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CREATING CLIMATE CHANGE AWARENESS IN SOUTH AFRICAN SCHOOLS THROUGH PRACTICAL CHEMISTRY DEMONSTRATIONS

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Abstract: In accordance with the requirements for the National Curriculum Statement for both Life sciences and Physical sciences and the importance of community engagement in Higher Education in South Africa, this paper described the use of the lecture-demonstration 'A Pollutant's Tale' to create climate change awareness amongst school learners. 'A Pollutant's Tale' was performed to a total of 981 school learners and 25 educators from both advantaged and disadvantaged areas of the Western Cape province of South Africa. Both learners and educators were asked to complete their respective questionnaires after the demonstration. The learners' attitudes towards science and the learning of science concepts after the demonstration were described. The educators' views, perceptions and evaluations on using such demonstrations to promote positive attitudes towards science were also discussed. Both the learners and their educators thoroughly enjoyed the demonstration of 'A Pollutant's Tale' and they were also made aware of the causes and effects of climate change on our environment. More importantly, this outreach initiative has helped to spark an interest in the learners' minds not only about chemistry but about science in general.

Keywords: Community engagement; demonstrations; climate change; outreach; science awareness; disadvantaged schools

1. Introduction

Science and technology in South Africa are facing a bleak future with a severe shortage of scientists and students attracted to careers in science. Only a small proportion of school learners in South Africa earn university entrance qualifications in mathematics and physical science, with 75% of all schools in the country producing only 13% of science passes at grade 12 level [1,2]. In the 2003 Trends in International maths and science Study (TIMSS) for grade 8 learners, South Africa scored the lowest in science out of the 50 participating countries and was shown to have a wide range in the quality of its schooling system [3]. Factors contributing to this problem are mainly the prevalence of unqualified science teachers in South Africa, coupled with the lack of exposure of learners to practical work in schools [4,5]. The pressure on the South African Government to provide quality in mathematics and science teaching has continued since former President Mbeki's speech at the opening of Parliament in 2005, in which he emphasised the importance of mathematics and science education [6] which has more recently been reiterated by the current South African leader, President Zuma [7]. Science education should serve two purposes: (i) to educate those who would like to pursue a career in science and technology and (ii) to inform 'the other 98%' of the population, who will encounter scientific concepts in their everyday lives and through health and well-being in particular, require a modicum of skills in this area to prosper [8,9].

Community engagement features as one of the core functions of higher education in South Africa [10] and, accordingly, since the late 1990's the Department of Chemistry at Rhodes University has been actively involved in promoting science and education in the local and surrounding communities of Grahamstown, South Africa [11,12]. The community engagement has incorporated various forms namely [12]:

- Hosting schools to do practical work in the undergraduate chemistry teaching laboratories at Rhodes University to give learners exposure to a practical environment [12] which they seldom or never encounter at school.
- Both theoretical and practical interactive workshops for teachers to improve their pedagogical content knowledge.
- A mathematics and science club that runs every Saturday aimed at learners of grades 7-12, the majority of whom are from previously disadvantaged schools [13]
- Outreach activities in the form of science shows and lecture-demonstrations [12]
- These activities not only fulfil the requirements for community engagement in higher education, as outlined in the White Paper for Education [10] but also address the need for the promotion of science and science education in South Africa [14].

2. Climate change in the South African curriculum

In the National Curriculum Statement (NCS) for both Life sciences and Physical sciences learning areas [15,16], (p 2-38) grades 10-12 learners are required to:

- ‘use science and technology effectively and critically showing responsibility towards the environment and the health of others.’
- to be able to show ‘how science relates to their everyday lives, to the environment and to a sustainable future.’
- behave as ‘responsible citizens’ and as such be able to make informed decisions on ‘environmental management and lifestyle choices for a sustainable future...., e.g. ozone, global warming and the greenhouse effect, acid rain and its consequences.’
- be able to present ‘scientific arguments on the risks and benefits of the combustion of organic products and the manufacturing of synthetic products on human development, society and the environment.’
- argue on the ‘economic, social and environmental impact of various energy sources.’

The requirements of the Natural sciences curriculum for grades 4-9 [17] are to:

- ‘suggest ways to minimise negative effects on the environment’.
- understand ‘sustainable use of the Earth’s resources and respond to the environmental impacts of the use of these resources.’
- be familiar with the different gases that are present in the atmosphere and their proportions at different levels of the atmosphere .
- identify carbon dioxide, oxygen and photosynthesis through reactions.

Why the need to educate learners about climate change? The 2006 Pisa study [18] indicated that students with a higher mean performance in science were more aware of environmental issues than those with a lower mean performance. According to Bangay and Blum [19] ‘education is as important as health: a well-educated population is better equipped to recognise in advance the threats posed by a changing climate’. Furthermore, one of the United Nations’ millennium development goals states that ‘environmental sustainability’ must be ensured [20] and this is only possible through ongoing education around environmental issues.

The demonstration of ‘A Pollutants Tale’ (APT) addresses aspects of grades 4-12 science curricula (vide supra) in South Africa whilst incorporating issues of local and global climate change. In this study, we describe our findings in taking APT to primary and secondary schools in both advantaged and disadvantaged areas in the Western Cape province of South Africa with the aim to inform and enthuse learners about chemistry and climate change [12].

