



## Science Outreach and Science Education at Primary Level in Ireland: a Mixed Methods Study

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### Abstract

Worldwide, science has become economically very important <sup>[1]</sup>. The European Union and different EU countries, such as Ireland, stress that science and technology graduates are fundamental for economic growth <sup>[2,3]</sup>. Nevertheless, reports show that, in Ireland the number of graduates in science are not achieving the desired targets <sup>[4]</sup>. Ireland is not an isolated case, and a trend of diminishing interest in science has been identified in other countries <sup>[1,5]</sup>. In response, policy documents of several countries state the need to change the way science is taught in schools (towards inquiry-based learning methods rooted in constructivist teaching and learning) and for further action to be taken to encourage students to pursue science degrees <sup>[4-8]</sup>.

Universities and other organizations (e.g. Industry) have been proactive in supporting and strengthening student uptake in science through the development of informal science programs for primary and second level students (science outreach). A number of reports have recently suggested the potential that science outreach can have in improving student engagement in science and also as a direct vehicle in assisting science education in the classroom <sup>[7-9]</sup>. It is argued that science outreach can create a third space in science education, one in which the formal school science and these informal programs form a partnership, with the objective of improving students science education <sup>[9]</sup>. The value of the partnership between schools and science outreach providers cannot be overemphasized, and as such, forms the basis of this research.

This study examines how initiatives of science outreach, offered by universities to primary level schools can assist science education at primary level. Particularly we are interested in understanding how teachers and science outreach practitioners choose and develop science activities. The specific aim of this study is to examine the perceptions and practices of both primary-level teachers and science outreach practitioners', in terms of their constructivist approach to the teaching and learning of science in the primary level classroom. The key research questions are:

What perceptions do primary-level teachers and science outreach practitioners have regarding of the role of constructivist teaching and learning environments in primary level education?

How do teachers and science outreach practitioners respond to different pedagogical and conceptual challenges in relation to a constructivist teaching and learning approach?

This study follows a mixed methods approach <sup>[10]</sup>. Quantitative data is being obtained through the Constructivist Learning Environment Survey (CLES) <sup>[11]</sup>. This data is being used to compare primary-level teachers and science outreach practitioners' perceptions of constructivist learning environments. Concurrent with this, qualitative and quantitative data is being obtained through a semi-structured interview format <sup>[12]</sup>, where educators and outreach practitioners are asked to analyse a series of conceptual and pedagogical dichotomies presented to them in a video format. The focus here is to explore the conceptual and practical choices of practitioners in science learning environments.

This research proposes to offer insights in how science outreach can position itself in primary level education. These insights can potentially assist in the effective creation of the aforementioned third space, enabling the formation of a collaborative community of elementary science education.

### 1. Introduction

Improving science education is a concern of the Irish and other European governments. Due to the economic relevance of science, policy makers aim to increase student engagement in science <sup>[13]</sup>. Furthermore, governments seek to encourage students to pursue science degrees <sup>[2,3]</sup> to further support this agenda

In order to achieve this twofold objective several measures have been developed by policymakers throughout the world <sup>[4,5,14]</sup>. In the case of Ireland, science curriculum reforms were made in the primary level education system, with a new science curriculum being integrated in 2003, and are underway at second level <sup>[15]</sup> with major curricular reforms over the past decade. These reforms emphasize inquiry



learning based methods, rooted in constructivist epistemology <sup>[16]</sup>. They also stress the role of more active and autonomous learning, a more inductive methodology, and they accentuate creativity <sup>[15]</sup>. To achieve the objectives of the curricular reform, specific training in science has been given to primary level teachers <sup>[17]</sup>. Similar curricular reforms have been reported in several other countries <sup>[18,19]</sup>.

In spite of curricular developments several reports have stated that science education is not changing, with deductive teacher led lessons being the norm <sup>[20,21]</sup>. Therefore, new ways of engaging primary and second level students with science have been pursued. One of which is by getting universities and research intuitions more involved in primary and second level science education. This involvement is achieved through informal science programs designed predominantly by Universities and other organizations such as Industry, for primary and second level students, henceforth denominated as science outreach programs <sup>[9,22]</sup>.

