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Constructivism in the third space: challenging pedagogical perceptions of science outreach and science education

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Constructivism in the third space: challenging pedagogical perceptions of science outreach and science education

Abstract

Informal opportunities for young people to engage with science have increased in response to declining uptake in science and a shortage of science graduates. This paper is set in the context of the recent introduction of science at primary level in Ireland and the existence of a great number of science outreach programmes, in particular from universities to support this sector. The recent movement to change science pedagogy in schools towards a focus on inquiry and constructivist methods commands discussion around pedagogical practice in both spaces (education and outreach). Building on the authors' research which embraced a qualitative approach to ascertain participant perception of constructivism and understanding of conceptual and pedagogical dilemmas within science education, this paper reports a singularly quantitative insight, carried out in parallel, to facilitate a more formal and standardised comparison within and between populations and to allow generalisation to the larger population. A Constructivist Learning Environment (CLES) survey of both primary teachers (N=148) and science outreach practitioners (N=81) in Ireland was conducted, eliciting multiple dimension perceptions, in terms of pedagogical choice and comparative differentiators regarding sex, school size, outreach frequency in the classroom, role of outreach practitioner within their institution, outreach experience of the outreach practitioner. Results challenge beliefs presented in the literature about a deficit of science pedagogy amongst primary level teachers and therefore questions the role of science outreach in this relationship. This study provokes the necessity for a discussion of the third space, arising from the juxtaposition between science outreach and education.

Keywords: Science Outreach, Primary Education, Constructivist Teaching and Learning, Third Space

Word Count: 8,503

Introduction

Informal opportunities for young people to engage with science have increased (Holmegaard, Madsen & Ulriksen, 2014; Jeffers, Safferman & Safferman, 2004; Stocklmayer, Rennie & Gilbert, 2010; Tan, Calabrese, Kang, & O'Neill, 2013) and are being recognised as a valuable supplement to the formal learning of science (European Commission, 2007; NSF [National Science Foundation], 1998; Stocklmayer et al., 2010). This increase is in response to the recognised declining interest in science by students and the consequent shortage of science graduates (European Commission, 2011; OECD [Organisation for Economic Cooperation and Development], 2010; Osborne & Dillon, 2010; Regan & DeWitt, 2015). Stocklmayer et al., (2010, p. 26) support the role of the informal education sector in being "relatively free to assist in the provision of worthwhile education by means of which young people become actively engaged in learning about science". The European Commission report (2007) further stresses that these informal opportunities can accelerate the pace of change in science education and it specifically highlights the role of scientists and universities in providing these opportunities to strengthen the links between formal and informal science education. The case for involvement of universities and scientists is also put forward by the National Science Foundation (NSF, 1998) in the United States who promote the dual role between education and science:

> We cannot expect the task of science (…) education to be the sole responsibility of (…) teachers while scientists and graduate students live only in their universities and laboratories. There is no group of people who should feel more responsible for science (…) education (…) than our scientists and scientists-to-be (para. 13).

In the widespread acknowledgement that there is a valued place for informal science learning in the formal classroom and a recent movement to change the way science is taught in schools, towards a focus on inquiry methods rooted in constructivism (Martins Gomes & McCauley, 2016; Koksal & Berberoglu, 2014; Jocz, Zhai, & Tan, 2014; The European Commission, 2007), a discussion is warranted around pedagogical practice in both factions. To extend the context around this study, the authors will now give a brief insight into both spaces (outreach and education), leading towards a dialogue about the third space, "a place in which students can encounter the offerings of the informal sector *within* the school" (Stocklmayer et al., 2010, p. 30). It is anticipated that this third space between outreach and education, and provides a valid opportunity for discussion around pedagogical practice.

Science outreach and its relation with formal education

The first space is formal education and refers to science education at primary level in Ireland for the purpose of this research. In 2003, a primary level curriculum for science, based on constructivist methods, was introduced. This curriculum emphasises autonomy, inductive-inquiry activities, and creativity. The curriculum advocates that students need to plan, design and perform investigations in order to learn and make sense of science. It is an approach that values inquiry learning and problem solving. Furthermore, the curriculum values explicitly a constructivist approach. This constructivist approach recommends starting from the child's ideas and favouring a developmental view. Finally, creativity in science and in the learning of science is highlighted. This aligns with other school curricula as "creative thought is often a stated goal of education" (Regan, 2011, para 2). Nevertheless, studies carried out in Ireland have revealed that transmissive methods are still the most common used by teachers (McCoy, Smyth & Banks, 2012). Furthermore, it is argued that primary level teachers do not feel confident when teaching science (Varley, Murphy & Veale, 2008) and the significance of this is critical when we consider that at the end of primary level most pupils have already excluded the choice of scientific subjects (Van Aalderen-Smeets & Walma van der Molen, 2013).

The second space that guides this study is science outreach. This study is focused on university driven science outreach because it forms the majority of outreach initiatives in Ireland (Davison, McCauley, Domegan & McClune, 2008). These initiatives are seen as having the potential to improve student engagement with science (European Commission, 2007; Stocklmayer et al., 2010). The authors believe that students, participating regularly in these outreach initiatives, can benefit from more active, autonomous and creative learning. Although science outreach programs are still considered to be sporadic and incoherent, lacking a structured approach with clear methods and aims, it is maintained that outreach practitioners do not suffer from the constraints of formal education systems; therefore, they can more easily create this type of environment for students (Stocklmayer et al., 2010). Moreover, it is argued that increased opportunities for cooperation between actors in the formal and informal arenas, including "scientists, engineers …, universities [and] research institutes,… is a key factor for the success" in supporting an improved science pedagogy in inquiry learning (European Commission, 2007, p. 17).

To contribute to the creation of the third space, science outreach (e.g. scientists and universities, as expert stakeholders in science education) needs to further develop connections with schools (European Commission, 2007). Both spaces have the same overarching aim – to engage their audiences in science (McKinnon & Vos, 2015) yet, there is a need to create hybridization between the agents of the first and second so that the third space can be a viable and sustainable reality. It is in this context, offerings of the informal sector within the school, that the concept of the third space is argued by Stocklmayer et al. (2010).

The third space (…) is the potential real space in which the informal sector can move, bridging the gap between school and community and hence blurring the boundaries between them. The space is currently quite empty, occupied here and there by an enthusiastic scientist; an outreach program from a Science centre or a university. (…) Critically it (the third space) requires acknowledgment from the world of formal education that help is needed, that all cannot be solved from within the system and that yet another new curriculum will not solve the problems of science education (Stocklmayer et al., 2010, p. 30).

