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A Comparison of Dome and Computer Planetaria in the Teaching of Astronomy

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ABSTRACT *The learning of pupils from Years 5 and 6 (9-and 10-year-olds) when taught with the aid of dome and computer planetaria was investigated. The two kinds of planetarium were found to be equally effective, although the learning was confined to female pupils. It is suggested that the use of planetaria might enable females to catch up with males in areas of astronomy which make heavy demands on spatial ability. Substantial learning also took place in the pre-service education students who led the planetaria sessions.*

Introduction

'The Earth and beyond' is included in the science National Curriculum for England and Wales from Key Stage 2 (7–11 years) onwards (Department for Education, 1995). However, astronomy is an area where many pupils and teachers have misconceptions (Preece, 1985; Mant & Summers, 1993; Baxter, 1995) and also where there are fewer opportunities for practical investigations than in many other areas of science (Preece & Clish, 1985; Baxter, 1991). In these circumstances, particularly the impracticability of night-time observation by most pupils, the teaching of astronomy relies heavily on the use of such aids as planispheres, telluria, orreries, and planetaria. In particular, the planetarium has been described as 'the most useful astronomical teaching aid yet conceived' (Seymour, 1985).

A dome planetarium, in which a realistic view of the night sky seen from anywhere on the Earth's surface is projected on to a hemispherical dome, can demonstrate the apparent motions of the Sun, Moon, planets and stars. Although many schools do not have ready access to a large, commercially manufactured, dome planetarium, low-cost versions can be constructed by teachers (Payne, 1984; Stockdale, 1997), and computer planetaria can also demonstrate these movements in the sky on monitor screens.

Mallon and Bruce (1982) compared the effectiveness of a traditional, non-interactive, programme with a participatory programme in a dome planetarium with elementary school pupils, and they reported that the latter, activity-oriented, programme was superior. This points to a possible advantage of computer planetaria: the great potential that computers have for involving pupils actively in their learning

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(Hornung, 1992, Latchem *et al.*, 1993). However, computer planetaria clearly lack the capacity of dome planetaria to show the whole night sky realistically. Accordingly, the investigation reported here is of the relative effectiveness of a dome and a computer planetarium for teaching Key Stage 2 pupils about the apparent motions of the Sun and stars resulting from the rotation of the Earth and from movement of the observer over the Earth's surface.

Sample

Forty-eight Year 5 and 6 pupils (23 males and 25 females) from local primary schools spent a 'science day' in the School of Education engaged in a series of activities, including work with dome and computer planetaria. As well as permitting the research on planetaria, the day enabled pupils to work with science resources not normally available in primary schools. The work with pupils was led by a team of 26 undergraduate science education students, supervised by tutors.

Method

Prior to the work with school pupils, the 26 pre-service science education students were all given the astronomy pre-test and then briefed on the science activities that they would be leading. Eleven students were prepared for the astronomy activities and provided with detailed guidance on the work with either a dome or a computer planetarium. Fifteen students were prepared for the other science-related activities in which the school pupils would be engaged.

At the beginning of the day when the school pupils visited the School of Education, six groups were formed, in effect randomly, each containing about eight pupils, and all pupils completed the pre-test. During the morning, each group worked on three separate science-related activities, spending 1 hour on each. Each group engaged in astronomy work either in the dome planetarium or with computer planetaria. The central aim of these astronomy sessions was to teach pupils about the apparent motions of the Sun and stars in the sky; in particular how these motions result from the rotation of the Earth or from movement of the observer over the Earth's surface. The other science activities were concerned with kitchen chemistry and data logging.

At the beginning of the afternoon all pupil groups completed the astronomy post-test. During the afternoon, short sessions in the dome planetarium were provided for those pupils who had not worked in the planetarium in the morning. Similarly, sessions with the computer planetaria were provided for the pupils who had previously worked in the dome planetarium. These afternoon sessions, which ensured that all pupils encountered both kinds of planetarium, were introduced for ethical reasons.

The pre-service education students also completed the astronomy post-test at the conclusion of the exercise.

Dome Planetarium Sessions

The planetarium, which was constructed on site by D.V. Clish, had a dome of diameter 2 metres and was initially set with Polaris overhead. The function of a planetarium was explained and Polaris identified, using Ursa Major as a guide. The changes in the position of Polaris in the night sky were demonstrated as the location was varied, north and south, from London.

The planetarium motor was started and pupils were asked whether the stars moved relative to each other (by observing Leo, as an example). Sunrise was demonstrated and, keeping the stars visible, pupils were asked if the Sun and stars moved together. Why stars cannot normally be seen during daylight was discussed.

The position of sunrise and the changes in the path of the Sun through the sky at different times of year were demonstrated.