3. 'A Pollutant's Tale'

'A Pollutant's Tale' is a lecture-demonstration developed by Professor Dudley Shallcross and Tim Harrison from Bristol ChemLabS at the School of Chemistry, University of Bristol in the United Kingdom and has been presented over 800 times worldwide [21-25]. In 2008, collaboration between Bristol ChemLabS and the Department of Chemistry at Rhodes University was initiated and, as a result, the contents of APT have been adapted to be more relevant to South African audiences. This demonstration has been presented in various areas of the Eastern Cape Province of South Africa.

The APT demonstration covers the following aspects:

- A description of the Earth's atmosphere.
- The gases that make up the Earth's atmosphere.
- The chemical and physical properties of the gases nitrogen, oxygen and carbon dioxide.
- Air pollutants such as carbon dioxide, nitrogen dioxide and volatile organic compounds.
- The role and effect of these various gases on climate change.

4. The APT Demonstration

APT begins with an introduction to the main gases that are present in the Earth's atmosphere to illustrate that this distinctive combination is vital for life on our planet. The presentation continues with a detailed look at each of the most important gases on Earth.

The learners are exposed to the idea that we cannot see, taste or smell nitrogen although it makes up 78% of our atmosphere. It is explained to the older learners that nitrogen is an inert gas due to its high bond energy in its diatomic form. Liquid nitrogen is used in a number of experiments involving bananas, eggs, flowers and rubber to explain the concepts of states of matter, heat conduction, chemical vs. physical changes and cell constitution in plants.

The photosynthetic production of oxygen from carbon dioxide by plants is explained to highlight the importance of plants on Earth. Oxygen is then prepared on stage by the catalytic decomposition of hydrogen peroxide. This experiment illustrates the concepts of catalysts and exothermic reactions and is visually enhanced by using detergent to rapidly produce large quantities of foam.

The position of the ozone layer in the Earth's atmosphere, relative to the troposphere and stratosphere, is shown and its importance in blocking harmful ultraviolet radiation from the Sun is explained. The cyclic process of formation and degradation of ozone by ultraviolet radiation is used to introduce the concept of free radicals to secondary school learners.

The concept of volatile organic compounds (VOCs), of both biogenic and anthropogenic origin, is discussed while some examples of naturally occurring VOCs, e.g. common smells such as lemon, vanilla, lavender and unusual smells relevant to the perfume industry, such as ambergris and civetone (natural pheromone from the African civet cat), are introduced to the learners. The removal of these VOCs through the process of combustion is then demonstrated, by using the burning of acetylene from the reaction of calcium carbide and water. This reaction is utilised to demonstrate incomplete combustion with a yellow flame while complete combustion with a blue flame is demonstrated by burning methanol vapour in a clear plastic container [25]. The natural breakdown of VOCs in the environment by the effect of sunlight is highlighted and the production of photochemical smog, i.e. the generation of NO_2 through combustion, is reproduced on stage by using concentrated nitric acid and copper turnings to make NO_2 as a thick brown gas. This is also used to demonstrate the difference in density of gases and visually explain why smog settles over cities.

The vital importance of naturally occurring greenhouse gases, such as carbon dioxide, in our atmosphere and the increase in temperature arising from the increase in atmospheric concentration of carbon dioxide are explained with the aid of cartoon pictures for visual conceptualisation.

Dry ice is used to demonstrate the properties of carbon dioxide. Sublimation of dry ice is simply shown by placing dry ice pellets/powder in a sealed surgical glove and allowing it to expand on heating. This is explained through the use of phase diagrams, thus exposing the older learners to university-level science. Solid carbon dioxide is dissolved in a dilute solution of sodium hydroxide and universal indicator, which changes colour as the pH of the solution decreases. This experiment is used to illustrate the concepts of pH, pH indicators and how a rise in atmospheric carbon dioxide levels can cause the oceans to become more acidic, with potentially dire consequences for the marine environment.

The impacts of climate change are illustrated using graphs and images and the demonstration is ended by suggesting different ways of minimising the effects of climate change, e.g. decreased reliance on cars and the use of solar and wind energy to decrease our carbon dioxide emissions. Finally, the learners are called up to ignite a number of balloons containing either helium or hydrogen gas to demonstrate the difference in chemical properties of these two gases with a 'BANG'!

The APT demonstration is also described in a recent publication by Harrison *et al.*[12] and a version of the MS PowerPoint presentation that accompanies this lecture demonstration may be found at: http://www.chemlabs.bristol.ac.uk/outreach/resources/PT2008_SciFest.ppt

5. The study

The main objectives of this study were to:

- inform and enthuse learners about climate change through the use of practical chemistry demonstrations.
- educate learners about the different gases that form part of the atmosphere and their effect and/or role on our environment.
- find out about both learners' and educators' attitudes towards science and the learning of science concepts after watching the APT demonstration.

The methodology employed was uncomplicated in that the lecture was presented and questionnaires were used to elicit response.

APT was demonstrated in primary and secondary schools in both previously advantaged and disadvantaged areas in the Western Cape province of South Africa. The participating schools are part of a four-year project known as the Systemic Education and Extra-Mural Development and Support (SEEDS) project funded by the Royal Netherlands Embassy and is implemented by Scifest Africa [26], which also facilitated this tour. The SEEDS project aims to benefit education in the Western Cape, with particular emphasis on mathematics and science.

