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# Recollections of Exhibits: Stimulated Recall Interviews With Primary School Children About Science Centre Visits

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**Recollections of Exhibits:  
Stimulated Recall Interviews With Primary School Children  
About Science Centre Visits**

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Running head: Recollections of exhibits

Recollections of Exhibits:

Stimulated Recall Interviews With Primary School Children About Science Centre Visits

For Peer Review Only

## Abstract

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11 One issue of interest to practitioners and researchers in science centres concerns what  
12 meanings visitors are making from their interactions with exhibits and how they make sense  
13 of these experiences. The research reported in this study is an exploratory attempt, therefore,  
14 to investigate this process by using video clips and still photographs of schoolchildren's  
15 interactions with science centre exhibits. These stimuli were used to facilitate reflection about  
16 those interactions in follow-up interviews. The data for this study were 63 small group  
17 interviews with UK primary school children (129 students, ages 9-11). Interviews were  
18 transcribed and then analysed for common themes. The analysis presented here explores how  
19 students explain or interpret particular exhibits and the extent to which they were cognitively  
20 engaged by the process of observing their interactions with exhibits. The findings show that  
21 digital media enable students to revisit their experience and engage them with the content  
22 underlying science centre exhibits. There was, however, little difference between the patterns  
23 of response stimulated by video as opposed to photographs. It seems that such 'revisitations'  
24 of exhibit interactions could serve as a valuable means of developing further students'  
25 scientific concepts and exploiting the value for learning from the experience afforded by  
26 informal contexts.  
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## Recollections of Exhibits:

## Stimulated Recall Interviews With Primary School Children About Science Centre Visits

One issue of interest to both practitioners and researchers in museums and science centres is what meanings visitors are making from their interactions with exhibits and how they make sense of these experiences. Understanding how exhibits<sup>1</sup> are interpreted by visitors could provide guidance for possible improvements and could also highlight ways interactions could be utilised to extend the experience of the visit.

Evidence suggests that interactions with exhibits can have a memorable impact on visitors (Falk et al., 2004; Rennie, 2007; Stevenson, 1991; Tulley & Lucas, 1991). For instance, Stevenson (1991) found that adult and child visitors were able to recall exhibits they had seen or experienced during a science centre visit up to six months after and, in a study conducted by Falk et al. (2004), adult visitors not only remembered the visit itself six months later but could also articulate the impression or impact it had made upon them. Moreover, years of research conducted in science centre settings affirms that visits – whether in family groups or on school trips – are not only remembered but also have the potential to generate both cognitive and affective outcomes (Anderson & Lucas, 1997; Bamberger & Tal, 2007, 2008; Borun et al., 1997; Falk & Dierking, 2000; Hein, 1998; Jarvis & Pell, 2002, 2005; Leinhardt, Crowley, & Knutson, 2002; Orion & Hofstein, 1994). In addition, research has found that such outcomes – particularly cognitive – can be strengthened by reinforcing experiences, such as follow-up activities in the classroom (c.f., Anderson, 1999; Anderson et al., 2000; Farmer & Wott, 1995).