Here, Stocklmayer et al. (2010) insist that science education has many problems that cannot be solved within the formal system. They highlight this deficit and challenge the formal education sector to respond and to welcome a collaborative venture with science outreach in this third space. Stocklmayer et al. (2010) acknowledge that reform is also required within the informal sector in evaluating their contribution, yet in order to embrace real change, that a holistic approach, driven from the world of formal education (and from the wider public and policy makers), is the only practical solution. Henriksen, Jensen & Sjaastad (2015) echo this in suggesting that stakeholders wishing to improve science participation need to consider partnerships with educational institutions. Jose, Patrick & Moseley (2017) and Fallik, Rosenfeld & Eylon (2013) recognise the need to create productive collaborations between formal and informal learning. In spite of its potential to contribute successfully to the third space, science outreach still lacks a structured approach with clear methods (Neuroscience Editor, 2009). As suggested by Henriksen et al. (2015) and Fallik et al. (2013), developing partnerships with formal science education may address this concern, and it is here where a reciprocated discussion between outreach and education around science pedagogy may prove beneficial.

In a recent paper (Gomes & McCauley, 2016) within this journal, the authors reported on a study with teachers (N=31) and outreach practitioners (N=30) that asked both participant groups to share their perception of a constructivist approach to science teaching and their understanding of conceptual and pedagogical dilemmas within science teaching and learning. Those research findings emerged from a semi-structured interview process that allowed for both qualitative and quantitative analysis and support a partnership between teachers and outreach practitioners, in addition to the realisation of the hybrid role of each participant. The research reported in this paper aligns with the research and was carried out in parallel, but takes a singular quantitative perspective that seeks to attain a representative viewpoint from both participant groups in terms of their understanding of the multiple dimensions of a constructivist teaching and learning environment. The fundamental aim of using this quantitative approach is to facilitate a more formal and standardised comparison within and between populations and to allow generalisation to the larger population with a 95% confidence interval. The aim of this research is to examine primary teacher's and science outreach practitioner's perceptions of the multiple dimensions of a constructivist teaching and learning environment, when employing the Constructivist Learning Environment Survey (CLES). A national survey of both teachers (N=148) and outreach practitioners (N=81) was conducted, involving further insight in terms of pedagogical choice and comparative differentiators regarding sex, school size, outreach frequency in the classroom, position of outreach practitioner within their institution, and outreach experience of the outreach practitioner. The findings of this study illustrate the necessity for a discussion between science outreach and science education in the third space, positioned within a school-based environment.

Methods

Quantitative data collection was employed to allow a more formal and standardised comparison within and between the education and outreach populations, and to produce a data set generalisable to the larger population. Online surveys are becoming a common research method in different fields of the social sciences (Raymond, Lee, Fielding & Blank, 2008) and the science education research field is no exception (Cooper, Kenny & Fraser, 2012). Two main advantages are highlighted in the literature. First, the answers collected are immediately saved in a computer database for processing, reducing mistakes, time and costs (Vehovar & Manfreda, 2008). Secondly, online surveys have the benefit of self-administration, which enables respondents to complete the survey at a time, place and pace, which they prefer. This can contribute to higher data quality, due to the sense of privacy and absence of interview related biases (Vehovar & Manfreda, 2008; Fricker, Galesic, Tourangeau & Yan, 2005; Kwak & Radler, 2002). Specifically, this research uses a web survey where respondents access and answer it through a web browser (Pitkow & Recker, 1995) for greater convenience. One of the key limitations of large scale quantitative research is that deductive logics are largely applied. In order to garner further insight, qualitative research was also carried out (Gomes & McCauley, 2016), allowing both deductive and inductive logics to be applied for both confirmation and exploratory purposes. The research reported here, as indicated earlier, if part of a larger mixed methods research project.

Sampling

A validated tool, the Constructivist Learning Environment Survey (CLES) is used in this study to analyse the perceptions of teachers and outreach practitioners in relation to constructivist learning environments. The research follows a correlational design in which two independent groups are sampled. Correlational designs look at the strength of relationships between the variables (Walsh, 1990). Specifically, in the current study, analysis is carried out to ascertain if there is a correlation between the perceptions of a teacher and outreach practitioner, in relation to their views of constructivist learning environments. This study uses a probability sampling strategy since this is the appropriate method for a correlational design (Onwuegbuzie & Collins, 2007).

The two populations studied are primary level teachers and science outreach practitioners in the Republic of Ireland. For the teachers, the decided sampling strategy was single stage cluster sampling. In a cluster, the members of a population are grouped in such a way that the members of the same cluster are more similar to each other than to those in other clusters (Pallant, 2010). A data set with all of the primary level schools in the country was created and clustered between small and large schools. Small schools are schools with less than 180 pupils (Ó Slatara & Morgan, 2004). Schools were clustered this way because previous research had shown size as a major differentiator between schools in Ireland in respect to their practices (Ó Slatara & Morgan, 2004). The formula selected to calculate the numbers of clusters is presented in Figure 1 below. Calculations were completed using Minitab 10. The final number of clusters corresponds to 96 schools, which were contacted to invite teacher participation. The calculations were made for a 95% confidence interval

[Figure 1 near here]

Outreach practitioners could not be sampled in the same way. As the outreach sample described here relies for the most part, on the volunteer work of graduate students and senior scientists. There is not a set database that one can obtain and use to sample. Therefore, this study targeted all university staff of science departments, including science outreach officers and post-graduate students, of the seven main universities in the Republic of Ireland. This research focused on university-based outreach practitioners because they lead the majority of outreach work carried out in Ireland (Davison et al., 2008). In order to draw up a contact list of the outreach practitioners, the public lists of science departments of the Irish universities selected, which were available online were searched. The final list contained 423 contacts, which corresponds to the sample population of outreach practitioners for this study. Table 1a and 1b presents the selected characteristics of the participants.

[Table 1a near here]

[Table 1b near here]

Constructivist Learning Environment Survey (CLES)

The data collection instrument employed in this research is the Constructivist Learning Environment Survey (CLES), initially developed in Australia (Taylor, Fraser & Fisher, 1993). This quantitative method measures teachers' perceptions of classroom practice (Taylor, Fraser & Fisher, 1997). The original version of the CLES was designed in 1991 and revised versions (Taylor et al. 1997) were developed with additions related to key dimensions of a critical constructivist learning environment. The instrument was subsequently reviewed to include a critical theory perspective (Taylor, Dawson & Fraser, 1995) to recognize socio-cultural constraints on the cognitive constructive activity of the individual learner (Aldridge, Fraser, Taylor & Chen, 2000). The version used in this study is the shortened version of the CLES survey, as it is a validated and reliable instrument used both in the formal and informal sector of education (Johnson & McClure, 2004).

