Understanding the Role of Embodied Interaction in Preschool Children's Learning About Science in Informal Settings

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Abstract: Science researchers and practitioners are often challenged by how best to assess the effectiveness of science activities in preschool children whose language skills are still emerging. Yet, research has demonstrated the critical importance of early learning on individual potential. Building on evidence that movement is tightly intertwined with thinking, this project will investigate how thought and movement link as embodied leaning to enhance science understanding. During a 3-year period, researcher-practitioner teams across six museum sites will collaboratively investigate links between movement and learning outcomes at selected science exhibits for young learners. The study aims to gather evidence for embodied interactions during science learning and articulate design principles about how museum exhibits can most effectively encourage cognitive and physical engagement with science. Such guidelines are largely absent in the field of informal science learning; hence this project seeks transformational change in how learning is understood.

Embodied science learning

Recent research is suggesting that the way we think is inseparably linked to our body-based experiences in the world. In other words, our thinking is *embodied*. Embodied cognition is an umbrella term that refers to the theory that thought is intertwined with how the body interacts with the world; or more simply put, the idea that the mind not only drives the body, but that the body very much influences our thinking. There is currently a large appetite for understanding how preschool children engage in Science, Technology, Engineering, and Mathematics (STEM), particularly around areas of science learning in informal settings (museums etc.). Assessments into preschool children's conceptual knowledge of science, even assessments in more domain-general abilities, are scant (Tolmie, Ghazali-Mohammed, Morris, 2016) meaning science education researchers and practitioners often face the challenges of designing and evaluating learning experiences for very young children whose language skills are still emerging.

In this regard, gesture studies have drawn attention to the importance of visual and motor imagery underpinning thought in domains including science and mathematics that have previously neglected these more embodied representations (Novack, Goldin-Meadow & Woodward, 2015). Such research has particular value for young children whose knowledge is often assessed on linguistic abilities (Brenneman, 2011), despite the likelihood of developing visual and motor imagery underpinning certain concepts before being able to express their thinking verbally (Kontra, Goldin-Meadow & Beilock, 2012). Given the importance of spatial-dynamic relationships in science concepts, it is possible that children are able to demonstrate their emergent understanding through gesture (Alibali & Nathan, 2011; Sauter, Uttal, Alman, Goldin-Meadow & Levine, 2012). Gesture could therefore provide a unique opportunity to capture children's thinking and offer greater recognition of children's capacity in areas such as science.

Hence, building on the evidence that movement is tightly intertwined with thinking, a research project named Move2Learn (M2L) was launched. This is a 3-year internationally collaborative project with the University of Edinburgh, University College London, and the University of Illinois Urbana Champaign. M2L is also working with six practitioner sites across the UK and USA including the Glasgow Science Centre, Science Museum London, Grounds for Learning, Children's Museum Indianapolis, Sciencecenter, Ithica New York, and the Phillip and Patricia Frost Museum of Science in Miami. M2L is funded by the National Science Foundation (USA), The Wellcome Trust (UK) and the Economic and Social Research Council (UK).

The focus of M2L is on how embodied cognition theory can inform the design of museum exhibits and educational programmes. The project seeks to identify key elements or characteristics of informal body-based science experiences that do not simply engage children through physical movement, but also support the internalization and activation of key science concepts as an integral part of early science learning. The research is also dedicated to advancing the understanding of how preschool children (aged 3-5 years), especially those from under-represented communities, think, learn, and communicate about science. It also focuses on conducting translational research that will change and inform practice in the informal science learning sector worldwide. Part of this work will involve using immersive technologies, such as Kinect sensors and fitness tracking watches, given the increasing role these are having in science centres and museums.

By challenging traditional accounts of the mind-body relationship, this research is theoretically significant and there are also exciting implications for how we help children learn in areas such as science. It is possible that we can facilitate learning by designing exhibits that encourage particular 'meaningful' actions; we can also encourage specific gestures that simulate meaningful actions. For these reasons, a design-based methodology will be applied in order to address three key research questions:

1. What elements of sensory and action experiences are key to informing the design of exhibits that aim to exploit embodied interactions for learning?

2. What is the role of bodily enactment /gestures in assessing children's understanding of science concepts?

3. What cultural differences in the kinds of embodied engagement emerge across diverse museum settings?

One of the broader aims of the project is to be able to provide feedback to museum exhibit designers about the core features of an exhibit children respond to, why and how these work, and to use our results as a way to inform the future design of new exhibits using technology. The project is working very closely with museum practitioners in order to achieve this goal and to better understand how research could inform the design and development of exhibits to produce favourable outcomes e.g. attract more visitors from disadvantaged backgrounds.

The contribution of the research to the Learning Sciences field is threefold. Firstly, over the course of the project, the empirical findings will enhance understanding of the role of the body-based movements in science concept development within several diverse settings and for numerous science topics. From these findings common themes and general principles will be extracted that will provide insights into the nature of embodied learning and how interactive and communicative experiences (e.g. gesturing) can support this learning. Second, the project aims to develop a supplementary observation tool that will enable practitioners and researchers to identify and analyse children's actions, gestures and movements that align with science concepts under study and provide a useful and standardised way of assessing engagement. Finally, by the end of this project, principles for intentionally designing exhibits that elicit productive sensorimotor activities will be documented. These research-based design guidelines could include how an exhibit elicits movement, promotes social interaction and collaboration, aligns with a science concept or idea, uses gestures as part of the signage/interpretation process, prolongs dwell time, or assesses the degree to which adults physically engage with children.

This project will raise awareness of embodied approaches to learning as well as build stronger collaborations between informal science educators and Learning Sciences researchers. It is also likely that we can develop better ways to find out what children know and understand by looking at how they interact and gesture in formal settings too. This may be particularly valuable for children who are less able to express themselves verbally or through writing. Embodied Learning therefore offers exiting new avenues for both the design of science exhibits and how we facilitate children's interaction. It is also increasingly possible to take advantage of emerging technologies that can capture and respond to how children move their bodies in informal and formal science environments.

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