ARTICLE

‘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

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Abstract

This article reports on students’ perspectives of an in-school promotional intervention aimed at challenging traditional methods of teaching science in schools in an effort to inspire interest in school science and increase enrolments. First, the context for the research is discussed before briefly describing the intervention strategy employed and finally, exploring the potential of this innovative pedagogy as a vehicle for addressing participation in science at the classroom level. It is argued that participation depends on engagement with a subject, and the author posits that providing innovative, motivating and fun approaches to learning within the classroom that interest and engage pupils will lead to better connections with school science and to science in society. This article gives some insights into the use of a chemical magic show through the qualitatively different views and attitudes towards the chemical magic show of a sample of Irish students (n = 328). Implications for participation and inclusive and motivational classroom pedagogy are discussed.

Keywords: alternative pedagogy, engagement, in-school interventions, science enrolments

Introduction

This article discusses an in-school promotional intervention aimed ultimately at increasing chemistry enrolments in secondary schools. This intervention is located in a continuing debate surrounding participation in Science, Technology, Engineering and Mathematics (STEM). In this section, the Irish context is discussed and compared to the international perspective providing a rational for the strategy employed.

Within the Irish context science at Junior Cycle[1] is not compulsory yet enrolments have been consistently high with almost 90 per cent (SSTI, 2006) of the entire Junior Cycle cohort sitting the examination in the Junior Certificate (JC). At a time when government strategy is focused on a scientific and knowledge based economy (NDP, 2007; SFI, 2009; SSTI, 2006) the physical sciences at Senior Cycle in all secondary schools[2] in Ireland have been struggling to sustain pupil enrolments, a phenomenon evident for

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over 20 years (Childs, 1998; Eivers et al., 2006; Schibeci, 1984; Task Force, 2002; Woods, 2000). Although the downward trend has been arrested, 2006 figures show 13.6 per cent of the cohort study chemistry, it is a far cry from the 20 per cent SSTI target by 2013 (SSTI, 2006). This problem is not confined to Ireland with concerns expressed worldwide. Debate centred on enrolments in STEM subjects and strategies to target the issue (including changes to teaching practices) have been frequent in Dail and parliamentary debates in Ireland, Northern Ireland and England in attempts to fuel the sustainable knowledge economy.

The reasons for the decline in the uptake of science subjects/courses at all levels are complex and varied. The issues that have been raised and debated relate both to within and without education systems. These include teaching qualifications, the content of the science curriculum, the way the subject is taught and assessed (Erinosho, 1997; Freedman, 1997; Hofstein et al., 1979; Kelly, 1988a; Stohr-Hunt, 1996), the influence of the teacher (Ormerod, 1975; Stables and Stables, 1995), the influence of parents (Nash et al., 1984; Olszewski-Kubilius and Yasumoto, 1994; Solomon, 1997), influence of peers (Dryler, 1999) and attitudes toward and perceptions of science (Creese, 1990; Gardner, 1975; Gauld and Hukins, 1980; Hasan, 1985). Consequently, many intervention strategies to tackle the situation were initiated in Ireland including most recently the Discover Science and Engineering (DSE)[3] national promotion program (Martin, 1999; Ni Charthaigh and O'Brien, 1996; Ni Charthaigh and O'Sullivan, 1988; O'Brien and Porter, 1994; O'Donnabhain and Porter, 1991; Woods, 2000). Factors considered in the design of the intervention described later relate both to attitudes toward and perceptions of the subject but also to the influence of the teacher, particularly in relation to classroom pedagogy and pupil experiences.

