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Micro and Macro Pedagogy for Science Education
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Introduction
Policy makers nationally and internationally have recognised the influential role of science and its capacity to promote economic growth (DETI, 2009; European Commission, 2007; Osborne and Dillon, 2008). As such, the decline in numbers of students opting for science, in particular the physical sciences, in Ireland has become a concern. Although curricular change and teacher education have been the traditional methods of targeting improved scientific capacity amongst students (Bell et al., 2009), as key stakeholders, universities have responded with a surge of science outreach strategies and interventions (Davison et al., 2008; DETI, 2009; Regan, 2009) to support Irish teachers. We argue that teachers and teacher educators could play a new role in science outreach by considering micro and macro pedagogical innovations. The proposed micro pedagogy involves the application of effective lesson hooks, and macro pedagogy involves embedding outreach strategies into science lessons, as a part of recognizing that the daily work of science teachers is conscious science promotion. This article will highlight the significant potential of teachers and teacher educators in promoting science and science careers.

Science Outreach Review
In response to the concern about the declining student interest and academic achievement in the sciences, the authors of this article have been working together in the area of science outreach for almost a decade. As teacher educators, we wanted to play a role in researching outreach and designing innovative approaches that would acknowledge the context of science teaching in Ireland. While we knew that there were diverse science outreach initiatives across the island of Ireland, there was little communication or coordination between these stakeholders, and little information about the work they do. In response to this, we organized (in conjunction with other colleagues: Marketing, NUI Galway, and Forfás, Engineers Ireland) the first all-island conference in STEM Outreach in 2007 which ignited national dialogue between outreach providers, practitioners, policy makers, teachers, teacher educators, and scientists, regarding science outreach, best practice and evaluation opportunities.

A key outcome from the first conference was the publication of a report (Davison et al., 2008) that mapped the diverse nature of STEM outreach initiatives, the majority of which (54%) were educational providers in third level institutions. Data also revealed the challenges in terms of greater integration of multiple partners, a more comprehensive evaluation of activities and in particular the need for a shift away from simply providing information about science or activities in science, and instead advancing a strategic approach that attempts to influence social behaviour towards science engagement. Conferences over the four following years introduced examples of science outreach from internationally recognised practitioners, teachers and researchers, including theories of social marketing aimed at voluntary behavioural change.

While we believe that the series of national science outreach conferences broadened knowledge of both theory and practice in the science outreach community, we felt that teachers and teacher educators were not considered key stakeholders. More often than not we regularly encountered research (Aikenhead, 2006; McCoy et al., 2012, Osborne and Dillon, 2010) and outreach practitioners questioning the way science is taught in the classroom. As stated by Zachary et al., (2000, p.1), "The way science and math are taught critically affects their [student] interest and later participation in science and engineering. If this is the case, then the responsibility falls primarily on the teaching profession". In response, outreach strategies are often designed to address a deficiency, which can position teachers as passive, silent partners in science outreach.
It is easy to understand how one might trace a path from unenthusiastic, underperforming science students to similar kinds of teachers. We concur with the argument that many primary teachers often do not have a background in science and therefore may be less prepared to teach foundational elements of science (Eivers and Clerkin, 2013), and that there are likely to be some poor teachers in the system. However, we think that it is much too simplistic and reductionist to blame science teaching when all qualified teachers have been taught pedagogical theory, and have the opportunity to attend regular professional development. As professional educators, primary and secondary teachers in Ireland are committed to quality teaching and learning, and as such, can play a significant role in promoting science.

Science outreach providers are less constrained by curricular and institutional structures and are therefore in a unique position to craft inspiring and unexpected science lessons which can supplement primary and secondary science education. These initiatives are highly valued by teachers, and unarguably function to promote science interest in students. However, if science teachers and science teacher educators are to play a greater role in the promotion of science, there is a need to consider approaches that do not function as additional curricular content, but rather are designed as innovations at the level of pedagogy. We are proposing the possibility of micro injections of pedagogy in the form of strategic and effective lesson hooks, as well as macro pedagogy which involve rethinking science teaching as inherently an outreach practice.

Micro Pedagogy: Lesson Hook Research

Lemov (2010) defines a hook as a short, introductory, pedagogical moment that captures what is interesting and engaging about the material to be covered. As teacher educators, we regularly tell our pre-service teachers about the benefits of lesson hooks, but we frequently found that, if hooks were used at all, the quality was often quite poor. In response to this, we worked with some of our pre-service teachers to research and collaboratively design effective lesson hooks for Junior Certificate-level science teaching (McCaulley et al., 2016). This research offered us a greater understanding of the degree of detail and consideration required in the design of truly effective lesson hooks (McHugh and McCaulley, 2016). Actively engaging students from the outset of a lesson has the potential to trigger and re-trigger student interest and may result in a more persistent, intrinsic personal interest in the topic.