The CLES is suited for this study as it has been used in a variety of studies relevant to the third space, as reported by Johnson & McClure (2004): qualitative studies of the nature of science knowledge and learning of science teachers and their students (Lucas & Roth, 1996; Roth & Bowen, 1995; Roth & Roychoudhury, 1993), a study of science education reform efforts in Korea (Kim, Fisher & Fraser, 1999), a study of pre-service science teachers' self-efficacy and science anxiety (Watters & Ginns, 1994), a comparison of classroom environments in Taiwan and Australia (Aldridge, Fraser, Taylor & Chen, 2000), a study of secondary pre-service teacher beliefs (Waggett, 2001), an investigation of the relationships between classroom environment and student academic efficacy (Dorman, 2001). Furthermore, it has also been employed to study informal science education. An example of this is the study of the learning environments of natural history museums (Bamberger & Tal, 2007)

The CLES survey has five components as evident in figure 2. The description of the components were adapted from Johnson & McClure (2004) to better reflect the content of the specific questions. Item examples from each scale are available in Appendix II.

[Figure 2 near here]

The CLES survey is an instrument whose reliability has been assessed in previous studies (e.g. Johnson and McClure, 2004) Reliability is defined as consistency and replicability over time and it is concerned with precision and accuracy (Cohen et al., 2007). Reliability can be assessed through internal consistency. Internal consistency represents the degree to which the items that make up a scale measure the same construct (Pallant, 2010). It is measured through the cronbach alpha consistency test. Alpha coefficient values above 0.7 indicate good reliability (Nunnally, 1967). All dimensions of the CLES survey used in this study have yielded alpha coefficient values higher than 0.7 (from 0.71 to 0.89).

Data analysis of the CLES survey

The survey data of the participant teachers and outreach practitioners was analysed through ordinal logistic regression tests. These tests were used to check for significant differences between the variables that characterise the profile of teachers and outreach practitioners. The general linear model was used to compare the responses of teachers and outreach practitioners.

Results and discussion

Overall results for teachers

The five dimensions of the CLES survey represent the core-valued components of constructivism and measure teacher perceptions of their preferred classroom environment (Savasci & Berlin, 2012). The survey results are presented below in line with the research questions, revealing the teachers' perception of their perceived classroom environment. Teachers' perceptions of constructivist methods are presented first, and followed by those of the outreach practitioner participants. Both the teachers' and outreach practitioners' mean responses to the five dimensions of the CLES survey are included within Appendix I as Stats 3 and 4 for further reference.

1.1 What perceptions do primary teachers have in relation to the multiple dimensions of a constructivist teaching and learning environment?

Based on a comparison of the five components of personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation from the CLES, it is possible to conclude that personal relevance (M=2.06, SD=0.55), critical voice (M=1.55, SD=0.58) and student negotiation (M=2.16, SD=0.64) rank highest, in terms of the teachers' preferred components of constructivism.

Overall, the mean range was between 1.55 for critical voice and 2.62 for shared control, representing responses between almost always and sometimes. Participants shared that school science should *often/almost always* be: relevant to student lives outside of school (personal relevance); that students should be encouraged to question the teachers' pedagogical plans and methods (critical voice); and they also believed that it was beneficial for students to have opportunities to explain and justify their ideas, and to peer discuss/debate and test the viability of their own and other students' scientific ideas (student negotiation). This suggests that these teachers have a strong preference for collaborative learning, self-directed learning and for contextualizing learning in students' everyday life. It also reveals that teachers' perceptions align with the Irish curricular reform, as evident from the key recommendation in relation to science methodology, from the teacher guidelines for teaching the Irish primary level curriculum:

> The methods and approaches adopted should create a learning environment where children's ideas are the starting point for science activities, practical activity is encouraged, links with the environment are fostered, children can apply scientific concepts to everyday situations and children have an opportunity to work together, share ideas and communicate their findings (DES [Department of Education and Skills], 1999, p. 52)

This is, perhaps, not a surprising alignment given that teachers tend to work in tandem with curricular guidelines and discourse.

Scientific uncertainty (M=2.66, SD=0.69) and shared control (M=2.62, SD=0.66) were ranked as the least preferred components of constructivism. Participants believed that they *sometimes* gave opportunities for students to learn that science is not always certain (that scientific knowledge evolves and is culturally and socially determined; that science is about asking and answering questions, but realising that the result is not always certain). They also perceived that it was beneficial *sometimes* to provide opportunities for students to share control with the teacher, for the design and management of learning activities. These results align with previous research carried out with science teachers. In the research developed by Savasci & Berlin (2012), science teachers preferred components of constructivism were personal relevance and student negotiation, and the least preferred were uncertainty and shared control. These results indicate that primary level teachers and science teachers had similar perceptions in relation to constructivist learning environments. This problematises the recurrent view that the lack of development of constructivist practices by primary level teachers is due to them not having expert scientific training (Avraamidou, 2013), as these results indicate that the primary level teacher participants had similar perceptions to those of expert science teachers and that they are very aware of and favour constructivist environments for teaching science.

Influence of sex, school size, outreach, on teacher's perception. The following questions address the five specific constructivist parameters (adapted from Johnson & McClure (2004)) identified in this research, highlighting the influence of biological sex, school size and frequency of hosting outreach activity in your classroom, in relation to the teacher participants. Further detailed statistics are available in Appendix I. The parameter estimate results are presented for all the dimensions. The scores of each respondent to the questions for each dimension were averaged. Ordinal logistic regression was carried out to assess the impact of the factors. Statistically significant factors are those with p value below 0.05.

The implications of these results in relation to the relevant research questions (1.2-1.4) are discussed below.

1.2 Does the biological sex of primary level teachers impact their perception of a constructivist learning environment?

Significant differences in respect to teachers' biological sex were found in the dimensions critical voice and shared control. In the dimension critical voice, male teachers had a mean response of 1.8 (often) and females of 1.4 (almost always). Male teachers perceived that in their classroom, they felt it was legitimate and beneficial for students to question teacher's plans and methods in terms of seeking clarification about activities and identifying barriers to their learning, questioning how and what is being taught. Female teachers perceived this happened almost always. In the dimension shared control, male teachers had a mean response of 2.55 (sometimes) and females of 2.25 (often). Female teachers perceived that in their classroom, students often shared control for the design and management of learning activities with the teacher. Male teachers perceived that this happened sometimes. These results indicate that the participant female teachers favoured the components of constructivist learning environments more than male teachers and also that female teachers were more comfortable than males in giving students more authority in the class, in terms of structuring their own learning experience. Similar results are evident in research carried out by Beck, Czerniak, & Lumpe (2000) which revealed that female primary level teachers beliefs as more aligned with constructivism than male primary level teachers. Further, the research carried out by Martin & Yin (1997) into classroom management revealed that male teachers were more controlling, interventionist and gave less space for students to express their wishes.