Questionnaires were handed out to learners and educators after each demonstration.

The subjects of the study were seven primary schools and two secondary schools, that were all funded by the SEEDS project, responded to our invitation to participate in this APT demonstration tour in the Western Cape province of South Africa. All seven primary schools are located in peri-urban areas and are disadvantaged. The primary focus of secondary school 1 (SS1) is mathematics, science and technology education and the learners are from disadvantaged areas, while secondary school 2 (SS2) is located in a privileged suburb of Cape Town and holds a high academic track record.

The gender distribution for the primary schools was almost equal for boys and girls and for SS1 was 54% boys and 45% girls, while 62% of SS2 comprised of boys (Table 1).

The 786 primary school learners were all in Grades 6-7 and aged 11-14. The 124 learners from SS1 were in Grades 10-12 and between the ages of 15-19, while the 71 learners from SS2 were all between the ages of 15 and 17 and in Grade 10.

Table 1: Demographics of learners (n = 981).

		Learners (%) [†]		
		Primary	SS1	SS2
Gender	Male :	44	54	62
	Female :	47	44	38
Language	English		35	100
	Xhosa	25	23	
	Afrikaans	66	38	
Race	Black	28	22	8
	Coloured	59	48	24
	Asian	9	19	6
	White	0.8	2	34
	Indian	0.3	2	1

Two different questionnaires (Appendix 1 and 2) were designed for the learners and their educators respectively 27 and were handed out after the APT demonstrations.

The questionnaire for the learners (Appendix 1) was divided into two parts:

Section A - Attitude to science Instrument (ASI)

Section B - The learning of science concepts from the APT demonstration.

In Section A, the ASI 28 component of our study comprised three main subscales:

- (i) Enjoyment of science
- (ii) Social implication of science
- (iii) Career preference for science

Section B comprised of four questions relating to some of the gases in the atmosphere that were mentioned and/or highlighted during the demonstration of APT. The responses to these questions were used to obtain an indication of whether the learners had gained some knowledge of some of the science concepts discussed during the demonstration.

The educators' questionnaire (Appendix 2) consisted of 6 open-ended questions and two yes/no questions where the educators could indicate their willingness to be involved in this research study post-visit. The responses of the educators were collated and categorised into common themes to obtain qualitative data. A personal background information section was included at the beginning of the questionnaire while the main part dealt with the pre-visit preparations, advantages and disadvantages of the APT demonstration and the post-visit activities.

6. Results

Responses from learners

Section A

The results obtained for section A of the questionnaire from primary schools, SS1 and SS2 were combined since all the responses from the learners followed the same trend when analysed separately. According to figure 1, about 73% of all learners agreed that they 'would enjoy being a scientist', two-thirds of learners agreed that they 'would like to work as a scientist' and almost 75% 'felt that the work of a scientist is good for them'. These results clearly show that the majority of learners expressed their interest in a science career after watching the APT demonstration.

Career Preference for Science

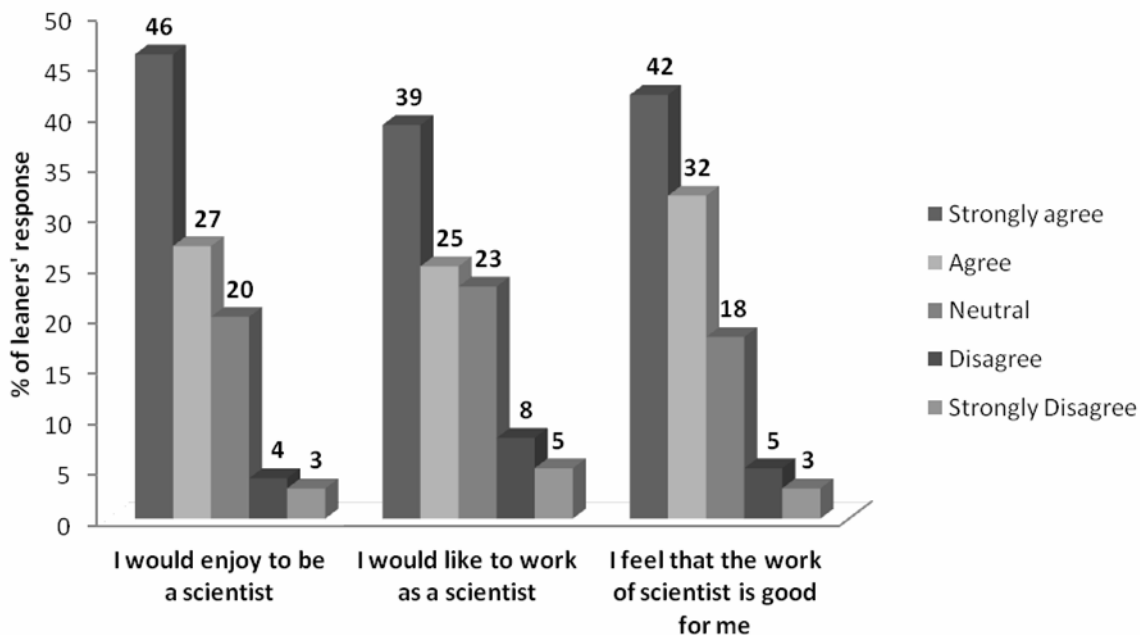


Figure 1: Distribution of the learners’ attitude from all schools towards science as a career preference.

