ESERA 2017 Conference
Dublin City University, Dublin, Ireland.
21st - 25th August 2017

HEAT ANGELS AND PAPER CUPS: PUPILS' MULTIMODAL EXPERIENCES OF HEAT USING THERMAL CAMERAS

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Understanding thermal concepts is a perennial obstacle for learners – ideas such as "heat" cannot be seen directly or accurately interpreted with our bodies. Albeit so, recent infrared (IR) camera technology provides new experiences for students to interrogate notoriously challenging heat and temperature phenomena. Approximately 35 4th-grade pupils interacted with thermal cameras whilst exploring "heat" at a science center. A quasi-ethnographic approach explored how the pupils engaged with IR cameras during spontaneous investigation of their surroundings, and modelling a paper cup thermos construction. Analysis of video and field notes suggests that pupils' engagement with the cameras fostered unique learning scenarios including the rendering of "thermal angel" heat signatures on insulating materials. Results also showed that pupils conversed about heat as entity-like that can be "kept confined" or move from "high to low" or from "inside to outside". Interpreting thermal visualizations inspired novel conceptual links that allowed pupils to experience heat in terms of colours and gestures. The study also revealed the cognitive conflict between bodily experiences (e.g. metals feeling 'cold') and perception of the actual thermal camera generated images (that 'cold' objects were in fact the same temperature as surrounding objects). Even though such conflicts remained unsolved, the experience induced pupils to reflect upon which of their bodily perception, reasoning, or perception of thermal images were most weighted in their multimodal experience. Pupils displayed a surprisingly advanced understanding of heat, suggesting that engagement with the IR cameras may have contributed to a novel and powerful multimodal access to abstract thermodynamic ideas.

Keywords: Inquiry-orientated learning, peer interaction, metaphors

INTRODUCTION AND AIM

One of the four key components of Lakoff and Johnson's (1999) integrated theory of primary metaphor is that human understanding and reasoning is grounded in conceptual metaphors. These metaphors are made up of two or more minimal metaphorical units termed *primary metaphors*. Primary metaphors arise from bodily experiences, whilst conceptual metaphors are learned (Lakoff & Johnsson, 1999). Ortiz (2011) applies these theories onto the notion of visual metaphors by using the primary metaphor as an analytical tool for understanding the manifestation of the primary metaphor in visual conceptual metaphors. Doing so opens up new possibilities for understanding underlying mechanisms for visual and multimodal learning by observing how users interact with visual augmentation tools such as IR-cameras.

Using hand-held infrared (IR) cameras as a window through which to view unseen thermal properties provides access to visual representations of heat. Such tools open the possibility of multimodal experiences of thermodynamic phenomena such as heat, an area of science learning that has proven challenging for students to conceptualise for several decades. Recent research has shown that using IR-cameras can serve as a catalyst for generating fruitful cognitive conflicts that can result in novel learning outcomes, which could help students confront thermodynamics concepts from their everyday experiences (Schönborn, Haglund & Xie, 2014).

The aim of this study was to observe how children interacted with IR-cameras within inquiry-orientated peer collaboration at a digital science center. Pupil visits to the center were orientated around:

i) a spontaneous exploration of the thermal properties of the surroundings, and
ii) a thermos building modelling task.

METHOD

This study observed eight groups of 4th-grade children's use of infrared cameras while exploring heat phenomena in a science center. The approach adopted a quasi-ethnographic method that centered on observing teaching and learning processes, and identifying "steps of learning" and understanding (Murtagh, 2007). In this regard, the field was the center and the researchers engaged in a reciprocal observation and interpretation of various pupil visits. The center environment is designed to promote a high degree of learner autonomy and creative problem solving, which provides opportunities for intuitive and informal learning experiences. Researcher-as-participant observations were conducted using video- and audio recording as well as additional field notes to consider how pupils interacted with and around the IR-camera. Episodes of what were interpreted as critical episodes of learning were transcribed together with thermal images taken by the pupils and used as the data analysed in the study.

RESULTS AND DISCUSSION

Heat as a confined entity

Qualitative video, image and field note analysis indicated that interaction with the IR cameras inspired children to construct, take ownership of, and conduct their own unique learning situations. Observations revealed that children rarely spoke of heat in terms of temperature (even though temperature was displayed on the image output), but rather in terms of an 'entity' that moves from one location to another – "from high to low", "from inside to outside" or "kept confined". The movement reflects what Lakoff and Johnson (1999) term a Source-Path-Goal Schema, and the confinement as the Container Schema. These movement-metaphors correlate with primary metaphors in arithmetic, and also with a change of state; heating or cooling (Lakoff & Núñez, 2000; Lakoff & Johnson, 1999).

Figure 1, Three peers observing the efficiency of their modelled paper cup thermos using a thermal camera.