In all cases, questions were used to encourage pupils to make the relevant observations.

Computer Planetaria Sessions

Pupils worked in pairs at a computer, using *Voyager II for the Macintosh* (Carina Software). Voyager was set up with the appropriate date and with only the stars, the Sun and the Moon showing. The function of the program was explained and pupils were shown how to change the observation location and to simulate the effects of the rotation of the Earth.

Tasks were then set which required pupils to find Polaris and to discover the effects of moving north and south from London. Similar tasks were set which required pupils to observe the same effects (relative motion of stars, position of sunrise, path of the Sun, etc.) as demonstrated in the parallel sessions with the dome planetarium.

Astronomy Test

The astronomy test used both as a pre-test and post-test with pupils consisted of 11 questions, mainly concerned with the apparent motion of the stars and the Sun as a result of the rotation of the Earth and with the different appearance of the night sky viewed from different locations on the Earth's surface. The same test was used with the student teachers, except that in the student pre-test one question was omitted by mistake. An example of one of the questions is shown in Fig. 1.

Results

Reliability of Scores

Question analyses were carried out on the pre-test and post-test scores for both the pupils and the student teachers. Using question-total correlations (discrimination coefficients) as the selection criterion enabled scales with satisfactory internal consistency reliability to be constructed from subsets of questions. For the pupils, this yielded a pre-test and a post-test, consisting of the same nine questions, with reliability coefficients (Cronbach's alpha) of 0·66 and 0·63, respectively. For the students, the reliability coefficients for the resulting pre-test consisting of five questions was 0·55. The reliability of the post-test for students, which consisted of six questions (the five in the pre-test plus the extra post-test question), was 0·575. The results reported below for pupils and students are for total scores calculated on these scales.

Pupils

The mean change scores (post-test total minus pre-test total) were calculated for male and female pupils in the dome and computer planetaria groups (see Table I). A two-way analysis of variance of the change scores showed that the group × gender interaction

(2) The diagrams below show photographs of a star taken at the same time on the same day. The star was photographed from three different positions on planet earth In each case the camera was pointing to the north.

Use lines to link each photograph with a position on the earth where you think each photograph was taken.