Many factors influence students in their choice of Leaving Certificate subjects including attitudes (Osborne, 2003; Ramsden, 1998). In addition, experiences at the Junior Certificate influence students' choice of subjects for the Leaving Certificate (Gago, 2004; Palmer, 2000; Task Force, 2002). Subject attitudes held by pupils were shown to be open to intervention from many programmes carried out in the US and the UK (Hannan et al., 1983). The issue of inciting interest and changing attitudes towards science and the consequences on student choice of Leaving Certificate Chemistry is the primary focus of this study and the rationale for an intervention that challenged traditional methods of teaching science in Ireland. Decisions made in secondary school regarding subject choices can have a profound effect on future academic and vocational choices, and also on economic issues. Consequently, enrolments in the sciences are a major concern amongst science educators, industry and educational policy-makers as a result of the possible economic ramifications. This article reports on details of an in-school one-off intervention designed to challenge traditional didactic teaching approaches in science in Ireland while reflecting on what we can learn about inclusive and promotion pedagogies. First, the issue of participation in science warrants some attention.

The issue of participation in the sciences

Subject choice has been widely researched, though the analysis has a tendency to focus on comparisons of enrolments in various subjects, and is usually examined in a gender and achievement context (Lamb and Ball, 1999; Stables and Stables, 1995). The reasons for the decline in the uptake of science subjects/courses at all levels are complex and multifarious.

Issues identified in the Irish context by the Task Force on the Physical Sciences (2000) include: provision of science in schools; student attitudes; differences between schools; curriculum and assessment, teaching science; and resources for practical science. The latter was of particular importance in the design of the promotional intervention employed, utilizing more easily accessible and inexpensive materials such as those found in kitchen chemistry. Causes of the decline in student enrolments in science in the Irish context suggested by AHSSIT (2002) and JCES (2000) include:

- Low level of exposure to science at the primary level and the possible consequence of low performance on the OECD league in science.
- Didactic teaching methods and reliance on terminal assessment without a practical aspect.
- Difficulty experienced by Leaving Certificate Science students in the attainment of high grades in comparison to other subjects; see also Johnson and Bell (1987).
- Low representation of Physics and Chemistry graduates entering teaching and the poor professional development opportunities for science teachers.
- School provision: one in three schools do not offer the full range of science subjects and just over 30 per cent do not offer Chemistry and 24 per cent do not offer Physics.

Since the intervention was designed and implemented the Junior Certificate curriculum has been revised particularly to incorporate a more investigative approach to teaching science including assessment of this work. As a result, teachers have reported an increase in practical teaching methods and increased student engagement with practical work (Eivers et al., 2006).

The message from the literature is 'that we are not going to find one single factor which is universally influential; different students are persuaded by quite different factors' (Woolnough, 1994a: 672; 1994b) and 'many different factors contribute to children's decisions, and these factors are inter-related among themselves' making it 'difficult to disentangle the effect of any one variable' (Kelly, 1988b: 18). Warton (1997a, 1997b) asserts that students can choose a subject that they are interested in, but may not necessarily need for future career options, or a subject that they feel they are competent in, and so will attain good grades. Students must balance the decision between the two. Thus when students are making subject or career decisions they generally attempt to match personal needs with the experiences which are likely to result from the choice (Malone and Cavanagh, 1997).

Interest as a predictor of subject choice is evident in the work of Stokking (2000) in relation to physics and as a pattern for career choices in Salmi (2002). In the Irish context, the Task Force (2002) highlighted the link between higher enrolments and high level of resource provision in the sciences, management's prioritization of science in the curriculum, good subject level planning and coordination, emphasis on positive experiences at junior level and practical work. Park et al. (2009) report on work that shows that students' lack of engagement in science in school may translate into an unwillingness to take science courses beyond high school or pursue scientific careers (Baggott La Velle et al., 2003; Choi et al., 2003; Jeon, 2004; Park, et al., 2004).