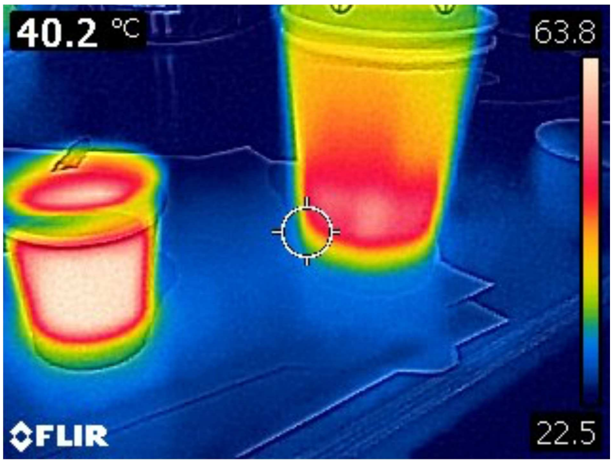

Figure 2, A corresponding example of thermal-imaging captured by the pupils during their modelling process

Access to new conceptual metaphors

The thermal images seem to have given the students access to new sets of conceptual metaphors, making it possible to communicate and to experience thermal dynamics in terms of range, nuance and depth of colour - "your nose is blue", "the table top is getting yellower", "the water is only light red". In these utterances, heat and/or temperature is being discussed in terms of colours, which serve as primary metaphors for understanding thermodynamics. By providing access to these visual conceptual metaphors, the IR camera ushers in a multimodal experience of thermal dynamics where primary metaphors, manifested in the IR-output can be activated and blended into larger and more complex conceptual metaphors (Lakoff & Johnsson, 1999, Ortiz, 2011). Objects, colours and/or, tactile sensations all become collaborative and cognitive resources for negotiating meaning of thermal dynamic phenomena,

Discrepancies between bodily experience and thermal images

Obtained observations showed that the curiosity of the participants and their construction of spontaneous inquiry-based learning situations often start with, and are driven by, discrepancies between bodily experiences (such as metal feeling 'cold') and their interpretation of the corresponding thermal image (that 'cold' objects are of the same temperature as the surroundings). As explored in Schönborn, Haglund and Xie (2014), this usually resulted in a cognitive conflict, which although remained largely unresolved, induced reflection upon what to trust most - their bodily senses, their reasoning, or the displayed camera data. These types of meaning negotiations were found in both peer-to-peer dialogue, individual statements as well as represented in gestures and body language.

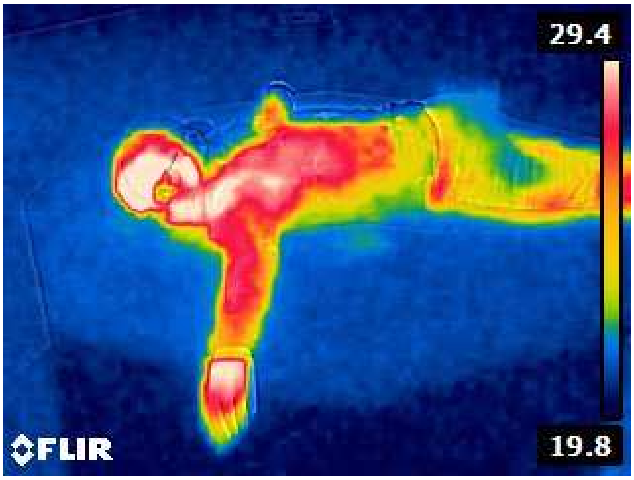

Figure 3. A pupil lying on a cloth-covered seat in an attempt to transfer heat from her body to the object

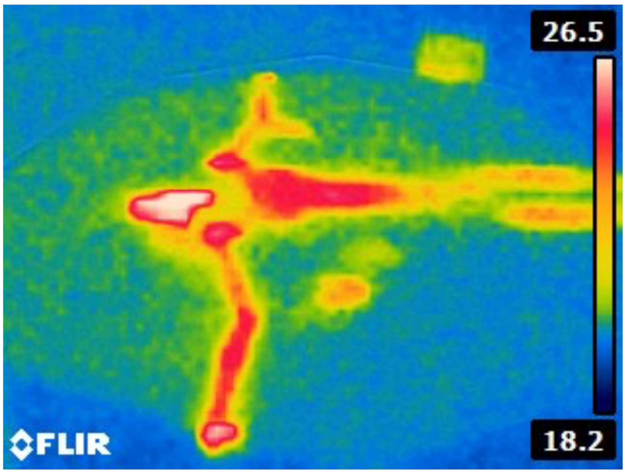

Figure 4. The resulting otherwise invisible thermal "heat angel" imprint left behind on the object

CONCLUSIONS AND FUTURE WORK

The children observed in this study showed a surprisingly developed understanding of heat, which implies that interaction with thermal cameras in an informal learning context may have served as a meaningful semiotic resource for both investigating and communicating thermodynamic concepts. Our evidence to date indicates that children's interaction with the cameras has opened up new ways for experiencing heat, and given pupils access to a novel set of primary metaphors, which makes it possible to reason, learn and expand their understanding of thermodynamics. Future studies will focus on how primary metaphors for heat are manifested in multimodal representations, and how these can be exploited in teaching.

ACKNOWLEDGEMENTS

The authors thank Visualiseringscenter C for the opportunity to conduct the thermal workshops that provided the empirical observation in this work, and the visiting pupils and teachers for their participation.

REFERENCES

Lakoff, G., & Johnson, M. (1999). Philosophy in the flesh : the embodied mind and its challenge to Western thought. New York : Basic Books, 1999.

Lakoff, G., & Núñez, R. E. (2000). Where mathematics comes from. how the embodied mind brings mathematics into being. New York: Basic Books.

Murtagh, L. (2007). Implementing a critically quasi-ethnographic approach. *The Qualitative Report, 12*(2), 193-215.

Ortiz, M. J. (2011). Primary metaphors and monomodal visual metaphors. *Journal of Pragmatics, 43*(6), 1568-1580.

Schönborn, K., Haglund, J., & Xie, C. (2014). Pupils' early explorations of thermoimaging to interpret heat and temperature. *Journal of Baltic Science Education, 13*(1), 118-132.