INSPIRING PUPILS TO STUDY PHYSICS AND ASTRONOMY AT THE SCIENCE CENTRE AT-BRISTOL, UK

E. Stengler[1], J. Tee[2]
[1]University of the West of England, Bristol, UK, Erik.Stengler@uwe.ac.uk
[2]University of the West of England, Bristol, UK, Jessica-T@hotmail.co.uk

ABSTRACT

An investigation was carried out to collect evidence that science centres can have a positive effect on young children's formal education in Physics and Astronomy. We explored whether the science centre At-Bristol's exhibitions and planetarium show align with the current UK curriculum guidelines in Physics and Astronomy and the point of view of pupils, a science centre educator and a teacher on whether they can increase further uptake of these particular subjects later on. The evidence gathered showed a positive alignment between science centres and curricular content and that science centres are indeed considered an adequate and effective tool in supporting learning and inspiration for subjects such as Physics and Astronomy.

INTRODUCTION

A report in 2001 stated that 'in many developed countries of the world, science education is seen to be in crisis. Pupils' attitudes to school science decline progressively across the age range of secondary schooling, and declining numbers of students are choosing to study science at higher levels and as a career' [1]. This suggested the importance to ensure primary school children are kept sufficiently interested in the study of Science. Particularly in Physics and Astronomy is interest likely to decrease at secondary school level [2]. It has been suggested that this could be due to the subjects themselves or to lack of scientific knowledge and enthusiasm from teachers [3].

As a response to this reality, many changes have been made in recent years to how Science is taught across the UK and to the subjects covered. As many of the subjects covered in the key stage 2 (KS2) National Curriculum are statutory, it is important to ensure children are engaging with the right information inside and outside of the classroom. According to the UK's Department for Education the three main changes made to the primary school National Curriculum in 2014 were towards 'More focus on learning outside the classroom', 'New content areas to be covered' and 'More types of inquiry are to be specified' [4].

In 2014 the science centre At-Bristol had approximately 35,000 visitors attending educational workshops at the KS2 level, an increase of 5,000 visitors with respect to the previous year 2013 [5]. A suggested reason for the increase of visits to a science centre could be linked to the government guidelines encouraging more focused learning outside of the classroom in Science subjects.

Science centres are often used by schools to encourage a hands-on fun approach to learning, but are also as important in supporting formal education [6]. Recent studies show that with increased visits to science centres, young pupils' existing knowledge is reinforced,

allowing them to discover subjects in more depth inside and outside of the curriculum. A report entitled 'The Effect of Science Centres on Students' Attitudes towards Science' concluded that 'Science centres can be used by educators as an effective way of increasing students' attitudes towards science.' [7].

On the other hand, a recent increase of students studying in Physics and Astronomy at the level of Higher Education has been reported. The Institute of Physics published these statistics in 2012 [8]:

- The total number of full-time students in the first year of first-degree physics courses increased by 25% between 2004/05 and 2009/10, from 3190 to 3975.
- In 2009/10, 51% of physics, 52% of astronomy, and 46% of chemistry fulltime first-year students are registered on enhanced first-degree courses compared to 19% of mathematics, 17% of electronic & electrical engineering, and less than 2% of biological science students.

It is important to establish what factors have contributed to the growth in interest in subjects such as Physics and Astronomy in order to be able to further promote and inspire young children into having an interest in these and other fields. If science centres are realistically creating exhibits and workshops that are aligned with the current Primary Science National Curriculum guidelines there should be clear evidence that they are a useful supporting tool for schools and families.

METHODS

Data were collected over a period of four months in a primary school and in the science centre At-Bristol.

First, quantitative content analysis methods were used to look at the amount of significant written content relating to Astronomy and Physics in the texts displayed on exhibits and in the planetarium show script at the Science Centre. Key words were identified and their counts compared to those in the KS2 National Curricular content. Irrelevant subject material, i.e. words that were not featured in the National Curriculum, was removed from summaries to simplify the detection of key words in the text.

Second, a classroom teacher asked a number of suitable questions to the year 3 pupils of Shield Road Primary School. Their responses were analysed and quantified regarding the pupils' knowledge of Physics and Space Sciences.

Third, a structured interview was carried out on the Key Stage 2 classroom teacher; predetermined key questions were asked, with the aim of establishing an academic opinion on the subjects taught on the curriculum and what more can be done to encourage further study.

Finally, an unstructured interview was completed with an Education Officer at the science centre, At-Bristol to gain insight into the current relevant Physics and Astronomy learning tools at the centre and explore the opinions of a professional working in education outside of the classroom.

RESULTS

The current National Curriculum at upper and lower Key stage 2 has 14 compulsory Science modules that are to be covered in the classroom. Five of these modules are based on Physical Processes and Astronomy.

The frequencies of selected key words relating to Astronomy and Physics in the 5 relevant modules are shown in Table 1.