Combining the notions of interest, attitudes and experience as influencing factors on subject choice and the belief that attitudes may be susceptible to influence by intervention

an in-school promotional intervention for junior level students (including Transition Year[4]) was devised and implemented to incite interest in science. The intervention sought to tackle student disengagement with science by providing positive learning experiences and by promoting an alternative pedagogy amongst teachers. SSTI (2006) have recently declared that 'there is a clear need . . . to find ways to stimulate interest in science before students enter Senior Cycle, so that they will be motivated to continue to study the subject and to choose it as a third level option' (p. 54), suggesting that perhaps teachers are continuing to focus on achievement in terminal examinations of those interested in completing them rather than taking responsibility for promoting their subjects to all students. This leads the author to question whether teachers believe science can be for all students rather than what had become known as the elite. In order to be successful in achieving the SSTI target by 2013 individual teachers in individual schools need to address issues of promotion, engagement and inclusive pedagogies within their practice. An examination of the science education literature shows a propensity to recommend demonstrations to inspire interest in a science subject and increase enrolments even though the literature lacks empirical evidence to support such a claim. This article (based on a doctoral research project[5]) reports on the use of a chemical magic show aimed at promoting the sciences and provides empirical evidence of its value as a promotional tool and as an alternative pedagogy within science classrooms.

The intervention: the chemical magic show

From Davy to Faraday and beyond the purpose of the appealing, spectacular, entertaining and often dangerous experiments was to give a broader public appeal to science (Anonymous, 1999) despite the absence of empirical evidence that demonstrations generated popular appeal. Demonstrations have been used as a method of inciting interest, motivation and fun in the classroom and other promotional situations (Krnel and Glazar, 2001). Discussions on the use of demonstrations and shows to motivate and stimulate students and to promote Chemistry have continued to interest educators in recent times (Anonymous, 2000; Battino et al., 1995; Beall, 1996; Blankespoor and Piers, 1991; Davidson and Slabaugh, 2003; Gammon, 1994; Katz, 1991, 1996; Kauffman, 1996, 1997; Louters and Huisman, 1999; Meyer et al., 2003; O'Brien, 1991; Sullivan, 1990; Wolfe, 1990). The most effective method is thought to be showing the fascinating nature of experimental science which appeared to be absent from some Irish classrooms where didactic teaching methods were the norm according to reports such as those from AHSST (2002) and JCES (2000).

The intervention in the Promotion of Chemistry in Schools Project (PCSP) is defined as:

> a coherent assembly of project activities and supporting resources designed as a course of action to address a problematic situation (enrolments in Chemistry). The PCSP was devised with an educational psychology and science education theoretical framework. The purpose was to change beliefs, attitudes and behaviour relating to subject choice at Leaving Certificate.

The PCSP evaluated the intervention strategy aimed at increasing interest in and choice of chemistry at Leaving Certificate level (Regan and Childs, 2003). The intervention strategy comprised a chemical magic show (Regan, 1999) since 'nothing seems to rouse an interest in chemistry more than a good old fashioned chemical magic show' (Hague, 1983: 742–3), a promotional science magazine for students and a teacher information

pack on chemical magic for teachers. The goals of the chemical magic show were similar to Ackerson (1985): the overall goal was to increase the numbers of students studying chemistry at Leaving Certificate level in subsequent years. This article focuses on the students' perceptions of the chemical magic show.

Background context

The intervention consisted of two stages: stage one involved interacting with the students in the participating schools to actively promote chemistry through the use of a chemical magic show; and stage two comprised distributing a promotional magazine to students and a teacher information booklet on incorporating chemical magic into their lessons to the teachers. The latter was intended to facilitate teachers' use of demonstrations in their classroom and also to plan classes which linked to topics covered within the show. The chemical magic show involved the presentation of a number of visual experiments with a 'wow' factor, some of which related to everyday life. Katz (1996) believes that magic is science without explanations and that demonstration without explanations are often of little value. The chemical magic show, however, aimed to strike a balance by changing science into magic and the intention was to explain some of the tricks, and allow the remainder as areas of class discussion with the teachers involved.[6] Ultimately, this was a one-off in-school promotional gimmick, however, efforts were made to facilitate the adoption of components of the show as an alternative pedagogy within 'normal' classroom practice. The chemical magic show was designed with due consideration to theatrical components such as scene, lighting, characters, costumes, props, positioning, character development and the theme of the show. The main focus of the performance or the theme of the show was to link the demonstrations to the Junior Certificate Science syllabus since the intervention strategy was targeted at third year and Transition Year students.