The responses of the learners to questions designed to assess their attitudes towards the enjoyment of science is represented in figure 2 and indicates a general positive attitude towards the enjoyment of science. About 80% of all learners recognised that they would ‘enjoy watching science programs/shows on television at home’, while some 65% of the learners agreed that they would ‘like to join a science club or society’.

Enjoyment of Science

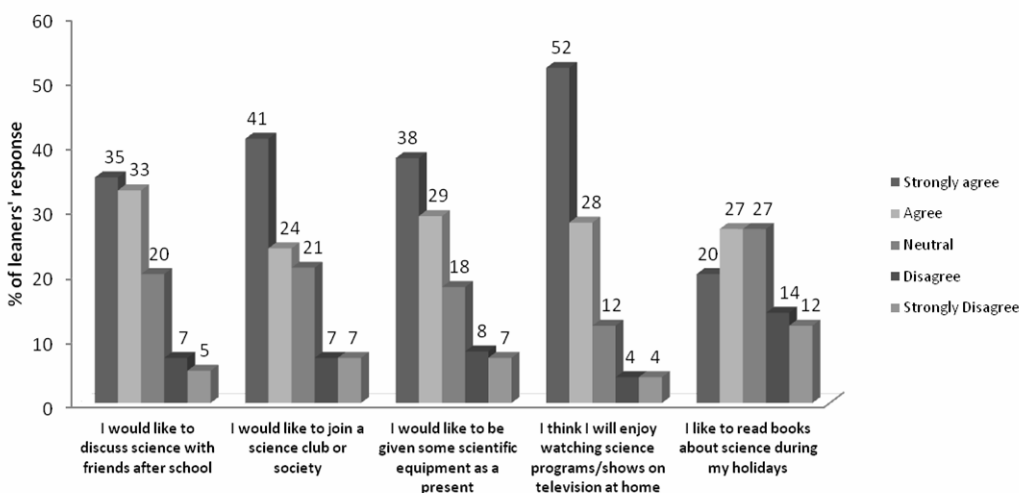


Figure 2: Bar graph representing the percentage of responses to questions in the ‘enjoyment of science’ category.

Interestingly, a majority of the learners were either neutral (27%) or disagreed (28%) when asked if they would ‘like to read about science during their holidays’ and this could be due to a variety of reasons [29-32] e.g., the learners might:

- think that science books are like their school text books
- think it is too difficult
- not know about the availability of popular science books
- not have access to books
- not read a lot

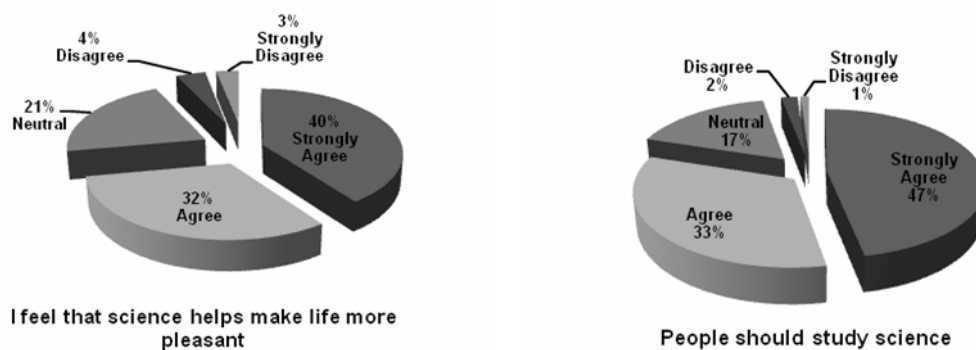


Figure 3: Pie charts showing the learners’ attitude towards ‘Social Implications of science’.

In general, the learners had a positive attitude towards the ‘Social Implication of science’ as represented in figure 3. About 80% of all learners agreed that ‘people should study science’ while almost three quarters of them felt that ‘science helps make life more pleasant’.

Finally, the last part of the ASI was an open-ended question and offered the learners an opportunity to express their views and/or opinions about science when asked: ‘What else would you like to say about science?’ These answers were not statistically analysed but merely utilized to obtain a qualitative assessment of the learners’ attitudes towards science in general. Most of the answers to this question were positive, with many mentioning the benefits of science and their thoughts about a future in science.

Selected responses are given below:

‘science Gives you a lot of knowledge about life its explains and give reasons to everything around us [sic]’ (SS1)

‘science is fun and in the same way interesting too. I like science because it teaches me a lot and expands my knowledge and wisdom of the world I live in’ (SS1)

‘That sciences is the key to our survival on Earth [sic]’ (SS1)

‘That is great to see how other people show you how it work [sic] and it is very exciting to do it. science is not difficult it is great.’ (primary)

‘It is pleasant. I would like to be a scientist’ (primary)

‘I would love to lirn [sic] more about science because it is very interesting and it help [sic] you to take good care of our planet Earth’

The responses obtained for Section A of the questionnaire (Figures 1-3) show a positive attitude of the learners towards science, which is also reinforced with the learners’ responses to the open-ended question of: ‘What else would you like to say about science?’ shown above. Therefore, we can

cautiously conclude that after the demonstration of APT the learners indicated a positive attitude towards science.

