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THERMAL CAMERAS AS A SEMIOTIC RESOURCE FOR TEACHING SCIENCE IN SOUTH AFRICAN TOWNSHIP SCHOOLS

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Abstract

This study investigates how thermal cameras can be used in meaning-making around thermal phenomena. Predict-observe-explain (POE) tasks were conducted with Grade 7 and 8 learners in two township schools. Results showed that learners coordinated multiple semiotic resources including dynamic thermal images, spoken language and touch in reasoning about heat and temperature. Although results support the literature in that inquiry-based approaches are challenging to implement in this context, the Grade 8 learners indicated that true dialogue was possible to achieve by demonstrating different lines of collaborative inquiry.

Introduction and Objective

The South African Curriculum and Assessment Policy Statement (CAPS) promotes inquiry-based instruction, guided by students' questions and curiosity (Department of Basic Education, 2011). However, research indicates that it is challenging to adopt inquiry-based approaches in disadvantaged South African schools (Clark & Linder, 2006; Ramnarain, 2014). Our work in a Swedish context (Authors, 2014, 2015, 2016) has used infrared (IR) cameras (Fig. 1) to develop inquiry activities for thermal science, a core component of international science curricula. These activities are found to catalyse "what if" explorations driven by meaning-making power offered through simple laboratory setups.

From a multimodal perspective (Jewitt et al., 2001), infrared imaging affords an opportunity to engage with thermal phenomena through vision, as a complement to the sense of touch. A South African and Sweden collaboration is exploring how thermal cameras can stimulate inquiry-based activities in Grade 7-8 South African township classrooms. This study investigates how thermal cameras can be used as a semiotic resource for meaning-making of thermal phenomena.

Literature Review

Heat conduction is the transfer of energy by molecular activity from an object of higher temperature to an object of lower temperature. The fact that metals feel cold to the touch, while wood at the same temperature feels warmer, induces many learners to believe that metal has a lower temperature (Erickson, 1985). Apart from heat conductivity differences as the classroom explanation,

understanding heat conduction is also dependent on cultural and personal contexts (Rosebery et al., 2010). Experiences of heat conduction from insulating a corrugated iron home in a South African township context is different to experiences of holding snowballs in Sweden. Also, terms used to communicate heat in everyday language often mean something different in science.

The CAPS Grade 7-9 curriculum emphasises heat transfer, energy and insulation, but these remain abstract and difficult concepts for students. The salient aspect of triadic dialogue (Lemke, 1990) – classroom exchange occurring as a triad of “moves” comprising a teacher question, followed by a student answer and then closing with a teacher evaluation limits opportunities for students to “talk science” and engage in collaborative inquiry through true dialogue.

Semiotic perspectives that explore classroom learning are based on semiotic affordances – the meanings that are communicated through different modalities (Kress et al., 2001). Modalities refer to how modes of communication (e.g. spoken words, written text, visual images, physical artefacts, and gestures) influence meaning making (Jewitt et al., 2001). One recent development has been on how the sense of touch may serve as a mode (Bezemer & Kress, 2014). An interesting semiotic dynamic of this study is that without coordinating any visual mode to communicate “heat”, learners will rely heavily on touch to make meaning about thermal phenomena.

Methods

The research context is Grade 7-8 general science education at two township schools in the XXXX. Grade 8 learners are selectively recruited to one of the schools based on high achievement and talent, while the Grade 7 learners can be considered as a more typical township class. Thermal cameras render the invisible infrared world as a visual mode of communication in the form of a colour scale where warmer objects appear red and colder objects blue (Fig. 1). Thermal cameras afford the opportunity to visually experience heat conduction as the “flow of heat” between objects of different temperatures. Various semiotic affordances of multimodal interaction with the camera include visual, tactile, verbal and actional modes of communication.



Figure 1. Respective heat conducting and insulating properties of metal and wood demonstrated by the image on the thermal camera.

A FLIR C2 camera (Fig. 1) was used in predict-observe-explain (POE) (White & Gunstone, 1992) activities consisting of pouring hot water into cups of different material and thickness, and engaging hand contact with wood and metal. Author XX participated in the dual role of facilitator and co-

researcher. POE activities, camera actions, group and teacher-learner interactions, were video and audio recorded and transcribed in English. A multimodal semiotic analysis explored the interplay of different modalities on pupils' meaning-making (e.g. Jewitt et al., 2001), informed by insight from XX's 19 years of experience as a teacher trainer and teacher in the township context.

Results and Discussion

Results focus on selected POE episodes. In the opening episode, Grade 8 learners are asked to *predict* which of a piece of wood or metal knife is the coldest, followed by which one *feels* colder:

L1: ...the metal knife is the, is much colder than the wood because the metal knife is a good absorber or should I say a conductor of any temperature around it. So, I think it absorbed the room temperature and I think it's the one that is colder than the wood.

The exchange continues:

XX: Do you also share the same view?

L3: No, I think they are both at the same temperature... at the same room temperature [...]

L4: I think the wood is colder than the metal knife because the wood cannot conduct heat well...

Three distinctly different predictions emerge from the learners – a highly dynamic POE situation that reveals various student lines of reasoning for justifying them.

In an *observe* episode with Grade 7 learners, the thermal image is projected onto a screen, and XX points the camera to the wooden piece:

XX: ...what do you see on the board? L3:

Blue

L2: Blue

XX: ... what does it say about the heat?

L3: It's cold

L4: It's cold, it's 24

XX: We talk of it as cold... ok, and then

what does it say in terms of the

temperature? Have a look at the temperature.

All: 24 degrees Celsius



Figure 2. Photographs of piece of wood and metal knife (left) and the projected thermal camera image (right).

The learners readily coordinate the rendered colour and temperature numerals on the screen, and interpret the wood as being cold due to the blue colour. From a semiotic perspective (Kress, 2010), blue is associated with cold by convention (e.g. markings on taps). The datum represents rapid transduction between modes, from colour, the perceived feeling of cold, to the visible values, and all communicated through spoken language.

In an episode *explaining* that the knife and wood had the same temperature as the room (ca. 25 °C), Grade 7 learners do not accept this explanation. XX views the objects with the IR camera again:

XX: ...the temperature of these objects is the same! [learners smile] It is the same! Isn't it the same...?

L4: I can't believe...

While XX points out that the objects have roughly the same temperatures, the learners acknowledge the observation, but L4 expresses his clear disbelief.

Conclusion

This study demonstrates learners' coordination of multiple semiotic resources, including dynamic coloured thermal images, visual numerals, spoken language and touch. As replicated in a Swedish context, the pupils' reasoning is dominated by the sense of touch. The study supports Ramnarain's (2014) findings that inquiry-based teaching approaches are challenging in the township context. However, the example of the particularly committed Grade 8 learners shows that Lemke's (1990) *true dialogue* is possible to achieve.

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