The intervention strategy designed was a form of a behaviour theory-based intervention aimed at modifying the way in which students are taught and how they choose Leaving Certificate subjects by altering the general environment or system in which the student must function. The magic shows were performed across one school year involving approximately 8500 students in 67 schools directly.[7] A total of 192 shows were performed of 40-minute duration, designed to replace one class period. The demonstrations utilized in the show are described in Regan (1999) and include 'genie in a bottle', 'disappearing ink', 'blue magic handkerchief', 'burning money', 'methanol cannon', 'disappearing coffee cups', 'mystery jug', 'disappearing water', 'chemical cannon' and 'white powder explosion'.

Methodology

The research was conducted within the second-level education system in Irish schools with third-year students of the Junior Certificate programme and Transition Year students. This group of students are in decision-making situations with regard to subject choice for the Leaving Certificate level. It is at this point that students choose to study science subjects or to drop them. Attitudes, views, opinions and difficulties are instrumental in the decisions made at this time. Phenomenography (Marton and Booth, 1997) was chosen as the approach in gaining an understanding of the chemical magic show phenomena through open questions from questionnaires administered by cooperating

teachers in the intervention schools. This ensured a higher response rate and eliminated researcher bias since the teacher had no 'investment' in the outcome of the pupils' responses (Oppenheim, 1992). A statistician generated a stratified random sample[8] of 328 students (66% female, 34% male) from a convenience sample of the study population (approximately 8500 students[9] from 67 schools that participated in the intervention strategy). The stratified sample is representative of the participating schools but is not necessarily representative of the population at large. The responses to the open questions were transcribed verbatim and transferred to NVivo where they were coded and analysed to identify categories of description relating to the meanings or conceptions of students' experience (Marton and Booth, 1997). Quotations from pupils are included in the results and discussions to exemplify the types of responses received in the words of the students.

Findings

The pupils in the sample responded extremely positively to the chemical magic show intervention and categories of description of the phenomenon centred on wonder and awe; bewilderment and confusion; amusement; and participation. These represent the 'hoped for' reactions in an intervention centred on edutainment and indicate that, on a superficial level at least, the intervention does incite interest. It is worth noting at this point that a teacher survey conducted as part of the doctoral study showed that the most common student reaction to their normal science classes was one of only mild interest. It is also noteworthy that the teachers did not seem to accept responsibility for the amount of interest students expressed towards science and their science classes. Teaching the syllabus for examination preparation was taking over from teaching science for any other reason (Regan, 2005). All three categories represent different conceptions of having experienced the intervention and emerged in the analysis of the open-ended survey questions.

The first category, 'wonder and awe', was the largest held conception and contains accounts relating to the surprise, amazement, incredulity at the unexpected drama and issues relating to participation experienced as a result of watching and/or taking part in the chemical magic show. In the second category, 'bewilderment and confusion', students' conceptions are associated with the mystery and magical element they encountered and the perceived mayhem of the demonstration experiments. The final category, 'amusement', recounts conceptions of the fun the students experienced and the laughter and entertainment as they viewed science in a different way and participated in the fun tricks.

Category 1: wonder and awe

This first category was the central conception held by the students and consists of three sub-categories 'unexpected drama that amazed', 'unexpected pedagogy' and 'participation' which covers statements relating to the nature of the wonder and awe experienced by the students. The analysis shows that the intervention did indeed challenge traditional methods and the experience was very much removed from students' classroom reality, that is, teachers were not utilizing similar methods in their classes.

1.1. Unexpected drama that amazed

The first sub-category 'unexpected drama that amazed' details statements involving the astonishment students experienced and the incredulity expressed. Students saw that the

chemical magic show contained demonstrations and experiments that had 'most eye-catching' visual effects that 'amazed the class and had a great effect'. The 'fire in a bottle' experiment was viewed by students as being different and unexpected since 'it looked deadly, [as] the flame was just shot up the bottle'. Because 'it was on fire and was big' and 'because the flame was huge' students thought:

> . . . it was amazing how the fire shot out of the neck but the bottle did not melt. (Student ID 61)

> It looked really cool. I'd never seen anything like it before. (Student ID 304)

Students '"like things exploding' because they are 'good to look at'. The 'white powder explosion' was unexpected and 'was the most dramatic' of the experiments, 'it was a mad little explosion'. Students were very excited by it because:

> The force of the explosion was unexpected. (Student ID 315)

A simple little demonstration like 'disappearing ink' caused magical disbelief and the visual effect 'genie in the bottle' 'was very sudden' and 'I wasn't expecting it'. 'The way the ''genie'' appeared by smoke' appeared magical and incited a sense of wonder.