The Interest Theory that drives this discussion is based on Hidi and Renninger’s (2006) Four Phase Model of Interest Development (see Figure 1 below), which illustrates a process of moving learners from where their interest is triggered, Situational Interest (SI), toward an intrinsically-generated Personal Interest (PI). Situational Interest refers to ‘focused attention and the affective reaction that is triggered in the moment by environmental stimuli’ (Hidi and Renninger, 2006, 113). SI plays a vital role in triggering student interest, whereas to maintain attention, PI is pivotal (Schraw et al., 2001). The model represents situational and individual interests in terms of cognitive and affective processes. Personal Interest is characterised by an intrinsic desire to understand and re-engage with a particular topic that persists over time (Hidi and Renninger, 2006; Hidi, 1990). SI is a necessary precursor for PI (Bergin, 1999).

Figure 1: The Four Phase Model of Interest Development (Hidi and Renninger, 2006)

The pre-service teachers discovered that adding a video clip to the beginning of a lesson has a limited capacity to engage students after the clip has ended. Understanding Interest Theory was a key component in the development of effective and engaging science hooks. The hooks which the pre-service teachers collaboratively designed, were made into Chemistry, Physics, and Biology iBooks (also as Gaelge) to serve as resources for science teachers nationally and internationally (www.sciencehooks.scotlnet.ie). A short series of science hooks, Kitchen Chemistry, for primary science will be launched in Spring 2016.
Our experience of collaboratively designing science lesson hooks played a significant role in raising our pre-service teachers’ awareness about what is involved in capturing the attention and interest of science students and how they might be able to move students to see that it is in their interest to engage in science.

We are not proposing lesson hooks as a panacea to transform the science classroom. However, we strongly believe that designing and using strategic and effective lesson hooks is a part of a teacher’s routine pedagogical practice that considers knowledge, skill and affect to arouse student interest, not only in the lesson that is to unfold, but also in science more broadly. Recognising the value and potential of a well-designed lesson hook is the first step science teachers can take in applying sound pedagogical principles in the service of promoting science.

**Macro Pedagogy: Hybrid Outreach Relationships**

We would argue that outreach is inherently a part of science teachers’ work, not an additional burden. However, teacher education rarely makes explicit reference to the fact that the very way teachers teach, their application of sound pedagogy and their explicit enthusiasm for their subject, are tools to promote interest in science, and in science careers. Focusing on teaching the curricular content in the limited time available, and ensuring students are well prepared for exams, often make it difficult for teachers to regularly demonstrate their enthusiasm for science. However, through our regular collaborations with science teachers, in the classroom, school corridors, staffrooms, continuous professional development (CPD) events, the zest for science and teaching science is evident.

While it may seem like a daunting task for teachers both to teach and provide outreach, it may be comforting to know that they have allies in the outreach community. Consciously weaving outreach theories into teaching science may be facilitated by building on the extant network of science outreach providers and practitioners, whose mandate is to support teachers and inspire students. Gomes and McCauley (2013) have argued for the growth of hybrid conversations and collaborations between teachers and outreach practitioners to open up a ‘third space’, where both parties can work together toward a common goal of engaging students in science in society. This is in line with the NCCA’s (2013, p. 18) vision of science students developing an appreciation of the Nature of Science, within the Proposed New Junior Science specification. This hybrid relationship, where teachers and outreach practitioners collaborate on outreach strategies, may have a greater chance of moving students toward personal interest in science, while at the same time making the promotion of science an ordinary part of the way science is taught.

**Conclusion**

Science teachers and science teacher educators have a lot to contribute to the promotion of science but are currently on the margins of the diverse outreach initiatives. However, subtle micro and macro pedagogical shifts may be a viable way to foster wide-spread personal interest in science without significant demands on the teacher. Science teacher educators may impart these pedagogical approaches to the next generation of science teachers through a focus on lesson hook design and science outreach theory as pedagogical practice. We hope our future research will introduce these approaches to science teachers in Ireland. Lesson hooks and conscious outreach teaching approaches facilitated by new hybrid relationships between teachers and outreach practitioners are small steps toward a common goal of the advancement of science and Irish society.

**References**


Regan, E. (2009). I liked the experiment because there aren't too many people who come into school to burn money: promoting participation in the sciences with chemical magic. *Improving Schools*, 13 (3), 261-276.


Dr. Veronica McCauley is a lecturer in Science Education at NUI Galway. Her research interests include: innovative science pedagogies, STEM outreach & engagement, and technology learning environments in the science classroom. Recent publications have drawn upon research in the third space, between science outreach and education, to explore pedagogical practices in both science education and STEM outreach activities.

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