Section B

The responses of the learners to Section B of the questionnaire are summarised in Table 2. The data obtained in these columns are the percentages of learners who answered the questions correctly and will be used as an indication of what their knowledge of the relevant concepts are after watching the APT presentation.

Table 2: Responses of learners to multiple choice questions in Section B of questionnaire

Questions	Correct (%)			Yes (%)		
	Primary	SS1	SS2	Primary	SS1	SS2
<p>1. 'From the demonstration, a stem of a flower and a banana were dipped into liquid nitrogen. Describe the properties of the two objects after the scientist took them out of the liquid nitrogen.'</p> <p>Answer: <i>Flower; breaks easily; Banana; hard</i></p>	17	40	61	80	85	86
<p>2. 'Which one of the following properties is <i>FALSE</i> about nitrogen?'</p> <p>Answer: <i>Liquid nitrogen is white in colour</i></p>	32	42	48	68	73	61
<p>3. 'Photosynthesis uses carbon dioxide to make oxygen in nature. $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$. We made oxygen from hydrogen peroxide $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$. Which statement is false?'</p> <p>Answer: <i>Photosynthesis uses oxygen to make carbon dioxide</i></p>	25	40	70	70	71	42
<p>4. 'The scientist put dry ice (solid carbon dioxide) in a beaker containing water where sodium hydroxide solution and universal indicator had been added to it earlier. What are the changes in the colour of the solution?'</p> <p>Answer: <i>Purple; blue; green; yellow; orange</i></p>	21	30	77	76	92	85

Table 2 shows that the percentage of correct answers from the primary school learners was the lowest (ca.17-32%) and the ones from the SS1 was only just higher (30-42%), while SS2 had a significantly higher percentage of correct answers (48-77%).

The learners from the primary schools were all aged 11-14 and therefore would have had less prior knowledge compared to SS1 and SS2. Additionally, more than 90% of the learners from the primary schools do not speak English as a first language (Table 1) and understanding the questions that were all in English could have been challenging.

With regards to questions 1, 3 and 4 (Table 2), it is interesting to note the discrepancy between the percentage of correct answers for SS1 and SS2 since the learners from those schools were within the same age group, i.e. SS1 learners were aged 15-19 and in grades 10-12 while the SS2 learners were all in grade 10 and between the ages of 15-17. Based on the social conditions of the learners at SS2, their general knowledge was better than the SS1 learners as they are considered to originate from more privileged backgrounds and it was also apparent that they had been exposed to practical science lessons. The learners at SS1 had a fairly good understanding of science but they would not have been exposed to as much science and general knowledge outside of the classroom. Additionally, SS2 is a former model C school and, according to a study by Reddy,^{33,34} former model C schools, especially in the Western Cape province of South Africa, are better than the other 'types' of schools such as SS1.

The medium of instruction in both SS1 and SS2 is English, but only 35% of SS1 learners spoke English as a first language (Table 1) while the learners from SS2 all spoke English, which could have been a disadvantage to the SS1 learners when answering the questions.

At the end of the questionnaire, the learners were asked an open-ended question: ‘What other science concepts/contents have you learnt from the lecture demonstration “A Pollutant’s Tale”?’ Similarly to Section A, these answers were not statistically analysed but merely utilized to qualitatively assess what science concepts/contents the learners may have learnt from this demonstration.

Some of the responses are included:

‘ In joburg there is things that polute the air that is why the air in joburg is brown but I think it is because the fabrics in joburg [sic]’ (primary)

‘We should try to do things to easen global warming like reuse/recycle. I learned how to help do things like that [sic]’ (primary)

I have learn about the Earth and about gases and about the Sun and planetary and that kind of stuf but it was fun [sic]’ (primary)

‘Pollutant’s can destroy the Earth. If we don’t do something [sic]’ (primary)

‘What people can do to keep the Earth clean and to slow down global warming’ (primary)

‘That some gases are harmful to men and Earth. But some is needed to keep a balance in the Earth[sic]’ (primary)

‘Plants and trees give off a vast range of organic material’ (primary)

Using the responses to the open-ended question: ‘What other science concepts/contents have you learnt from the lecture demonstration “A Pollutant’s Tale”?’ it is evident that the learners learnt something about climate change and how they can do something towards preventing this global issue. Not surprisingly though, during some informal discussions after the demonstration, we found out that most of the learners had never seen or been shown most of the chemicals, e.g. liquid nitrogen and dry ice, used during the APT demonstration. Additionally, the majority of the learners from all the schools only learnt about some aspects of climate change for the first time when they saw the APT demonstration. Therefore, we can conclude that the learners gained some knowledge about the science concepts discussed during the APT demonstration.

Responses from Educators

The questionnaire for the educators (Appendix 2) was designed to find out the educators’ perceptions on both the benefits and limitations of the APT demonstration in promoting attitudes towards science and the learning of science concepts.