> It was just magic and really amazing. (Student ID 46)

> A. Cause I liked when all the smoke came out of the bottle, it looked magical. (Student ID 78)

The visual impact of the 'five different drinks from one bottle' was also unexpected and students thought 'it was cool the way they all change a different colour' and the 'drinks look very real'. Students were amazed as they 'had no idea how it was done'.

> G. I liked the five different drinks because it looked so weird when the colours changed. (Student ID 82)

1.2. Unexpected pedagogy

The second sub-category, 'unexpected pedagogy', emerged from the students' comparisons of the chemical magic show to their normal classroom experience of science. Students experienced awe and astonishment as a direct result of the impact of the experiments but also experienced surprise by the presentation of the science because it was out of the ordinary for them.

> It was more fun than normal science class and we saw things we had never seen before. (Student ID 81)

Students liked 'the way all the experiments were done well' and 'the different experiments and the way in which they worked'. The white powder explosion, for instance, was presented as a story which the students enjoyed:

> It was good the way it was incorporated into a funny story. (Student ID 326)

From this example we can learn that, though in this case the experiments were an important feature of the edutainment experience, the storytelling component and unusual

presentation engaged the students. In this way, differing the presentation strategies engage students with different learning styles and preferences.

Students felt that the manner in which the presentation focused on learning 'was very interesting [and a] good way to remember things'.

> The exciting and brilliant new way in which I learnt about science in my new exciting world of mine. (Student ID 55)

The students felt that 'it was a bit of craic, plus we were learning at the same time' and 'the way it helped me remember experiments it was a way of revision'.

> That it was fast moving, had fun experiments and revised our Junior Cert chemistry. (Student ID 83)

Combining drama, music, humour and experiments engaged the students but also created a successful learning environment. For some students, being removed from the comfort zone of regular science class caused concern and evidence of an assessment culture was visible. The quote below illustrates the anxiety one student experienced as a result of the new experience. Students were fearful that 'there was things I didn't understand and were explained too quickly' and showed a little resistance to getting into the fun of the event. A number of students thought that it was 'a bit pointless' as there was 'nothing in connection with JC level experiments'. This exam-focused attitude, some science educators have speculated, has caused students to turn off science.

> Some things I may have known turned up and something I didn't know didn't really turn up. (Student ID 5)

Even the 'wow' of the show was not enough to change some students' views of science.

> It didn't make me more interested in doing chemistry. (Student ID 211)

1.3. Participation

The third sub-category, 'participation', contains statements relating to students' conceptions of being involved in the show. The interactive nature of the show was enjoyed by most students and was even more impressive because of the actions in certain parts of the show. Teachers and students alike were involved in various ways such as inadvertently donating money to the 'burning money' demonstration: 'she burned our teachers' money!'.

> Because you least expect it and the girl that gave the fiver nearly died. (Student ID 220)

The involvement of the audience of pupils and their teachers meant that it was even more 'fun to see' 'because we didn't know the money wasn't actually burnt' and students thought that 'it was cool and like magic' and they 'didn't think it was possible'.

Participation was successful with regard to generating wonder and awe, bewilderment and amusement. The involvement and interaction with the audience and their reactions to this involvement increased audience enjoyment of the experiment 'because she done it to everyone and then you knew it was not fixed' and 'it was exciting and unusual'.