1.3 Does school size (large/small) impact primary teachers' perception of a constructivist teaching and learning environment?

Significant differences in respect to school size were found in the dimension critical voice. In this dimension, teachers from small schools scored on average 1.4 (almost always) whilst the answers from teachers working in large schools averaged 1.59 (often). These results indicate that teachers from small schools perceived that in their classroom, students almost always felt it was legitimate and beneficial to question teacher's plans and methods, in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught. Teachers from large schools perceived that this happened often. These results are supported by Ó Slatara & Morgan (2004) who argue that small schools offer more opportunities for more innovative strategies as they usually have smaller class sizes. As small schools have a smaller number of students per class and a smaller number of classes overall, Ó Slatara & Morgan (2004) affirm that students have more time to complete activities, to help plan what they are going to learn and to connect learning with their out of schools lives.

1.4 Does frequency of outreach initiative in the classroom impact primary teachers' perception of a constructivist teaching and learning environment?

No significant differences were found between teachers that had experienced science outreach initiatives in their classroom and teachers that had not. These results indicate that having outreach initiatives in the school does not impact teachers' perceptions of a constructivist learning environment. They already have a clear understanding of this science pedagogy and whether or not outreach enters their classroom, their theoretical understanding of the concept remains the same. The European Commission report (2007) argues that outreach can function as a catalyst to change the way science is taught in schools towards more constructivist practices. The results of this survey problematize this view since having, or not, outreach in the school did not influence teachers' constructivist perceptions. As such, it calls into question the belief that teachers' approach to science is problematic.

Overall results for science outreach practitioners

The survey results are presented below in line with the research questions, revealing the science outreach practitioner's perception of their perceived classroom environment.

2.1 What perceptions do science outreach practitioners have in relation to the multiple dimensions of a constructivist teaching and learning environment?

Positioned in relation to the five CLES dimensions, it is possible to conclude that personal relevance (M=1.72, SD=0.69) and critical voice (M=1.84, SD=0.68) are the most preferred dimensions of constructivism for science outreach practitioners, as they regard these activities as happening *often*, whereas other aspects (uncertainty, shared control, student negotiation) less frequently.

Participants shared that school science should *often* be relevant to students' everyday out-of-school experiences (personal relevance). They also indicated that it is *often* legitimate and beneficial for students to question the teachers' pedagogical plans and methods, in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught (critical voice). These findings reveal that the outreach practitioners have views congruent with two of the main objectives of science outreach. McCallie, Bell, Lohwater, Falk, Lehr, Lewenstein, Needham & Wiehe (2009) affirm that one of the main objectives of science outreach practices is to "make apparent the relevance and importance of science to everyday life and society" (p. 21). This objective aligns itself with the personal relevance dimension of constructivism that outreach practitioners favoured. Furthermore, Bell, Lewenstein, Shouse & Feder (2009) argue that science outreach "should also focus on helping learners become aware of and express their own ideas, giving them new information and models that can build on or challenge their intuitive ideas" (p. 34). It is evident that the view put forward by Bell et al. (2009) is the one represented by the constructivist dimension critical voice, which the participant outreach practitioners favour.

Scientific uncertainty (M=2.70, SD=0.75), student negotiation (M=2.53, SD=0.81) and shared control (mean=3.12) were the least preferred components of constructivism, as advocated by the outreach practitioners. Participants shared that there were *sometimes* opportunities for students to experience that scientific knowledge evolves and is culturally and socially determined; that science is about asking and answering questions, but realising that the result is not always certain. They also believe that there were *sometimes* opportunities for students to share the control for the design and management of learning activities. There is no previous research, to our knowledge, in relation to constructivist perceptions of outreach practitioners. Nevertheless, outreach practitioners may be compared to science teachers in a sense, in terms of their shared scientific background. Savasci & Berlin (2012) have shown in their research that science teacher's least preferred dimensions of constructivism are uncertainty and shared control. This data suggests that both outreach practitioners and science teachers have doubts about sharing control for the design and management of learning activities with the students. Furthermore, both groups also have doubts about promoting uncertainty in science (providing opportunities for students to learn that science is not always certain). The lack of promotion of scientific uncertainty has been identified in previous reports regarding societal issues. Professor Tim Palmer from the Royal Society (2010, p. 6) has stated that "recent public debate about climate change has undoubtedly demonstrated that uncertainty in science needs to be more effectively explained".

Influence of sex, role, outreach experience, on science outreach practitioner's perception. The following questions address the five specific constructivist parameters (adapted from

Johnson & McClure (2004)) identified in this research, highlighting the influence of biological sex, outreach role and frequency of facilitating outreach activity, in relation to the science outreach practitioner participants. Further detailed statistics are available in Appendix I. The parameter estimate results are presented for all the dimensions. The five scores of each respondent were averaged. Ordinal logistic regression was carried out to assess the impact of each factor. In the multinomial variables, SPSS 20 assigns the lowest variable as the reference category. In the case of role, the reference category is ‘graduate student’. In the case of frequency of outreach, the reference category is ‘every week’. Each response category is paired with the reference category and interpreted in reference to it (Agresti, 1996).

2.2 Does the biological sex of an outreach practitioner impact their perception of a constructivist teaching and learning environment?

Biological sex played a significant role in the dimension critical voice. For male practitioners, the mean response was 1.97 and for female practitioners, 1.70, representing responses from almost always to often. This indicates that male respondents were more likely to answer that they often feel it is legitimate and beneficial for students to question the teachers’ pedagogical plans and methods (in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught). Females were more likely to answer they did it *almost always*. Although there isn’t any previous research, to our knowledge, carried out with science outreach practitioners in relation to the CLES, this result aligns with research carried out with teacher participants in this research, and in the literature. Beck et al. (2000) reported that female primary level teachers revealed beliefs, which are more aligned with constructivism than their male counterparts.

2.3 Do different categories of outreach practitioner impact their perception of a constructivist teaching and learning environment?