The educators were also asked: ‘Did you prepare in any way for our visit? If so, please describe briefly.’ Of the 25 educators that were interviewed, only one reported to have prepared the class for the presentation but admitted that it was due to the fact that the material had been previously covered in the curriculum, rather than a special lesson in preparation of the presentation. The only preparation made by the educators was with regards to logistical details, e.g. setting up a room for the demonstration. The teachers also indicated that, in the future, they should be informed about the subject of the presentation or demonstration prior to the visit, so that they can brief the learners on the subject matter, which could more than likely help the learners to gain more knowledge and interest on the subject.

The responses obtained in the questionnaire indicate that all the educators felt that APT was useful in promoting positive attitudes towards science and the learning of several science concepts. Additionally, all the educators appreciated how suitable and relevant APT is to all levels of the South African science curriculum.

The educators were also asked about the advantages and disadvantages of exposing their learners to science demonstrations such as APT and most educators agreed that, due to the lack of laboratory facilities in schools, such extra-curricular activities are highly beneficial for the learners in terms of exposure to practical science.

Some quotes on the advantages are listed:

‘Just the fact that they move to a different environment make [sic] them curious, excited. The demonstrations were very interesting.’

‘Learner excitement of travel to a new environment. Exposure to a university which has a motivational effect’

‘Gives a learner the chance to get firsthand experiences – give a glimpse of the world of science – especially much of our learners – disadvantage society [sic]’

‘Learners gain knowledge better. Learning outside the normal classroom is always good and learn better by experiencing and seeing these. Engage learners. They are definitely more interested. Stay with them a long time. Weaker learners also gain knowledge and take part.’

The most common limitation according to the educators is financial, i.e. the schools do not have the finance and/or transport facilities to get the learners to and from the venues for such activities. Other disadvantages mentioned in the educators’ responses were that the groups were too big and that they would prefer smaller hands-on activities.

When asked what they would do as a follow-up to the presentation, most of the educators replied that they would continue giving lessons to create more environmental awareness amongst their learners. All the educators were science teachers, with the exception of three educators who were language teachers and indicated that they would allow their learners to do orals and essays on environmental issues. Only one educator expressed an intention to do more demonstrations in class.

7. Conclusion

The main objectives of this study were to inform and enthuse school learners in the Western Cape Province of South Africa about science in general and climate change in particular through the use of practical chemistry demonstrations, while also educating them about the different gases that form part of the atmosphere and their effect and/or role on our environment. We also aimed to investigate both learners’ and educators’ attitudes towards science and the learning of science concepts after watching the APT demonstration. The responses obtained in this study highlight the positive influence that the demonstration of APT had on the school learners.

The learners and their educators not only thoroughly enjoyed the demonstration of ‘A Pollutant’s Tale’ but were also made aware of the causes and effects of climate change on our environment. This is reflected in the responses obtained from the open-ended questions in both questionnaires which clearly indicate that the majority of the school learners learnt something about climate change and/or chemistry from the APT demonstration.

All the educators appreciated the relevance of the demonstration towards all levels of the South African science curriculum and the added bonus of their learners being exposed to practical science demonstrations that they rarely have a chance to experience. Most of the educators also indicated that, after watching the APT demonstration, they would continue giving lessons to create more environmental awareness amongst their learners.

We believe that this outreach initiative has also helped to spark an interest in the learners’ minds not only about chemistry but also about science in general, which is instrumental in the promotion of sciences and science education in South Africa. The APT demonstration also fulfils the requirements for the Natural sciences curriculum for grades 4-9 and the National Curriculum Statement for both

Life science and Physical sciences for grades 10-12. Outreach activities such as APT not only address the need for community engagement in higher education but also serve as an ideal tool in informing and enthusing school learners about chemistry and also create a much needed awareness about climate change and the global issues surrounding it, as shown by the results obtained in this study.

