in a South African context. In the cup experiment, learners were found to be quite certain in their predictions that the temperature of both the cups would rise, with the temperature of the plastic cup increasing more rapidly than the ceramic cup. Students generated various valid explanations that included identifying differences in cup material and thickness, although at times struggled to find the necessary scientific words to convey their understanding. Nevertheless, learners’ dialogue was found to be adequate for their age, with utterances such as, “When you pour hot water in the cups, both will have a lot of heat in them” revealing an everyday, substance-like idea of heat, which is certainly appropriate at this educational level.

The knife and wood experiment exposed interesting predictions in the small-group context, when students assessed which of the knife or wood felt “colder”, and subsequently confirmed the universal alternative
conception that metals are thought to be inherently colder than wooden objects (e.g. Erickson, 1985). The source may reside in students’ daily sensory experiences associated with “hot” and “cold” objects. Albeit so, students exposed an understanding of heat transfer, with a student suggesting, “I’ve noticed that the metal takes in the heat while the wood ignores it. If you can see there… the area where I placed my thumb, the wood didn’t conduct the heat it just ignored it while the metal took it …from my thumb”. Given this example datum, what has also been of high interest in the results is students’ use of language during the tasks, where even though they often lacked the scientific terms in their reasoning, through direct observation of macroscopic heat transfer processes, they could still nevertheless infer the scientific assertion that metals conduct heat more rapidly than wood, and hence feel colder.

Lastly, preliminary observations have revealed a marked increase in students’ engagement and interest in the thermal topics, accompanied with a change in learners’ thermal-related understanding. This was also manifested in a shift of students’ use of everyday language such as “hotter and colder” toward more scientific words such as “high and low temperatures”.

Future work will entail further systematic studies with more groups of students and classroom contexts, and further investigation of how IR-based inquiry tasks may be a powerful visualization medium for developing understanding of abstract science concepts, especially in contexts where English is usually students’ second, and often third language of instruction.

References