Statistically significant differences were identified; concerning the role an outreach practitioner has in the university and their perception of the dimension student negotiation. For this dimension Senior Lecturers had a mean response of 2.9 (sometimes) as did lecturers (mean 2.96). The mean response for all outreach practitioners was 2.53 (from often to sometimes). Senior Lecturers and lecturers perceived that sometimes students have opportunities to explain and justify their ideas and to peer discuss/debate and test the viability of their own and other students’ scientific ideas. The remainder of outreach practitioners mean response was that this happened often.. These results indicate that Lecturers and Senior Lecturers are less likely to give opportunities for students to explain and justify their ideas than the other categories (in relation to university role) of science outreach practitioners. Student negotiation is a key component of constructivism and involves the extent to which students have opportunities to explain and justify their ideas and to peer discuss/debate and test the viability of their own and other students’ scientific ideas (Johnson and McClure, 2004). The results indicate that lecturers and senior lecturers might transfer a lecturing style of teaching common in higher education, to outreach initiatives, one which gives less opportunities for students to explain their ideas (Thiry, Laursen & Hunter, 2008).

2.4 Does frequency of outreach carried out by the outreach practitioner, impact their perception of a constructivist teaching and learning environment?

Frequency of outreach revealed significant difference within the dimension critical voice. Scientists that never did outreach had a mean score of 3.06 (sometimes). for critical voice whilst the mean response for all practitioners was 1.84 (often). Scientists that never performed outreach activities perceived that only sometimes educators feel it is legitimate and beneficial for students to question the teachers' pedagogical plans and methods (in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught). Scientists that did outreach once a year had a mean response of 1.55 (almost always to often), which was also a significant difference. The remainder of outreach practitioners felt that this happened often. These results are supported by Thiry et al. (2008) who argue that scientists that are new to outreach tend to develop practices less congruent with constructivist practices and are not confident in giving more control to students. Therefore, scientists that are new to outreach are less likely to develop one of the key aspects of informal learning as stated by Bell et al. (2009) that involves assisting students in becoming aware of and expressing their own ideas, giving them new information and models that can build on or challenge their intuitive ideas, *i.e.*, critical voice.

Overall comparison between teachers' and outreach practitioners' constructivist perceptions

The CLES results facilitated the comparison of teachers' and outreach participants' perceptions in relation to five valued components of constructivism (Savasci & Berlin, 2012) and therefore address the following research question:

3. What differences/similarities arise when teachers and outreach practitioners are asked to give their perceptions of a constructivist teaching and learning environment?

A univariate GLM test was used to compare the two groups with responses being the mean score, and inputs being the factors sex and role, as represented in Table 2. For completeness and further reassurance, a natural log transformation of the responses was carried out and the analysis was re-run to ensure that the residuals look more like a sample from a normal distribution. Although normality was still rejected, this is not important due to the large sample size (with a large sample size, one will always reject normality). The results obtained were consistent with the general linear model.

[Table 2 near here]

Significant differences between teachers and outreach practitioners were found within four of the five dimensions (personal relevance, critical voice, shared control and student negotiation), as illustrated in Table 2.

In the dimension personal relevance, teachers' mean response was 2.05 (often) whilst outreach practitioners were 1.72 (from almost always to often). Teachers perceived that school science was often relevant to students' everyday out-of-school experiences whilst outreach practitioners argued that this happens in their initiatives almost always to often. Therefore both groups align with the Irish primary level curriculum for science (DES, 1999) that argues that students should apply science concepts to everyday situations. The fact that outreach practitioners agree even more with personal relevance than teachers indicates they recognize one of the main objectives of science outreach as stated by McCallie et al. (2009, p. 21): "make apparent the relevance and importance of science to everyday life and society".

In the dimension critical voice, the teachers mean score was 1.55 (from almost always to often) and outreach practitioners were 1.84 (from almost always to often, but closer to often). This indicates that teacher respondents were more likely to answer that they almost always felt that it is legitimate and beneficial for students to question the teachers' pedagogical plans and methods; in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught. For the most part, both outreach practitioners and teachers felt that students should have more control of their learning and as such, that it is 'often to almost always' legitimate and beneficial to allow students to question teachers' plans and methods, with outreach practitioners leaning slightly more towards often, than almost always, on occasion.

For shared control the mean response of teachers was 2.62 (from often to sometimes) and outreach practitioners was 3.11 (sometimes). Teachers and outreach practitioners perceived that only sometimes, control for the design and management of learning activities is shared between the students and the teacher, but teachers were more inclined towards often. Shared control is the dimension of constructivism for which both types of participants were less aligned. Previous research carried out with science teachers by Savasci & Berlin (2012) revealed similar results. This data suggests that outreach practitioners and primary level teachers share with science teachers their uncertainties in sharing control for the design and management of learning activities, with their students.

Lastly, for student negotiation, teachers' average score was 2.16 (often) and outreach practitioners were 2.53 (from often to sometimes). Teachers perceived that students often have opportunities to explain and justify their ideas and to peer discuss/debate and test the viability of their own and other students' scientific ideas, whilst outreach practitioners believe these opportunities occur from often to sometimes. These results indicate that teachers are more aligned with the Irish primary level curriculum when it is argued that children should "have an opportunity to work together, share ideas and communicate their findings" (DES, 1999, p. 52), indicating that primary teachers' pedagogical training has provided them with an understanding of what will work well in the context of a primary classroom, which is in greater alignment with constructivist teaching.

Based on a comparison with the five components of CLES, it is possible to conclude that teachers reported preferring, more than outreach practitioners, three of the five valued components of constructivist practice (critical voice, shared control and student negotiation), although both groups were overall favourable. Only in one of the dimensions, outreach practitioners were more inclined to constructivist practices than teachers (personal relevance). These results problematise some of the assumptions made in science outreach. It is assumed that outreach has the capability of developing more constructivist practices as outreach programmes usually bring hands on inquiry based activities to schools (Bell et al., 2009; European Commission, 2007; Thiry et al., 2008). The results of this survey suggest that in three valued components of constructivism, outreach practitioners have perceptions less aligned with constructivist practices than teachers. Therefore, one can question if outreach will develop more constructivist practices in schools than teachers will. Nevertheless, outreach practitioners were still favourable towards constructivist practice, although to some slight degree, not as much as teachers. As outreach practitioners do not suffer from some of the constraints teachers do (e.g. curriculum coverage) and revealed perceptions favourable to constructivism they are still in a position to instil constructivist learning environments in the classroom.

Finally, when analysing the differences between outreach practitioners and teachers another variable was relevant, the biological sex of participants. Biological sex was revealed to cause a statistically significant difference across the overall results of CLES. These results indicate that both male outreach practitioners and male teachers are less favourable (significantly so) to constructivist practices than females. These results are congruent with previous research carried out with science teachers (Beck et al., 2000) and research that analysed classroom management research (Martin & Yin 1997). Both reported results that indicate that male teachers develop practices less aligned with constructivism.