It is argued that science outreach programs, specifically directed at primary and second level students, have the potential to integrate more inquiry based learning in the science classroom and ideally impact an increased interest in science <sup>[2,9]</sup>. The European Commission Report <sup>[2]</sup> advocates that science outreach can serve as a catalyst to accelerate the pace of change in science education. Stocklmayer, Rennie, and Gilbert <sup>[9]</sup> argue that science outreach can create a third space in science education. This third space is envisaged as one in which the students, participating regularly in these outreach initiatives, can benefit from more active, autonomous and creative learning. It is argued that due to the fact that outreach practitioners do not suffer from the constraints of formal education systems they can more easily create this type of environment for students <sup>[9]</sup>.

In spite of the positive effects argued for science outreach in the enhancement of students' science education, a variety of issues have been identified. A recurrent one is the fact that researchers and outreach officers that develop these science outreach programs are often not aware of what happens in a classroom or of curriculum content/sequence. Consequently, it is argued that in order to contribute adequately to the creation of a third space, science outreach providers need to further develop connections with the curricula and schools <sup>[23]</sup>. A second issue reported in the literature is that science outreach programs are still sporadic and incoherent depending on enthusiastic science outreach officers or volunteer scientists <sup>[9]</sup>. Therefore, there is not often a structured approach to science outreach with clear methods and practical aims. This study examines these two issues through a mixed methods approach focusing on perceptions and challenges (both pedagogical and conceptual) faced by practitioners in science education.

## 2. Research rationale

In order to understand the potential of the third space it is relevant to understand and compare the views that teachers and outreach practitioners have regarding the objectives envisaged by the curricular reforms. The specific aim of this study is to examine the perceptions and practices of both primary-level teachers and science outreach practitioners', in terms of their constructivist approach to the teaching and learning of science in the primary level classroom. The key research questions are:

What are the perceptions that primary-level teachers and science outreach practitioners have regarding constructivist teaching and learning environments?

How do teachers and science outreach practitioners respond to different pedagogical and conceptual challenges regarding a constructivist teaching and learning approach?

This study adopts a theoretical position that Greene & Hall <sup>[24]</sup> call a dialectical stance to mixed methods. This dialectical stance is one that actively welcomes more than one paradigmatic tradition and mental model, along with more than one methodology and type of method, into the same inquiry space and engages them in a respectful dialogue with each other <sup>[25]</sup>. The methods will be mixed through a triangulation design and convergence model <sup>[26]</sup>. Quantitative data is being obtained through the Constructivist Learning Environment Survey (CLES) <sup>[11]</sup>, which will be used to compare primary-level teachers and science outreach practitioners' perceptions of constructivist learning environments. Concurrent with this, qualitative and quantitative data is being obtained through a semi-structured interview format, where educators and outreach practitioners are asked to analyze a series of conceptual and pedagogical dichotomies presented to them in a video format. The focus here will be to explore the conceptual and practical choices of practitioners in science learning environments.



## 2.1 Research Participants

Two distinct sample groups will be targeted for this study: primary level teachers and science outreach practitioners. The survey follows a correlation design having a sample size of 180 (90 for each group). This sample size follows the guidelines from <sup>[27]</sup> for a correlation design. In this study, the correlation between primary level teachers and outreach practitioners and their views regarding constructivist learning environments is being analysed. In terms of the semi-structured interviews, a smaller sample was selected, 30 research participants for each sub group. This number of research participants is chosen as it allows a qualitative interpretive framework (20 is the reference number advised by <sup>[27]</sup> for an interpretive framework). The final number, 30, was chosen as it is the minimum sample size that allows descriptive statistical analysis according to Cohen, Manion and Morrison <sup>[12]</sup>.