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3 A review of this body of research reflects that much of it has focused traditionally on  
4 learning outcomes (DeWitt & Storksdieck, 2008; Falk & Dierking, 1992; Rahm, 2004), but  
5  
6 more recently, research has also begun to examine more closely the *processes* of meaning  
7  
8 making, with a particular emphasis on conversations that occur during visits (e.g., Ash, 2003;  
9  
10 Leinhardt, Crowley, & Knutson, 2002). However, there still seems to be relatively limited  
11  
12 work exploring visitors' – especially children's – perspective on exhibits, on how they  
13  
14 interpret or explain exhibits and their interactions with them. In one example, Tuckey (1992a)  
15  
16 asked children aged 8 to 11 to explain the function and purpose of exhibits during their visits  
17  
18 to an interactive science centre. She found that they often drew on their previous knowledge  
19  
20 and experience, although the depth and accuracy of their explanations varied considerably.  
21  
22 Questionnaires filled out a week later revealed that older children seemed to have some  
23  
24 degree of understanding about the underlying principles, while younger children tended to  
25  
26 give simpler descriptions of what they had observed (Tuckey, 1992b). However, these data  
27  
28 did not reveal what resources or conceptions they brought to bear on understanding or  
29  
30 interpreting the exhibits and provided only limited insight into the sense students made of the  
31  
32 exhibits. Moreover, this study only investigated children's understanding and memories  
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34 shortly after the visit, leaving open the question about what the longer-term impressions of the  
35  
36 visit might be. Apart from the work of Stevenson (1991) and Falk and his colleagues (2004),  
37  
38 most research exploring how visitors, especially children, interpret or explain interactive  
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40 exhibits has been conducted either during the visit, or shortly after (e.g., Feher & Rice, 1985).  
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50 Nevertheless, the field of research on learning in informal settings is not only  
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52 interested in the sense visitors make of their experiences at the time, but also how their  
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54 interpretations may change over time. Falk and his colleagues (2004) interviewed visitors to a  
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56 science centre immediately following their visit as well as four to six months later. Analysis  
57  
58 of visitors' responses about what they learned from particular exhibits indicated limited  
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3 correlations between short-term and long-term outcomes, suggesting that the impact of the  
4  
5 visit may shift over time.  
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8 The possibility that the impact of a science centre visit, or of exhibit interactions, may  
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10 change over time, as well as ongoing questions about the nature of longer-term impacts of  
11  
12 these experiences, has led us to ask how visitor recollections might be explored in more detail.  
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14 One promising method involves using the technique of stimulated recall in follow-up  
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16 interviews. With this method interviewees, such as museum visitors, are shown photos from a  
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18 setting, such as an exhibition, with the intention of facilitating recall and reflection on the  
19  
20 experience. Such techniques have been used in previous research on learning from visits to  
21  
22 zoos (Tofield et al., 2003) and science centres (Stevenson, 1991). In his research Stevenson  
23  
24 (1991) used photos of exhibits in interviews conducted approximately six months after a visit  
25  
26 to an interactive science centre. This study indicated that stimulated recall techniques were  
27  
28 effective in prompting recall about the experience, though most of visitors' memories were  
29  
30 fairly straightforward accounts of what happened during the exhibit interaction. Memories  
31  
32 indicating further reflection were less frequent.  
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38 However, trips to science centres are busy, active experiences and any still photograph  
39  
40 will fail to capture the dynamic nature of exhibit interactions. Video has a greater capability  
41  
42 than static photographs to capture the range and sequence of actions that occur during  
43  
44 interactions with science centre exhibits. Therefore, stimulated recall techniques using video  
45  
46 may prove more effective than photographs in prompting recall and reflection on these kinds  
47  
48 of experiences. Indeed, video has been found to be effective in encouraging adults and  
49  
50 children to reflect on their interactions with science centre exhibits immediately after the  
51  
52 experience (Falcao & Gilbert, 2005; Stevens & Hall, 1997; Stevens & Martell, 2003). Other  
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54 researchers have used it as a tool to help secondary school students re-visit and reflect on their  
55  
56 learning processes following an amusement park excursion with a physics focus (Anderson &  
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3 Nashon, 2007). However, previous studies of science centre visits that have used video have  
4  
5 not focused on school trips or have worked with only very small numbers of school children,  
6  
7 despite the popularity of science centres as field trip destinations.  
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11 Given this evidence suggesting the potential of video to encourage a 're-engagement'  
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13 with prior experience (Anderson & Nashon, 2007; Falcao & Gilbert, 2005; Stevens & Hall,  
14  
15 1997), the question for us was what potential value did it offer for science centre visits? A  
16  
17 particular focus was whether video might offer more promise in encouraging school children  
18  
19 to reflect on their interactions with exhibits – that is why they did what they did and/or what  
20  
21 they think an exhibit shows – than did the static photos used in previous research (e.g.,  
22  
23 Stevenson, 1991). Such reflections, in turn, may provide valuable insights into the nature of  
24  
25 their experience and into the meanings they are making from their interactions. They may  
26  
27 even provide some insight into the processes by which students make meaning – or the  
28  
29 resources they bring to bear in interpreting exhibits. Consequently, the research reported here  
30  
31 seeks to extend and build on previous work by using video clips of school children's  
32  
33 interactions with selected science centre exhibits to facilitate their reflection about those  
34  
35 interactions in follow-up interviews – an approach which has not been used elsewhere, other  
36  
37 than in a very small pilot study (Falcao & Gilbert, 2005) and then only immediately after a  
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39 visit. Insight into students' meaning making about exhibits may also potentially highlight new  
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41 ways to reinforce and enhance learning from these experiences.  
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49 It should be noted that the questions explored in this research focus first and foremost  
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51 on students' cognitive engagement with exhibits and how they make meaning of their  
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53 experiences. More specifically, this paper will attempt to explore how students explain or  
54  
55 interpret particular exhibits and the extent to which they draw on or elaborate concepts in the  
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57 process. This is not to say that there are not social and affective dimensions to their exhibit  
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59 interactions and their science centre trip – elements of which are reported here. However, the  
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3 primary focus of this work was on the potential of video to encourage reflection and cognitive  
4  
5 engagement, as this seems to offer more possibilities of supporting and extending conceptual  
6  
7 learning afforded by the children's interactions with science centre exhibits.  
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#### 10 Research Design and Data Collection