Table 1: Frequencies of key words in Physics and Astronomy in the KS2 National Curriculum

Astronomy:	**Total**
Earth	11
Sun	8
Moon	5
Solar System	5
Planets	4
Space	1

Physics:	**Total**
Light	28
Sound	11
Magnet	16
Force	9
Electricity	7
Gravity	1

Of an overall exhibit total of 164 in At-Bristol, 36 exhibits are directly related to Physics and Astronomy. This is 22% overall. Key words correlating with the Physics and Astronomy subjects covered in the KS2 National Curriculum were searched for in the exhibit texts as an indication of how many are related specifically to the National Curriculum at KS2 (Table 2).

Table 2: Physics and Astronomy key word frequencies in exhibit texts

Astronomy:	**Total**
Earth	22
Sun	9
Moon	2
Solar System	0
Planets	7
Space	20

Physics:	**Total**
Light	41
Sound	31
Magnet	21
Force	9
Electricity	11
Gravity	11

It can be seen that practically all the key words are covered with several occurrences in the exhibit texts.

From the transcript used in the show 'Exploring the Solar System' in the Planetarium of At-Bristol we identified the key words that align with the relevant National Curriculum content (Table 3).

Table 3: Physics and Astronomy key words in the planetarium show

Astronomy:	**Total**
Earth	39
Sun	28
Moon	16
Solar System	21
Planets	21
Space	6

Physics:	**Total**
Light	7
Sound	0
Magnet	0
Force	0
Electricity	0
Gravity	0

Whilst the absence of Physics key words is understandable given the topic of the show, a Chi-Squared test shows that the distribution of words in the National Curriculum relating to Astronomy is not significantly different from that of the planetarium show transcript (Chi-square= 0.95), the P-value of 0.97 suggesting that the two distributions are equivalent.

The KS2 Planetarium show transcript covered 75% of statutory requirement topics that pupils should be taught in the Earth and Space module at upper KS2, including:

- Describing the movement of the Earth and other planets relative to the Sun
- Describing the movement of the Moon relative to the Earth
- The Earth's rotation to explain day and night and the apparent movement of the Sun across the sky

Further, 50% of the non-statutory guided learning topics recommended in the Earth and Space module are also covered in more depth throughout the Planetarium show, including

- That the Sun is a star at the centre of our Solar System and that it has eight planets.
- A moon is a celestial body that orbits a planet (Earth has one, Jupiter has many)
- Pluto is now a dwarf planet

Responses to questions asked by the teacher at Shield Road Primary School to 30 KS2 pupils show that only one third have a knowledge of what Physics is, that two thirds have knowledge on Astronomy and Space that is not taught in school and that all would like to learn more about these topics. Also, two thirds have already had the opportunity to pursue this interest by visiting a Science Centre. (Fig.1).

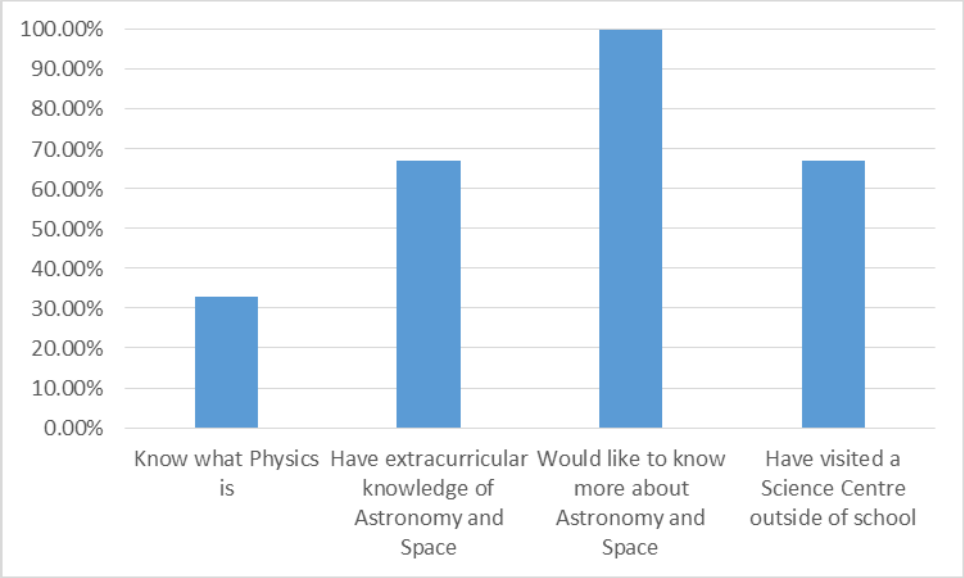

Fig.1: KS2 Pupils' responses to questions asked by the class teacher

The interview of the teacher showed that she and her colleagues agreed that the pupils would benefit from covering more topics in Physics/Space related subjects from a lower age, to give a better basis for the subjects and open up a potential interest even before upper KS2. Regarding interest in subjects that are not necessarily covered on the curriculum, especially in Science subjects such as Physics she pointed out the need for appropriate facilities such as science centres, museums and libraries, as it is sometimes difficult for parents to teach their children Physics based topics outside of the classroom as they are often not educated in these particular subjects themselves. Regarding school trips to At-Bristol and other opportunities to get hands-on with science, feedback was overwhelming and many pupils came out with solid knowledge of subjects they may not have been so confident in before, as well as expressing less of a dislike for subjects they labelled as 'boring' beforehand. So she would largely recommend more use of hands-on learning and encourage more trips.