> I was amazed and delighted with this one because she put loads on me. (Student ID 98)

Students stated that they had 'never seen it done befo' and 'because the woman went around squirting it on everyone and we all got the laugh'. Involvement was the largest influencing factor with students explaining that 'I lost the head when she threw it over my white top':

> Because she threw it over a few of the lads and they were about to kill her, but then it disappeared. (Student ID 273)

The 'vinegar and baking soda cannon' was 'interesting, cool and funny' and particularly liked because engagement could continue after the one-off event. The students could repeat this experiment at home: many of the pupils 'learned how to do it' and in the eyes of the students 'It was brilliant . . . because explosions and loud noises are cool'.

> I like this because it was good and you could do it yourself at home. (Student ID 26)

Students engaged with the show to the extent that the largest complaint was:

> The way it had to end. (Student ID 214)

Pedagogies that ensure that students are actively involved in the activities and in which they feel a part of are important, particularly activities that extend beyond the classroom and facilitate sustained engagement at home.

In some circumstances students were uncomfortable with the participative nature of the alternative pedagogy and expressed that they did not like it 'when we were asked to take part in the show', or 'when she asked us the questions' or when there was 'too much people talking'. This suggests than many teachers still favour quiet classrooms incorporating didactic approaches and little collaboration and group work.

> The presenter making you be a part of the show. (Student ID 194)

Category 2: bewilderment and confusion

The second category, 'bewilderment and confusion', contains conceptions associated with the emotional reactions to the mystery and the magic of the encounter. Students' favourite experiment was the 'burning money' because it left students confused and because 'it amazed everybody'. The bewilderment of the 'trick' was achieved because 'the money was on fire [but] it didn't burn', 'it was really real looking' and 'because something could have gone wrong and the money could have been burnt'. Students saw something unexpected and this caused the excitement, confusion and bewilderment:

> Liked the experiment because there aren't too many people who come into school to burn money. (Student ID 47)

> D [Burning Money]. Because it was exciting to see money burning, but not being burnt at all. (Student ID 85)

The students saw something 'unusual and I never seen it done before' and it was 'good' 'because the money was not even damaged afterwards' and students 'couldn't believe that she was burning a 20 pound note'.

When the students didn't know what was happening while 'disappearing ink' was being performed 'everyone was trying to hide their shirts' and 'because we were all involved' mayhem and bafflement resulted.

> I liked it because it came as such a surprise to me; she ran up to me and sprayed me, it was fun. (Student ID 67)

> because when she squirted the ink on people they got all worried and thought that it wouldn't come off. (Student ID 6)

Category 3: amusement

The final category, 'amusement', consists of statements which show the conception of interest, fun, laughter and entertainment. Students overall conception of the demonstrations were that they were 'fun/interesting experiments' that they were 'good', 'exciting', 'different', and 'very entertaining'. The 'explosions and fire' of some of demonstrations included were enjoyed 'because they were fun' and due to 'the magical effect' particularly among the boys. 'There was a variety of fun tricks' which amused and entertained them.

Amusement stemmed from students' belief that the show 'was presented well' because 'she made everything to be so easy' and 'it was very entertaining' since 'it showed chemistry in a more funny, accessible and interesting way'.

> I liked how science was made fun and interesting. (Student ID 82)

The humorous presentation appealed to students who thought that the show was 'good craic' and they enjoyed 'the laugh we had'. 'The jokes and the way science was more fun' charmed the students in the sample.

> I liked the humour and fun; I wish learning science could always be that fun. (Student ID 22)

Not all of the students appreciated the same element of humour, however, with some claiming to dislike 'the jokes the presenter made' which were considered to be 'stupid' and 'sad' – apparently the author was not funny! Some students thought 'it was quite childish and boring' and 'a bit silly at times'. One student did not like,

> How it was geared towards little kiddies who believed in genies, I mean we're 15, come on. (Student ID 157)

> Presenter acted as if we were 10 years old. (Student ID 126)

> The jokes were unhumorous. (Student ID 105)

Amusement and entertainment was provided by experiments such as 'the magic handkerchief', 'the disappearing polystyrene cups' and 'disappearing water' because 'it was funny', 'weird' and also 'because it was like real magic'.