Conclusion

This study presented a quantitative analysis of the perceptions of primary level teachers and science outreach practitioners in relation to constructivist learning environments, using results obtained from a national representation of the population. Analysis was carried out on the CLES survey results, which challenged beliefs that were presented in the literature about primary level teachers and science outreach practitioners. Primary level teachers have been accused of not being knowledgeable of or implementing constructivist principles in their teaching and learning, which threatens science as a subject at primary level. Statements, like the one from the former president of the University of Limerick, Dr. Ed Walsh, which called primary level a ‘disaster’ in terms of science teaching (Burke, 2008) and the large number of science education reports that criticise primary science teaching, emphasise this perception. For instance, Avraamidou (2013, p. 1703) argues that there are “various related problematic issues with primary level teachers” in relation to the teaching of science. Also, Appleton (2007) argues that many primary level teachers have a limited understanding of the science content, which they are required to teach and also lack pedagogical knowledge in science. In addition, Weiss et al. (2003) report that primary level teachers are not familiar with inquiry science and often avoid science because of their low levels of confidence in their own knowledge of the subject.

While some primary teachers may not have a strong background in science may indeed have less confidence when teaching science, this research suggests that their understanding of the constructivist pedagogical principals that underpin the teaching of science are sound. The analyses of the survey results are an indication that this criticism of primary level teachers, visible in the work of Burke (2008), Appleton (2007) and Weiss et al. (2003) literature is rather simplistic. The quantitative survey gave an insight into primary level teachers' views of constructivist learning environments as a central part of their pedagogical understanding across the curriculum. The findings revealed that the participant teachers were favourable towards the five valued dimensions of constructivism, with shared control and student negotiation being the only two dimensions they were less convinced about, but nevertheless viewed as favourable. Furthermore, an identical survey applied to secondary science teachers, conducted by Savasci & Berlin (2012) yielded similar results. In this case, their least preferred dimensions were also uncertainty and shared control (Savasci & Berlin, 2012). Expert science teachers did not offer more constructivist perceptions than the primary level teachers in this research.

Moreover, to the best of the authors' knowledge, this study is the first to evaluate science outreach practitioners' perceptions of constructivist learning environments. The survey also facilitated a comparison of views between science outreach practitioners' perception of constructivist learning environments. By comparing outreach practitioners to teachers, it was possible to conclude that only one of the five dimensions of constructivism, namely personal relevance, was perceived more favourably by outreach practitioners than by teachers. In the other four, teachers had views that were significantly more biased towards the constructivist dimensions than the views of outreach practitioners, although the latter also favoured constructivist learning environments overall. Therefore, the results of this survey also challenge the view that science outreach is a remedy for a *broken system of science education at primary level*. This view is exemplified by Rushton, Cyr, Gravel & Prouty. (2002, p. 7975). The authors developed a program for Massachusetts's science teachers. Rushton et al. (2002) believe that these teachers are in need of assistance and outreach will provide it:

> The primary intent of Tufts' outreach program centered on introducing graduate-level engineering students as resources to assist classroom teachers in implementing activity and constructivist based engineering curricula.

The belief, that outreach practitioners develop constructivist practices that teachers do not have, has been identified as being based on vague justification, or assumption instead of hard facts (Bouville, 2008; Xie & Shauman, 2003). For the first time, outreach practitioners are compared with primary level teachers and the data reveals the belief that assuming outreach practitioners are more disposed to develop constructivist practices than teachers is fallacious. In fact, primary level teachers revealed stronger tendencies towards constructivist perceptions than the outreach practitioners surveyed in this study. In recognition of this new information, that primary teachers of science and outreach practitioners both have a shared understanding of scientific pedagogy, a renewed role for science outreach arises. This suggests the need to reconsider the possibilities of a collaborative partnership between outreach providers and primary school teachers. As echoed in the literature (Stocklmayer et al., 2010), the third space, where providers come to classrooms, has the potential to facilitate this discussion in a collaborative environment that ensures that the teacher-outreach dyad work together to produce sustainable primary science activities that promote prolonged interest in science and science careers..

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Table 1a. Selected characteristics: teachers

Biological sex of teachers	Frequency	Percentage
Male	33	22.3%
Female	115	77.7%
Total	148	100.0%
Small vs. large school		
Small	46	31.1%
Large	101	68.2%
No Response	1	0.7%
Total	148	100%
Outreach initiatives in classroom		
Yes	100	67.6%
No	48	32.4%
Total	148	100%

Table 1b. Selected characteristics: outreach practitioners

Biological sex of outreach practitioners	Frequency	Percentage
Male	43	53.1%
Female	38	46.9%
Total	81	100.0%
Role of outreach practitioner		
Postgraduate student (A)	23	28.4%
Outreach officer (B)	13	16.0%
Postdoc (C)	13	16.0%
Lecturer (D)	13	16.0%
Senior Lecturer (E)	11	13.6%
Professor (F)	8	9.9%
Total	81	100%
Number of outreach events facilitated		
Every week	14	17.3%
Less than once a week but more than once a month	9	11.1%
Once a month	8	9.9%
Less than once a month but more than once a year	32	39.5%
Once a year	11	13.6%
Less than once a year	3	3.7%
Never did one*	4	4.9%
Total	81	100%

*'Never did one' refers to the category of respondents who are intending to partake in science outreach, but have not yet. It was felt that it may draw interest to compare this novice group with those who are proficient.