11  
12 In order to explore how they interpreted their experiences, video recordings and still  
13  
14 photographs were taken of students interacting with selected exhibits during their school trips  
15  
16 to a science centre in the United Kingdom, and these photos and video were later used as  
17  
18 stimuli to prompt their recall in interviews. The science centre was housed in a dedicated  
19  
20 modern, purpose-built building and contained a wide range of exhibits typical of many  
21  
22 science centres. The 'target' exhibits included in this study were ones which the researchers  
23  
24 could be reasonably certain the students would visit and also permitted filming (i.e., were  
25  
26 sufficiently well-lit). Most school trips to this science centre are focused on particular themes  
27  
28 (e.g., Forces), which connect to topics in the National Curriculum for England and Wales.  
29  
30 During their visits, students are given a paper-based worksheet or 'trail' of five thematically-  
31  
32 related exhibits to explore while they are on the exhibit floor, and the 'target' exhibits (where  
33  
34 filming took place) were selected from this trail. However, the order in which they visit the  
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36 exhibits and their timing was under the control of the students, and students had ample time to  
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38 visit exhibits not on the trail.  
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46 Students from upper primary classes (ages 9-11) from five schools participated in the  
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48 research, representing a convenience sample of schools already scheduled to visit this centre.  
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50 This was not seen as a limitation as the basic design of this study was exploratory – an  
51  
52 attempt to investigate the potential value of such a methodological approach<sup>2</sup>. Exploring new  
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54 methods is important, as one of the challenges facing the field is to establish good methods for  
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56 collecting valid and reliable data about what happens during visits to science centres and  
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58 possible learning outcomes (Osborne & Dillon, 2007). All five schools were publicly-funded  
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3 and located in suburban areas or small towns. All students for whom consent had been  
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5 obtained, which was the majority of students in each class, were interviewed following their  
6  
7 trips. The interviews were conducted at the schools, using both video clips and still  
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9 photographs as a prompt to reflection. Both types of stimuli were included to test the  
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11 possibility that the dynamic medium of video would be more effective than static photographs  
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13 at stimulating recall and cognitive activation.  
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17 Students were interviewed in pairs or groups of three because it was felt that they were  
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19 likely to be more comfortable being interviewed with a peer than on their own and that the  
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21 opportunity for peer interaction may stimulate more extensive discourse and elaborated recall.  
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23 In addition, this research takes a sociocultural perspective on learning, which holds that  
24  
25 knowledge is constructed via discourse, in interactions among individuals (Wells, 1999; Wells  
26  
27 & Claxton, 2002), and the actions of the individual, the social environment and their  
28  
29 interaction all form an inseparable whole. Interviewing students in pairs or threes facilitated  
30  
31 social interactions within the context of the interview which, in turn, might have helped  
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33 students to mutually reconstruct their knowledge and potentially stimulated more extensive  
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35 recall of their visit. Or, to put it another way, the context of the interview replicated the  
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37 context of the visit where students explored exhibits predominantly with their peers and  
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39 possibly enhanced their recall of that experience.  
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46 The pairs (or groups of three) in the interviews consisted of peers who had explored  
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48 the exhibits together. In total, 129 students from the five schools participated in 63 interviews,  
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50 in which they were shown a combination of video clips and still photographs of themselves at  
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52 the target exhibits. As shown below, the target exhibits varied with the theme of the visit. In  
53  
54 most interviews, students would see a photograph (or photographs) taken at one target exhibit  
55  
56 and a video clip (or clips) recorded at another. If there were three target exhibits for that class,  
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58 the stimulus for the third could be of either type. Occasionally, students saw only video clips  
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3 or photographs, depending upon what had been recorded during their visit, which was  
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5 sometimes limited by technical difficulties with the equipment. However, attempts were made  
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7 to balance roughly whether photos or videos were shown for each exhibit across interviews.  
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9 The details of the sample, the theme (or focus) of the visit, and the timing of the interviews  
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11 are summarised in Table 1.  
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17 --- Insert Table 1 about here ---  
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22 The interview protocols used were developed to explore the cognitive and affective  
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24 elements of students' interactions with the exhibits, as well as the visit overall. To gain initial  
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26 insight into students' perspectives on their exhibit interactions, they were first asked questions  
27  
28 about what was happening in the clip or photo and how the exhibit 'worked'. To explore  
29  
30 cognitive learning outcomes more specifically, students were also asked to discuss what they  
31  
32 learned from the experience and what they thought the purpose of the exhibit was (e.g., 'What  
33  
34 do you think this exhibit is trying to show you?'). The interviews also addressed affective  
35  
36 outcomes, using questions about whether or not students had enjoyed each exhibit they were  
37  
38 shown (in a photo or video) and why. Students were not restricted to discussing solely the  
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40 'target' exhibits, and during the course of their interviews most students referred to additional  
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42 exhibits (which did not appear in a video or photo) they had interacted with during their visits.  
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44 Finally, students were asked to rate how interesting they had found the visit overall and to  
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46 justify these ratings. [The interview protocol is available from the authors.](#)  
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53 The qualitative and essentially exploratory nature of this study permitted a degree of  
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55 flexibility in its design. As Table 1 shows, the participating classes did not have the same  
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57 'target' exhibits – these varied depending on the theme of the visit. (A description of the  
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59 exhibits is found in Appendix 1.) Such a design had the added advantage of allowing the visits  
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3 to be experienced with a minimum of disruption, in that students were not asked to do  
4  
5 anything different from what they would have done normally. Students from two schools  
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7 were interviewed the week following their visit, but those from the remaining three were  
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9 interviewed ten to twelve weeks later (after an intervening summer holiday) in order to  
10  
11 explore possible differences in recall and reflection over different time periods.  
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15 It should also be noted that teachers reported undertaking minimal preparation and no  
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17 specific follow up to these visits. Given this, it is also unlikely that students were encouraged  
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19 to discuss or reflect upon the visit prior to the interviews, with the possible exception of  
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21 students from Chestnut School, whose visit had the 'Living in Space' theme (or focus) and  
22  
23 occurred at the beginning of a short classroom unit about space.  
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#### 26 27 Coding and Analysis