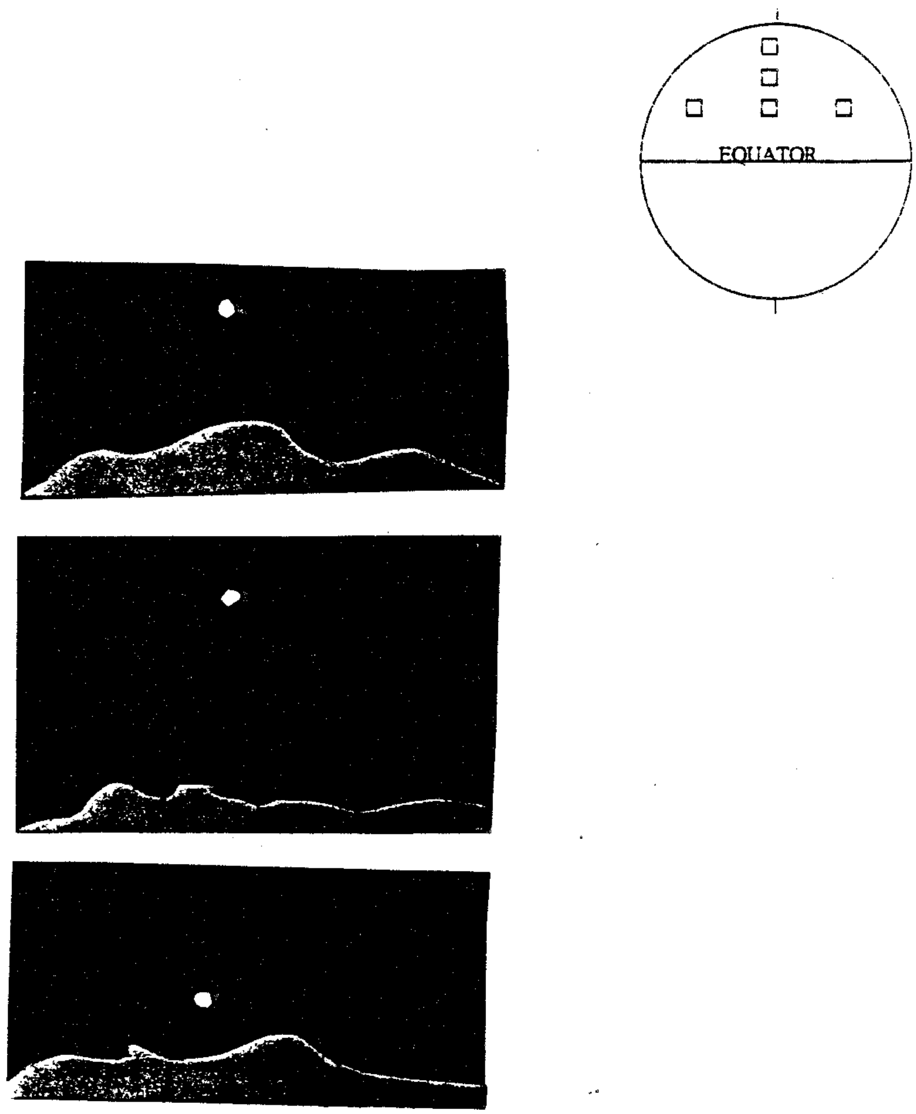

FIG. 1. An example of one question from the astronomy test.

was not significant ($F = 1{\cdot}15$, $df = 1/44$, $p > 0{\cdot}05$). Thus, any gender effect was essentially the same in the two groups or, equivalently, any differences between the dome and computer planetaria intervention effects were essentially the same for both sexes. This permitted main effects to be explored, and overall there was no significant difference between the intervention effects ($F = 0{\cdot}184$, $df = 1/44$, $p > 0{\cdot}05$), but there was a significant gender effect ($F = 9{\cdot}34$, $df = 1/44$, $p < 0{\cdot}01$). An analysis of covariance, with the pre-test score as covariate and the post-test score as the independent variable, yielded essentially the same results.

For both groups, female pupils had higher mean scores on the post-test than on the

TABLE I. Change scores for school pupils on astronomy test

	Male		Female	
	Mean	SD	Mean	SD
Dome planetarium	− 0·50	1·07	1·00	1·11
Computer planetarium	− 0·27	1·49	0·45	1·04

SD, standard deviation.

pre-test, whilst the converse was found for male pupils for whom a small decline in mean scores was recorded. Paired sample *t*-tests indicated that for females the mean post-test score (both groups combined) was significantly higher than the mean pre-test score ($t = 3{\cdot}48$, $df = 24$, $p < 0{\cdot}01$), whereas the pre-test/post-test difference was not significant for males ($t = 1{\cdot}25$, $df = 22$, $p > 0{\cdot}05$). Furthermore, whereas the females had lower mean scores than the males on the pre-test, the reverse was the case for the post-test, although the gender difference in mean scores on the post-test was not significant ($t = 1{\cdot}22$, $df = 46$, $p > 0{\cdot}05$).

Students

Table II gives the mean change scores for the student teachers who led the astronomy sessions with computer and dome planetaria and also for the control group students who led the non-astronomy 'filler' sessions. The mean change score of the astronomy-teaching group was significantly greater than that of the control group ($t = 3{\cdot}12$, $df = 24$, $p < 0{\cdot}005$). Because of the extra question in the student post-test scale, an effect size (d) was calculated by dividing the difference in mean change scores between the astronomy and the control groups by the average of the pre-test and post-test standard deviations for the control group. This gave a value for d of 1·34, indicating a large effect on the students of leading the astronomy sessions (Cohen, 1977).

Discussion

The results obtained for the pupils were unexpected and intriguing. Although no statistically significant differences were found between the effects of dome and computer planetaria on pupil learning, significant gender effects were obtained. The positive effects of the planetaria sessions were confined, on average, to the female pupils. Although the females lagged behind the males on the achievement pre-test, after the intervention they surpassed the males on the post-test. This is potentially particularly important as Bishop (1990) has noted that many studies, including some with astronomy concepts, have found

TABLE II. Change scores for students on astronomy test

Leading astronomy sessions		Leading other sessions	
Mean	SD	Mean	SD
3·00	1·10	1·33	1·45

The post-test contained an additional question.
SD, standard deviation.

gender differences in favour of males in learning material which makes demands on spatial ability, an aptitude in which there is a gender gap in favour of males (Hacker, 1986). Our results suggest that the use of planetaria might enable females to catch up with males in this area which makes such heavy demands on spatial thinking. Although the mean female change score for the dome planetarium group was higher than for the computer planetarium group, the difference was not significant, and this suggests that a computer planetarium could be an effective and readily available alternative to a dome planetarium for most schools. However, in the absence of a delayed post-test, this result must be treated with some caution. In general, the potential of interactions with computer graphics for helping pupils, particularly females, to handle tasks requiring spatial thinking is an area where further research would be worthwhile (see also Hays (1996)).

For the student teachers, the results were, perhaps, less surprising. A large effect on student achievement was obtained as a result of preparing for and leading the planetaria sessions. We suggest that this indicates the value of combining the incentive to learn induced by having to teach a difficult topic with the support and guidance provided by a tutor with appropriate expertise.

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