Table 2. General linear model comparing teachers and outreach practitioners

	DF	Seq SS	Adj SS	Adj Ms	F	p (Sig.)
Personal Relevance						
Biological sex	1	0.050	0.8095	0.8095	2.23	0.136
Role	1	6.7462	6.7462	6.7462	18.62	0.000
Error	226	81.8607	81.8607	0.3622		
Total	228	88.6119				
Uncertainty						
Biological sex	1	0.2461	0.2079	0.2079	0.41	0.525
Role	1	0.093	0.093	0.093	0.02	0.893
Error	226	115.7398	115.7398	0.5121		
Total	228	116.0131				
Critical voice						
Biological sex	1	6.7529	4.1630	4.1630	11.30	0.01
Role	1	1.7262	1.7262	1.7262	4.68	0.031
Error	226	83.2823	83.2823	0.3685		
Total	228	91.7615				
Shared Control						
Biological sex	1	6.8720	2.4301	2.4301	3.99	0.047
Role	1	8.3128	8.3128	8.3128	13.64	0.00
Error	226	137.7497	137.7497	0.6095		
Total	228	152.9345				
Student Negotiation						
Biological sex	1	4.8999	2.0330	2.0330	4.16	0.043
Role	1	4.3806	4.3806	4.3806	8.96	0.003
Error	226	110.5334	110.5334	0.4891		
Total	228	119.8139				

Figure Captions:

Figure 1. Formula for the sampling design (adapted from Scheaffer, Mendenhall & Ott, 2006)

$$n = \frac{N\sigma^2}{ND + \sigma_c^2} \qquad D = \frac{B^2\bar{m}^2}{4}$$

n = number of clusters – 95.54
N = total population – 20.000
D = 0.0625
σ_c^2 = standard deviation - 6
B = Bound of estimate p - 0.005
$\bar{m}$ = average cluster size - 10

Figure 1. Formula for the sampling design (adapted from Scheaffer, Mendenhall & Ott, 2006)

Figure 2. Five components of the CLES survey

Dimension	Descriptors
Personal relevance	Extent to which science is relevant to students' everyday out-of-school experiences.
Uncertainty	Extent to which opportunities are provided for students to learn that science is not always certain (that scientific knowledge evolves and is culturally and socially determined; that science is about asking and answering questions, but realising that the result is not always certain).
Critical voice	Extent to which educators feel it is legitimate and beneficial for students to question the teachers' pedagogical plans and methods (in terms of seeking clarification about activities, identifying barriers to their learning, questioning how and what is being taught).
Shared control	Extent to which control for the design and management of learning activities is shared between the students and the teacher.
Student negotiation	Extent to which students have opportunities to explain and justify their ideas and to peer discuss/debate and test the viability of their own and other students' scientific ideas

NOTE: Each descriptor was coded as follows: 1. Almost always (<1.45), 2. Often (<2.45), 3. Sometimes (<3.45), 4. Seldom (<4.45), 5. Almost never (≥4.45 and ≤5)

Figure 2. Five components of the CLES survey

Appendix I: Detailed Quantitative Statistics for Further Reference

Stats 1. Teachers constructivist perceptions when differentiated by sex, school size and outreach frequency

	Coef	SE Coef	Z	p (Sig.)	Odds Ratio	95% C.I. for Odds Ratio	
						Lower	Upper
Personal relevance							
Biological sex	0.582209	0.358110	1.63	0.104	1.79	0.89	3.61
Has your class ever had science outreach?	-0.528332	0.316669	-1.67	0.095	0.59	0.32	1.10
Size of school	-0.587275	0.318486	-1.84	0.065	0.56	0.30	1.04
Uncertainty							
Biological sex	0.2641	0.351469	0.75	0.452	1.30	0.65	2.59
Has your class ever had science outreach?	-0.282	0.311	-0.91	0.365	0.75	0.41	1.39
Size of school	-0.354975	0.313591	1.13	0.258	0.70	0.38	1.30
Critical voice							
Biological sex	0.740897	0.357085	2.07	0.038	2.10	1,04	4,22
Has your class ever had science outreach?	-0.505857	0.316692	-1.60	0.110	0.60	0,32	1,12
Size of school	-0.814680	0.326610	-2.49	0.013	0.44	0,23	0,84
Shared control							
Biological sex	0.825752	0.359765	2.30	0.022	2.28	1.13	4.62
Has your class ever had science outreach?	-0.0742509	0.313106	0.24	0.813	-0.93	0.50	1.72
Size of school	-0.337753	0.316023	-1.07	0.285	0.71	0.38	1.33
Student negotiation							
Biological sex	0.402824	0.353905	1.14	0.255	1.50	0.75	2.99
Has your class ever had science outreach?	-0.425952	0.313898	-1.36	0.175	0.65	0.35	1.21
Size of school	-0.0687693	0.314655	-0.22	0.827	0.93	0.50	1.73

Stats 2a. Science Outreach Practitioners' constructivist perceptions when differentiated by biological sex

	Coef	SE Coef	Z	p (Sig.)	Odds Ratio	95% C.I. for Odds Ratio
Biological sex						
Personal Relevance	0.162950	0.437138	0.37	0.709	1.18	0.50
Uncertainty	-0.329810	0.439037	-0.75	0.453	0.72	0.30
Critical Voice	1.13340	0.452170	2.51	0.012	3.11	1.28
Shared Control	-0.144834	0.437224	-0.33	0.740	0.87	0.37
Student Negotiation	0.162950	0.437138	0.37	0.709	1.18	0.50

Stats 2b. Outreach practitioners' constructivist perceptions when differentiated by outreach practitioner role

	Coef	SE Coef	Z	p (Sig.)	Odds Ratio	95% C.I. for Odds Ratio	
						Lower	Upper
Personal Relevance							
Role:							
Graduate student			Reference Category				
Outreach officer	0.0352078	0.659120	0.05	0.957	1.04	0.28	3.77
Post-graduate	-0.683310	-1.06	0.647075	0.291	0.50	0.14	1.79
Lecturer	-1.81740	0.650119	-2.80	0.005	0.16	0.05	0.58
Senior Lecturer	-1.36785	0.678358	-2.02	0.044	0.25	0.07	0.96
Professor	-1.12488	0.788322	-1.43	0.154	0.32	0.07	1.52
Uncertainty Role							
Role:							
Graduate student			Reference category				
Outreach officer	0.0734263	0.660471	0.11	0.911	1.08	0.29	3.93
Post-graduate	-0.0914549	0.645431	-0.14	0.887	0.91	0.26	3.23
Lecturer	-0.0012491	0.624432	-0.00	0.998	1.00	0.29	3.40
Senior Lecturer	0.374756	0.665313	0.56	0.573	1.45	0.39	5.36
Professor	-1.16180	0.792296	-1.47	0.143	0.31	0.07	1.48