> C. Because she was having a laugh and she put ink on the handkerchief and it went blue. (Student ID 44)

The link to the world outside the classroom with everyday examples like nappies and nail polish remover engaged and delighted the students.

> It was interesting to see something as simple as nail varnish remover could dissolve the polystyrene. (Student ID 83)

> H. Because I always wondered how nappies worked and the white stuff was kind of cool. (Student ID 148)

The students took such pleasure in the edutainment provided that the main complaint was that the show was too short since it 'should have took more classes' as 'it was not long enough' and 'it was over too soon'.

> It was rather short. It still didn't make me interested in chemistry. (Student ID 85)

Discussion and conclusion

Research has shown that students' experience of science and choice of science subject was improved when the orientation of science towards everyday life and active participation was emphasized (Labudde and Herzog, 2000; Stokking, 2000). Thus, listening to the voices of the students can prove to be valuable in the fight against the decline in the enrolment in the sciences. However, we must as educators, accept responsibility for more effective communication in science, in fact in all our subjects. We must aim to inspire. If this means adapting and evolving to the current climate of edutainment, then this author welcomes the adaptations. Changing pedagogical practice to re-engage disaffected students is common (see Deed, 2008; Riley et al., 2006), making changes to pedagogical practice to sustain engagement in one's subject may also have a role to play.

Educational entertainment can be found everywhere from art exhibitions to museums and science centres. Educational entertainment can inspire as well as inform, open up new possibilities, stimulate curiosity, move people to action, and transform the way we view the world. However, there is surprisingly little in the science education literature on the application of entertainment technologies (storytelling, theatrical design, immersive environments, lighting, music, sound, film and video) to achieving specific educational objectives. Some of the most valuable insights in this area come from related fields, such as drama in education, museum literature and public understanding of science area. The exploration of these diverse ideas may help to create a new generation of effective, inclusive, participatory and empowering educational experiences.

The chemical magic show as an intervention aimed to be an imaginative tool that challenged the traditional methods of teaching science in schools as a means of promoting Leaving Certificate Chemistry among students in the junior level in Irish schools. Magic certainly manifested itself in the student conceptions of the experience and reviews from student consumers were extremely positive. The ma in categories of qualitatively different pupil conceptions of the chemical magic show experience include 'wonder and awe', 'bewilderment and confusion' and 'amusement', all common descriptors of the responses to chemical magic from anecdotal accounts in science education literature. An examination of pupil conceptions of the show reveal that the main parts of the show that pupils liked the most were the experiments and the different presentation/teaching style, indicating that the procedures utilized in the intervention were appropriate for the task.

This article reports on pupils' conceptions of the show, however, the intervention ultimately aspired to help increase enrolments and consequently other sources of data from the larger doctoral study need to be mentioned here. Evidence from other sources such as Department of Education Statistics for each school involved in the intervention and teacher surveys shows that it may have helped by inciting interest in chemistry and causing pupils to consider their options in the short term, but the long-term effect on enrolments was inconclusive since schools did not record class level enrolment data. This may be due to the number of promotional strategies in place at the time this evaluation was conducted (Regan, 2005). However, the intervention was successful in achieving the following goals, addressing some the concerns identified by AHSSIT (2002), JCES (2000) and the Task Force (2002):

- To promote a positive image of science and chemistry.
- To establish personally relevant links between students and chemistry using alternative pedagogy.
- To show the fun and mystery of chemistry.
- To promote a better student understanding of the relevance of chemistry with experiments associated common everyday products.