References

- [1] The Centre for Development and Enterprise (2010, *Maths and science performance in South Africa's public schools; Some lessons from the past decade.*
- [2] Cherry M. (2010), African Science: black, white and grey. *Nature*; 463(7282):726-728.
- [3] Reddy V. (2006) *Mathematics and science achievement at South African schools in TIMSS 2003*, Cape Town: HSRC Press from: <http://www.hsrcpress.ac.za/product.php?productid=2148> [Last accessed 1 December 2010]
- [4] Muwanga-Zake (2011) JWF. Education-science crisis: <http://www.scienceinAfrica.co.za/scicrisis.htm>. [Last accessed 5/2/2011].
- [5] Selvaratnam M.(2011), Competence of matric physical science teachers in some basic problem-solving strategies, *S. Afr. J Sci.*,107(1-2).
- [6] Mbeki T. (2005), Address of the President of South Africa, Thabo Mbeki, at the Second Joint sitting of the third Democratic Parliament, Cape Town, February 2005: <http://www.info.gov.za/speeches/2005/05021110501001.htm>. [Last accessed April 13, 2011]
- [7] Zuma J.(2011) State of the nation address by His Excellency Jacob G Zuma, President of the Republic of South Africa, at the joint sitting of parliament, Cape Town: <http://www.info.gov.za/speech/DynamicAction?pageid=461&sid=16154&tid=27985>. [Last accessed April, 13, 2011]
- [8] Treffel J.(2008), Science education for everyone: Why and what? *Liberal Educ.*, 94(1):6-11.
- [9] Harrison TG, Shallcross DE. (2009),What should be expected of successful engagement between schools, colleges and universities? *School Science Review* ,91(335):97-102.
- [10] DoE. (1997), Education White Paper 3, *A Programme for the transformation of higher education*. Pretoria, Government Gazette (No. 18207).
- [11] Brown ME, Cosser RC, Davies-Coleman MT, Kaye PT, Klein R, Lamprecht E, *et al* (2010), Introducing chemistry students to the "real world" of chemistry, *J. Chem. Educ.*,87(5):500-503.
- [12] Harrison TG, Shallcross DE, Norman NC, Sewry JD, Davies-Coleman MT. (2011), Publicising chemistry in a multicultural society through chemistry outreach. *S Afr J Sci* ;107(11/12),Art. #669, 6 pages, <http://dx.doi.org/10.4102/sajs.v107i11/12.669> [Last accessed 10/01/2012]
- [13] Community Outreach - Chemistry Department - Rhodes University (2011), <http://www.ru.ac.za/chemistry/communityoutreach> [Last accessed 5/2/2011]
- [14] Shaw AJ, Harrison TG, Shallcross DE. (2010), What value has chemistry outreach by a university department to secondary schools? Teacher perceptions of Bristol ChemLabS outreach events, *Acta Didactica Napocensia*, 3:15-23.
- [15] DoE. (2008) National Curriculum Statement, Grades 10-12 (General) Physical Sciences. Pretoria: Department of Education.
- [16] DoE. (2003), National Curriculum Statement, Grades 10-12, (General), Life Sciences. Pretoria: Department of Education.
- [17] DoE. (2002), Revised National Curriculum Statement for Grades R-9 (Schools) Natural Sciences. Pretoria: Department of Education.
- [18] OECD. Programme for International Assessment (PISA) 2006. 2007. which year???

- [19] Bangay C, Blum N. (2010), Education responses to climate change and quality: Two parts of the same agenda? *Int J Educ Dev*30(4):359-368.
- [20] UN. United Nations Millennium Development Goals (2011), <http://www.un.org/millenniumgoals/> [Last accessed 5/2/2011]
- [21] A Pollutant's Tale - ChemLabS _ Bristol ChemLabS Outreach - School of Chemistry - University of Bristol (2011), <http://www.chemlabs.bristol.ac.uk/outreach/A-Pollutant-Tale.html>. [Last accessed 5/3/2011].
- [22] Norman NC, (2010), Bristol ChemLabS. Bristol ChemLabS: A Centre for Excellence in Teaching in Learning; Annual Report 2008-2009, *University of Bristol*.
- [23] Hayes E.(2008), Science on Stage: recent activities. *Sci Sch* (10).
- [24] Tuah J, Harrison TG, Shallcross DE. (2011), A review of the use of demonstration lectures in the promotion of positive attitudes towards, and the learning of science with reference to a 'A Pollutant's Tale', a demonstration lecture on air quality and climate change, *RoJEd* (3-4):93-102.
- [25] Shallcross DE, Harrison TG (2008), Practical demonstrations to augment climate change lessons. *Sci Sch*10:46-59.
- [26] Scifest Africa - Welcome (2011) <http://www.scifest.org.za/>. [Last accessed 5/2/2011]
- [27] Tuah J. (2008), Investigating Bristol ChemLabS outreach: How does a science lecture demonstration and a practical science workshop impact upon secondary school students' attitudes towards science and learning of science concepts?. [unpublished dissertation]. *University of Bristol, UK*.
- [28] Foong YY, Lam TL. (1988), Development and validation of the attitudes to science instrument.. *Singapore: National Institute of Education*
- [29] van Ours JC. (2008), When do children read books? *Educ Econ*, 12/01;16(4):313-328.
- [30] Tella A, Akande S. (2007), Children reading habits and availability of books in Botswana primary schools: Implications for achieving quality education. *Reading Matrix*, 08;7(2):117-142.
- [31] Ennemoser M, Schneider W. (2007), Relations of television viewing and reading: Findings from a 4-year longitudinal study. *J Educ Psychol* 05/01;99(2):349-368.
- [32] Covington V. (1987), Leisure time reading versus television viewing time for seventh grade reading students, *Resources in Education*, 22 (4),.30
- [33] Reddy V. (2006), Mathematics and Science achievement at South African schools in TIMSS 2003, HSRC Press.
- [34] Reddy V.(2006), The state of mathematics and science education: schools are not equal. In: Buhlungu S, Daniel J, Southall R, Lutchman J, editors. *State of the Nation South Africa 2005 - 2006 Cape Town: HSRC Press;*. p. 392.

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Appendix 1

A Pollutant's Tale - Questionnaire for Learners

School:		Grade :	
Gender:	Male	Female	Date:
(Please Tick ✓ in one of the boxes below)			
Age:	Language:		
Race: Black	<input type="checkbox"/>	White	<input type="checkbox"/>
Asian	<input type="checkbox"/>	Coloured	<input type="checkbox"/>
		Indian	<input type="checkbox"/>
		Other:	

Instructions to students:

- This questionnaire is designed to study your perceptions (opinions) on the Rhodes University (RU) activities (lecture demonstration and science workshop) in which you have participated.
- There are no right or wrong answers to any questions of this questionnaire.
- Please write the answers based on your real experience and honest opinions.
- It is OPTIONAL for you to complete this questionnaire.