Critical Voice							
Role							
Graduate student			Reference category				
Outreach officer	1.08972	0.671995	1.62	0.105	2.97	0.80	11.10
Post-graduate	0.298780	0.646125	0.46	0.644	1.35	0.38	4.78
Lecturer	0.717973	0.628813	1.14	0.254	2.05	0.60	703
Senior Lecturer	0.569939	0.666907	0.85	0.393	1.77	0.48	6.53
Professor	0.293183	0.780845	0.38	0.707	1.34	0.29	6.19
Shared Control							
Role							
Graduate student			Reference category				
Outreach officer	1.02920	0.667270	1.54	0.123	2.80	0.76	10.35
Post-graduate	0.335553	0.644526	0.52	0.603	1.40	0.40	4.95
Lecturer	-0.187116	0.623841	-0.30	0.764	0.83	0.24	2.82
Senior Lecturer	0.332150	0.664058	0.50	0.617	1.39	0.38	5.12
Professor	-0.918655	0.787411	-1.17	0.243	0.40	0.09	1.87
Student Negotiation							
Role							
Graduate student			Reference category				
Outreach officer	0.0352078	0.659120	0.05	0.957	1.04	0.28	3.77
Post-graduate	-0.683310	-1.06	0.647075	0.291	0.50	0.14	1.79
Lecturer	-1.81740	0.650119	-2.80	0.005	0.16	0.05	0.58
Senior Lecturer	-1.36785	0.678358	-2.02	0.044	0.25	0.07	0.96
Professor	-1.12488	0.788322	-1.43	0.154	0.32	0.07	1.52

Stats 2c. Outreach practitioners' constructivist perceptions when differentiated by outreach experience of the practitioner

	Coef	SE Coef	Z	p (Sig.)	Odds Ratio	95% C.I. for Odds Ratio	
						Lower	Upper
Personal relevance							
Frequency of outreach							
Every week				Reference category			
Less than once a week but more than once a month	0.729895	0.774782	0.94	0.346	2.07	0.45	9.47
Once a month	-0.565522 -0.475255	0.785737	-0.72	0.472	0.57	0.12	2.65
Less than once a month but more than once a year	-0.738279	0.591338	-0.80	0.422	0.62	0.20	1.98
Once a year	-0.831351	0.756727	-0.98	0.329	0.48	0.11	2.11
Less than once a year	-1.10669	1.13763	-0.73	0.465	0.44	0.05	4.05
Never did one	0.729895	1.06444	-1.04	0.298	0.33	0.04	2.66
Uncertainty							
Frequency of outreach							
Every week				Reference category			
Less than once a week but more than once a month	0.683039	0.773485	0.88	0.377	1.98	0.43	9.02
Once a month	0.595334	0.787050	0.76	0.449	1.81	0.39	8.48
Less than once a month but more than once a year	-0.0345099	0.591166	-0.06	0.953	0.97	0.30	3.08
Once a year	-0.100406	0.755333	-0.13	0.894	0.90	0.21	3.97
Less than once a year	-0.710519	1.14423	-0.62	0.535	0.49	0.05	4.63
Never did one	0.417871	1.06173	0.39	0.694	1.52	0.19	12.17
Critical Voice							
Frequency of outreach							
Every week				Reference category			
Less than once a week but more than once a month	0.870128	0.778280	1.12	0.264	2.39	0.52	10.97
Once a month	0.636835	0.788242	0.81	0.419	1.89	0.40	8.86
Less than once a month but more than once a year	0.721161	0.594751	1.21	0.225	2.06	064	6.60

Once a year	1.67750	0.774046	2.17	0.030	5.35	1.17	24.40
Less than once a year	0.119695	1.13714	0.11	0.916	1.13	0.12	10.47
Never did one	-2.60216	1.13870	-2.29	0.022	0.07	0.01	0.69
Shared Control							
Frequency of outreach							
Every week				Reference category			
Less than once a week but more than once a month	0.342838	0.769990	0.45	0.656	1.41	0.31	6.37
Once a month	0.989254	0.790033	1.25	0.211	2.69	0.57	12.65
Less than once a month but more than once a year	-0.108788	0.590039	-0.18	0.854	0.90	0.28	2.85
Once a year	0.0984305	0.753536	0.13	0.896	1.10	0.25	4.83
Less than once a year	-0.871697	1.14110	-0.76	0.445	0.42	0.04	3.92
Never did one	-0.802870	1.06468	-0.75	0.451	0.45	0.06	3.61
Student Negotiation							
Frequency of outreach							
Every week							
Less than once a week but more than once a month	0.729895	0.774782	0.94	0.346	2.07	0.45	9.47
Once a month	-0.565522 - 0.475255	0.785737	-0.72	0.472	0.57	0.12	2.65
Less than once a month but more than once a year	-0.738279	0.591338	-0.80	0.422	0.62	0.20	1.98
Once a year	-0.831351	0.756727	-0.98	0.329	0.48	0.11	2.11
Less than once a year	-1.10669	1.13763	-0.73	0.465	0.44	0.05	4.05
Never did one	0.729895	1.06444	-1.04	0.298	0.33	0.04	2.66

Stats 3. Teachers' mean responses to the 5 dimensions of CLES

	N	Mean	Std. Deviation
Personal Relevance	148	2.0591	0.5466
Uncertainty	148	2.6622	0.6912
Critical Voice	148	1.5524	0.5834
Shared Control	148	2.6216	0.6583
Student Negotiation	148	2.1588	0.6416

Stats 4. Outreach practitioners' mean responses to the 5 dimensions of CLES

	N	Mean	Std. Deviation
Personal Relevance	81	1.72	0.700
Uncertainty	81	2.70	0.756
Critical Voice	81	1.84	0.684
Shared Control	81	3.12	0.978
Student Negotiation	81	2.53	0.81

Appendix II: Item examples from the CLES instrument used in this research

Response choices for all items are:

A Almost Always
B Often
C Sometimes
D Seldom
E Almost Never

Outreach Practitioners' survey:

In outreach initiatives . . .

1. Students learn about the world outside of school
2. New learning relates to experiences or questions about the world inside and outside of school.
3. Students learn how science is a part of their inside- and outside-of-school lives.
4. Students learn interesting things about the world inside and outside of school
5. Students learn that science cannot always provide answers to problems
6. Students learn that scientific explanations have changed over time
7. Students learn that science is influenced by people's cultural values and opinions.
8. Students learn that science is a way to raise questions and seek answers
9. Students feel safe questioning what or how they are being taught.
10. I feel students learn better when they are allowed to question what or how they are being taught.
11. It's acceptable for students to ask for clarification about activities that are confusing.

…..

Teachers' survey:

In my classroom…

1. Students learn about the world of science outside of school
2. New learning builds on experiences or questions about the world inside and outside of school.
3. Students learn how science is a part of their inside- and outside-of-school lives.
4. Students learn interesting things about the world inside and outside of school.
5. Students learn that science cannot always provide answers to problems
6. Students learn that scientific explanations have changed over time
7. Students learn that science is influenced by people's cultural values and opinions.
8. Students learn that science is a way to raise questions and seek answers
9. Students feel safe questioning what or how they are being taught.
10. I feel students learn better when they are allowed to question what or how they are being taught

…….