The majority of teachers surveyed reported a change in the response to science after the intervention. Teachers reported that students 'enjoyed it well and came back enthusiastic about the subject'. Students were 'full of enthusiasm and showed an interest in continuing with the subject as it seemed so exciting' and some students questioned their teachers about why they never made science so exciting. Overall, as a one-off gimmick, teachers did not feel that students' attitudes changed and though increased enrolments were reported by some of the teachers, they were unsure if it had been as a result of the show. This connects with findings reported in Campbell (2006) where teachers sought statistical evidence of success of an alternative pedagogy while undertaking a professional development workshop on the use of inquiry in the science classroom. This finding has implications for promotional strategies employed in events such Science Week or other outreach activities: is the investment worthwhile without changes to daily classroom experience? More specifically, should investment in promotional strategies target teachers rather than students, given the influence of the teacher and the impact of classroom experiences? The strategy can however, easily be incorporated into classroom practice rather than one-off promotional events and result in engagement with science in school and society, which is central to participation. If teachers use a hook like something unexpected, which will also promote observations skills, then further engagement with the subject matter can result. Deed (2008) reports success of alternative pedagogy (to re-engage students) with interesting discussion surrounding clear pathways to the dominant curriculum-based program. The strength of the pupil data reported here lies in the manner in which it highlights the effect of pedagogical practice on pupil experience of learning in science. The author is a strong advocate of the art and science of lecture demonstrations, but also of active and innovative teaching strategies (such as those reported in Deuchar, 2008; Wurdinger et al., 2007) and she hopes that more teachers and consequently more students can experience and benefit from the value of this type of promotional and pedagogical tool.

The intervention was effective as a means of changing beliefs and attitudes in the short term, but not long term according to survey of students' attitudes (Regan, 2005). In light

of the pupils' conceptions and other evidence referred to, the author believes that chemical magic shows may act as a means of changing subject choice behaviour but the tactic of 'wow' demonstrations and innovative presentation/pedagogy needs to be incorporated in the usual teaching pedagogy of teachers to be truly effective. The students were enthralled, mesmerized, engaged, attentive and, for the most part, eager to participate. If science classes were described in this way participation in the physical sciences may not be in such 'crisis' (Walsh, 2000). The dominance of didactic teaching methods[10] has taken its toll on student enrolment in science. The author believes that the intervention is likely to be even more successful as a pedagogical tool utilized by teachers within their regular teaching styles. Ultimately, we all wish for learning environments that foster student engagement, result in positive learning experiences and academic success and ultimately sustained participation. Regardless of the subject we wish to promote in our schools the message remains the same: inspire, educate and have fun, and do that often!

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Notes

1 Junior Cycle in Ireland represents lower secondary education (ISCED2 according to The International Standard of Classification of Education 1997) and terminates with the Junior Certificate State examination. Senior Cycle represents upper secondary education and terminates with the Leaving Certificate Examination. This level (ISCED3) includes the Transition Year between Junior and Leaving Certificate.

2 Second-level schools in Ireland can be classified in terms of management and include secondary schools, vocational schools and community and comprehensive schools; see Bhreathnach (1995).

3 Discover Science & Engineering (DSE) is Ireland's national science promotion programme aimed at increasing interest in science, technology, innovation and engineering among students, teachers and members of the public, see [http://www.discover-science.ie/], accessed 19 May 2009.

4 Transition Year (TY) is an optional one-year programme that can be taken in the year after the Junior Certificate and is intended to make the Senior Cycle a three-year programme encompassing both Transition Year and Leaving Certificate.

5 The doctoral program was funded jointly by The Irish Pharmaceutical and Chemical Manufacturing Federation and The Department Chemical and Environmental Sciences at the University of Limerick.

6 To incorporate the content of the 'chemical magic' into the curriculum in schools and to aid the teachers in discussions of the concepts addressed in the show, a teacher's information booklet on chemical magic was prepared and distributed to the participating teachers.

7 The show operated before the introduction of the revised Junior Certificate Syllabus.

8 A random stratified subset (stratified according to school type) yielded 328 pupils from eight different schools; 81 per cent of the schools were secondary schools, 13 per cent were community schools and 5 per cent were comprehensive schools.

9 Though approximately 8500 students experienced the show, only a total of approximately 2000 matched pre- and post-questionnaires were returned.

10 This may have altered slightly as a result of the introduction of the new Junior Certificate Syllabus. Eivers et al. (2006) report changes to teachers' practice as a result of the new syllabus.

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