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29 All interviews with students were transcribed, and a coding schema was developed  
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31 and refined in an iterative process, in which categories emerged from the data (Lincoln &  
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33 Guba, 1985). An extensive coding schema was utilised, although the current discussion  
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35 focuses primarily on findings corresponding to the cognitive dimension of students'  
36  
37 responses. 'Cognitive' codes ranged from statements about how the exhibits functioned, to  
38  
39 descriptions of the phenomena that were observed, to their understanding of the underlying  
40  
41 scientific principles that the exhibits demonstrated. Further sets of codes were developed in  
42  
43 order to capture the affective dimensions of students' interactions with exhibits and responses  
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45 to the visit overall. Affective codes were generally used to categorise students' reasons for  
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47 considering exhibits as enjoyable, fun or interesting, such as the fact that an exhibit was  
48  
49 challenging or allowed for hands-on interaction. [A list of all code definitions is available from](#)  
50  
51 [the authors](#). In addition, transcripts were also coded to indicate whether students were  
52  
53 referring to a photo or a video at any given point, so that any differences in their responses  
54  
55 based on the type of stimulus could be noted.  
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3 The transcripts themselves were coded using the NVIVO software package, which  
4 permits a picture of the frequency of code use to emerge. However, while it is of interest to  
5 explore what kinds of statements students seemed to be making most frequently when  
6 describing their interactions with exhibits, the analyses also note whether particular codes,  
7 such as ‘science conception’, appeared at all in the interview.  
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## 15 Findings