The primary level teachers were selected through stratified sampling and the outreach practitioners were selected through snowball sampling <sup>[12]</sup>. Since science outreach relies mainly on volunteers or part-time staff, it makes it difficult to define this population and contact it. Snowball sampling is argued as suitable for this type of population <sup>[12]</sup>. The outreach practitioners are divided into two groups. The first group is the science outreach officers, who are working in university settings with the job of promoting science to a larger audience. The second group is the postgraduate students and postdocs/research staff that volunteer in outreach initiatives. These are only two of a great number of divisions that could have been selected. Nevertheless, these were elected as most relevant to answer the research questions of this study, in terms of their engagement in the primary level classroom. Furthermore, with the small sample size of this research, dividing the population further would make the analysis unpractical. The reason that this survey is limited to those working in a university setting is that they represent the majority of outreach practitioners in Ireland <sup>[28]</sup>.

## 2.2 Methods

The CLES Survey has been used in different studies, ranging from qualitative studies of the nature of science knowledge of teachers to international comparisons of learning environments <sup>[11]</sup>. This instrument has also been adapted to measure beliefs in informal science learning settings <sup>[29]</sup>. This is a validated instrument in the formal and informal sectors of science education, making it a suitable instrument for this research.

Concurrent with the CLES survey, qualitative and quantitative data is being obtained through a semi-structured interview format, where educators and outreach practitioners are asked to analyze a series of conceptual and pedagogical dichotomies presented to them in a video format. The focus here is to explore the conceptual and practical choices of practitioners in science learning environments. The method used for the conceptual dichotomies consists of having the research participants analyzing opposing views of a series of concepts (figure 1). This method is congruent with previous studies which used claims from researchers to evaluate research participants' beliefs regarding inquiry based learning <sup>[30]</sup>. The concepts presented in the conceptual dichotomies also guide the pedagogical dichotomies, the ones that relate with specific teaching and learning activities selected by the Irish curriculum. The use of the curriculum to generate research instruments targeting teachers has strong support in the science education literature; it is argued that notions of learning relate to practice more closely when they are assessed at the specific level of a curriculum <sup>[31,32]</sup>. Furthermore, the Irish primary science curriculum offers various possibilities, in terms of practices, for the teachers. The curriculum can be reconstructed in accordance with different beliefs <sup>[15]</sup>. And there is strong evidence that shows that this happens, as previous research focusing on curricula has concluded that teachers often reconstruct it in their practice <sup>[33]</sup>. The topics and activities suggested by the curriculum can then be presented according to different conceptualizations of science education. The curriculum can be followed according to either of the dialectical poles of the conceptual dichotomies, or somewhere in the continuum between them. Therefore, the method selected to present the pedagogical dichotomies consists of having the research participants examining curricular activities designed according to the opposing concepts (figure 1).



Conceptual dichotomies	Pedagogical dichotomies
Autonomy <sup>[34,35]</sup> ← → Dependency	Open inquiry ← → Structured Inquiry  Activity selected to be presented according to both dialectical poles: - The Colored Plant <sup>[36]</sup> (curricular strand investigate factors that affect plant growth )
Deduction <sup>[37,38]</sup> ← → Induction	Observation and identification for deduction ← → Experimentation through manipulation for induction  Activity selected to be presented according to both dialectical poles: - Wag: the dog <sup>[36]</sup> (from the curricular strand explore how levers may be used to help lift different objects: design and make a toy using a lever)
Creativity <sup>[31,39]</sup> ← → Guidance	Open construction of object ← → Specific construction of object  Activity selected to be presented according to both dialectical poles: - Build a magnetic car <sup>[36]</sup> (from the curricular strand Learn that magnets can push or pull different materials)

Figure 1: Pedagogical and conceptual dichotomies

### 3. Analysis of results

This study follows a concurrent data analysis method. This is the advised method for a triangulation design. Accordingly, the analysis will have two stages. In stage 1, there will be a separate data analysis of the qualitative and quantitative databases. This involves coding, theme development and theme relationship for the qualitative element; and descriptive and inferential analysis for the quantitative. In stage 2, there will be a merge of the two datasets to develop a complete picture [26, p.136].

At this moment the analysis of the semistructured interviews is being performed. In the first step of this analysis we are looking to the distribution of the answers of the different research participants to the six dichotomies presented. The next step of the research will be to analyze the reasoning of the research participants to the different choices they made in the six dichotomies.

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