The Education Officer of At-Bristol pointed out that Science Communication research suggests that if teaching and understanding of Science early in Primary Schools is sufficient then pupils are more likely to study the subject with confidence in later years. Ensuring pupils are getting the correct teaching is key, using Science Centres or other tools is sometimes necessary to support this. Visits to At-Bristol are designed to excite interest and build enthusiasm in Science as well as support learning in school. Many students have the opportunity to ask expert scientists questions that teachers do not cover and may not be able

to answer in schools. It also gives students the chance to experience hands-on learning in laboratories and resources that are limited in schools. At-Bristol also encourages parents of children to come along and get involved with their children so they are able to engage about subjects that they can learn together when they have left the science centre.

DISCUSSION AND CONCLUSIONS

The evidence gathered shows a clear alignment between exhibits and planetarium shows at At-Bristol and the content taught on the Key Stage 2 National Curriculum, and that science centres are indeed perceived by pupils, teachers and science centre educators as an adequate and effective tool in supporting the content taught in school, particularly in difficult subjects such as Physics and Astronomy.

A study published in 2000 explores children's ideas in science. It explains that children, even when very young, draw different scientific conclusions and each have personal ideas and concepts when studying Physics based subjects. The study states 'students approach science in classes with previously acquired notions and these influence what is learnt from new experiences in a number of ways'. The study goes on to explain that students acquire information from several sources including texts and experimentation outside of class. It concludes that using supporting resources is paramount to ensure all levels of students attain a basic knowledge of Physics [9].

The views of the teacher and At-Bristol's Education Officer are consistent with a recent study on primary school children's developments in Astronomy concepts in the Planetarium. The results showed 'significant improvement in knowledge of all areas of apparent celestial motion covered by the planetarium program'. As well as results demonstrating that 'The value of both kinaesthetic learning techniques and the rich visual environment of the planetarium for improved understanding' [10].

This is further supported for example by a longitudinal study entitled 'Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre' [11], which tested 10- and 11-year-old pupils from four schools regarding attitudes toward Science and Space before and after visiting the UK National Space Centre. The report concluded that nearly 20% of the pupils showed an increased desire to become scientists in the future and that immediately after the visit all pupils showed a more positive view on Space and a moderate increase in their views about the value of science in society. It also stated that the pupils that visited the centre 'showed a positive advantage over the other children with regard to science enthusiasm and space interest' and that 'Two months later, they continued to be more positive about being future scientist'. Again evidence shows there is a clear positive change in young children's attitudes toward science subjects when involving interactive and hands on learning spaces.

Although many improvements have been made to the science curricular content overall in recent years, this study suggests there is still a need for the inclusion of more Physics and Astronomy subjects at early primary school level to encourage future study in science based subjects, given that there is interest in such topics in KS2-aged pupils and that resources are available to schools and parents to support the pursuit of this interest.

REFERENCES

1. D. Goodrum, M. Hackling, and L.J. Rennie, (2001). The state of science in Australian secondary schools. Australian Science Teachers' Journal, **47**, 6, 2001
2. R. Millar and J. Osborne, eds.: *Beyond 2000: Science Education for the future*, School of Education, King's College London, London, 1998

3. I. V. S. Mullin, M. O. Martin and P. Foy, *IEA's TIMSS 2003 International Report on Achievement in the Mathematics Cognitive Domains*, TIMSS & PIRLS International Study Center, Boston College, Chestnut Hill, MA, USA, 2005
4. https://www.gov.uk/government/publications/national-curriculum-in-england-primary-curriculum [Accessed 4 April 2015]
5. https://www.at-bristol.org.uk/ [Accessed 2 April 2015]
6. B. Schiele, Science museums and science centres, in: *Handbook of Public Communication of Science and Technology*, eds: M. Bucchi and B. Trench, Routledge, Oxon, 2008
7. E. Şentürk, and Ö. Özdemir, The Effect of Science Centres on Students' Attitudes Towards Science. International Journal of Science Education, Part B. **4**, 1, 2012
8. S. McWhinnie: *Physics Students in UK Higher Education Institutions*, Institute of Physics, London, 2012
9. R. Driver, *Children's Ideas in Science.* Open University Press, Buckingham, UK, 2000
10. J. Plummer, Early elementary students' development of astronomy concepts in the planetarium. Journal of Research in Science Teaching **46**, 192, 2009
11. T. Jarvis and A. Pell, Factors influencing elementary school children's attitudes toward science before, during, and after a visit to the UK National Space Centre. Journal of Research in Science Teaching **42**, 53, 2004