SECTION A: Attitude to Science Instrument (ASI)

Instructions:

1. This section aims to find out what *you think about science*. There is no right or wrong answer. Your honest opinions on each of the statements are what is wanted.
2. Answer all the items. **Circle** one response that best describes your feeling for each statement. The meaning of each response and the corresponding “smiley face” are given below:



SD If you **STRONGLY DISAGREE** (SD) with the statement.



D If you **DISAGREE** (D) with the statement.



N If you are **NOT SURE** (N).



A If you **AGREE** (A) with the statement.








SA If you **STRONGLY AGREE** (SA) with the statement.

For example : I like science. If you **Strongly Agree** with this statement, then you should circle **SA** on your response sheet like this:

SD **D** **N** **A** **SA**

3. Cross out (**X**) any response you wish to change, and choose another response. Do not think too long on one statement. Give the first response as it comes to you.

Response Sheet for Attitude to Science Instrument (ASI)

Statement					
	SD	D	N	A	SA
1. I would enjoy being a scientist.	SD	D	N	A	SA
2. I would like to discuss science with friends after school.	SD	D	N	A	SA
3. People should study science.	SD	D	N	A	SA
4. I would like to work as a scientist.	SD	D	N	A	SA
5. I would like to join a science club or society.	SD	D	N	A	SA
6. I think I will enjoy watching science programs/shows on television at home.	SD	D	N	A	SA
7. I feel that the work of a scientist is good for me.	SD	D	N	A	SA
8. I like reading books about science during my holidays.	SD	D	N	A	SA
9. I feel that science helps to make life pleasant	SD	D	N	A	SA
10. I would like to be given some scientific equipment as a present.	SD	D	N	A	SA

What else would you like to say about Science?

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Section B: Learning Science Concepts from “A Pollutant’s Tale”

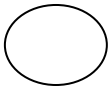
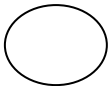
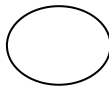

Instructions:

Please write your answer (A, B, C or D) in the circle and tick ✓ (yes or no) in the box.

For example:

Question	Answer (please write A, B, C or D as your answer)	Did you <i>learn</i> this today, i.e. from this lecture demonstration? (please tick ✓ your answer)
1. What is the name of the South African men’s soccer team? A. Springboks B. Banyana Banyana C. Proteas D. Bafana Bafana	(D)	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>

Questions on science concepts/content perceived from the lecture demonstration:

Question	Answer (please write A, B, C or D as your answer)
1. From the demonstration, a stem of a flower and a banana were dipped into liquid nitrogen. Describe the properties of two objects after the scientist took them out of liquid nitrogen. <u>flower</u> <u>banana</u> A. hard and strong breaks easily B. soft soft C. breaks easily hard D. soft and "bendy" hard	
2. Which of the following is FALSE about nitrogen? A. 78% of the atmosphere consists of inert nitrogen B. The boiling point of liquid nitrogen is -196°C C. Nitrogen can be obtained by fractional distillation of liquefied air D. Nitrogen is white in colour	
3. Photosynthesis uses carbon dioxide to make oxygen in nature. $6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Sunlight} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ We made oxygen from hydrogen peroxide $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$ Which statement is FALSE ? A. Photosynthesis uses oxygen to make carbon dioxide B. Decomposition of hydrogen peroxide gives off heat C. Fast decomposition of hydrogen peroxide does not need a catalyst D. Both photosynthesis and decomposition of hydrogen peroxide produce oxygen gas	
4. The scientist put dry ice (solid carbon dioxide) in a beaker containing water where sodium hydroxide solution and universal indicator had been added to it earlier. What are the changes in the colour of the solution? A. Purple → green → yellow → orange B. Green → purple → green → yellow → orange C. Purple → blue → green → yellow → orange D. Green → purple → green → blue → yellow → orange	

What other science concepts/content have you learnt from the lecture demonstration "A Pollutant's Tale"?

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Appendix 2

Questionnaires for Teachers

Please give your information below:

School Name:

Teacher's Name:

Grades : **Date:**

Subject taught:

Gender: Male Female (*Please tick ✓ in one of the boxes*)

Age (Optional):

Years of teaching experience

0-5 years 6-10 years >10 years

(*Please tick ✓ in one of the boxes above*)

Instructions:

There are ***no right or wrong answers*** to questions in this questionnaire.
 Please write the answers based on your ***real*** experience and your ***honest*** opinions.

1) Did you prepare in any way for our visit? If so, please describe briefly.

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2) What are your views/opinions about the lecture demonstration on “A Pollutant’s Tale” in ***promoting positive attitudes*** towards science among students and the way in which they learn science?

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3) In general, what are your opinions about the ***advantages and disadvantages*** of bringing students for school trips to a school/university to learn science from activities such as the lecture demonstration on “A Pollutant’s Tale”?

Advantages:

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Disadvantages:

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4) What do you plan to do with your learners as a result of seeing “A Pollutant’s Tale”?

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5) Does “A Pollutant’s Tale” fit into the curriculum? If so, please tell us where?

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6) Please write any additional comments or suggestions for improvement.

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7) Would you be willing to answer any further questions in the future? (Please tick ✓one)

Yes No

8) Would you be willing to answer further questions by email?

Yes Email address

No