### 17 *Eliciting Cognitive Response*

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19 The codes used to capture the cognitive dimension of students’ reflections, or their  
20 cognitive engagement with the content of the video or photo and with the phenomena  
21 displayed by these stimuli, were:  
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- 26 • exhibit appearance (visual descriptions of exhibit appearance or ‘what it looks like’),
  - 27 • student action (students’ physical interactions with an exhibit),
  - 28 • observed phenomenon (phenomena that were demonstrated or ‘what happened’),
  - 29 • fact (discrete factual statement, generally a property or process),
  - 30 • exhibit-focused fact (similar to ‘fact’ but more closely tied to the exhibit),
  - 31 • causal (causal explanation),
  - 32 • science skill (e.g. comparing, classifying) and
  - 33 • science conception (attempts to use understanding of scientific concept).
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46 A Piagetian analysis would suggest that the order of the scheme represents, roughly,  
47 increasing levels of abstraction from that which students could observe visually and  
48 experience physically at the exhibit towards more cognitive engagement or reflection on the  
49 underlying content of the exhibit. Table 2 summarises the frequency with which these codes  
50 were applied to students’ interview transcripts.  
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--- Insert Table 2 about here ---

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6 Because the codes could be applied to statements of varying length (and because of  
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8 the semi-structured nature of the interviews, in which students talked to varying degrees),  
9  
10 statistical analyses of the data are inappropriate. Nevertheless, frequency counts of the data do  
11  
12 provide the broad features of their post-hoc reflection. It would seem that the majority of  
13  
14 statements made by students when discussing their interactions with exhibits and what they  
15  
16 found out from those experiences were fairly straightforward descriptions of the exhibits'  
17  
18 appearance or observable features (*exhibit appearance*), of what they did physically with the  
19  
20 exhibits (*student action*) and, especially, of the phenomena that were observed (*observed*  
21  
22 *phenomenon*). In addition, this pattern generally held whether video clips or still photographs  
23  
24 were used as stimuli (Table 3) and whether interviews were conducted shortly after the visit  
25  
26 or following an interval of 10-12 weeks (Table 4).  
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34 --- Insert Table 3 about here ---  
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39 --- Insert Table 4 about here ---  
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43 Thus, as the two samples are similar in the general pattern of codes they produce,  
44  
45 further discussion of these findings will draw on all student interviews as the data source in  
46  
47 the sections that follow. It is also inappropriate to make a statistical comparison of the number  
48  
49 of comments made by students when looking at photos as compared to video clips, as the  
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51 length of the video clips varied, and students sometimes saw more than a single photo of  
52  
53 themselves at an exhibit.  
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3 We now turn to discuss the major features emerging from this aspect of the coding,  
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5 namely statements about what was readily perceptible, statements that indicated further  
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7 cognitive engagement, and statements utilising students' prior knowledge.  
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10 *Readily Perceptible.* As can be observed from the tables, comments about what  
11  
12 exhibits looked like (coded *exhibit appearance*) were one of the most frequent kinds of  
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14 statements and included descriptions such as: 'There's four of those balls' (*Chestnut School,*  
15  
16 *Orbits*) and 'There's this big triangle thing and the air' (*Sugaroak School, Bernoulli Blower*).  
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18 (For a description of exhibits, please see Appendix 1.)  
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21

22 While the above statements simply named what could be noticed visually about the  
23  
24 exhibit itself, other statements (coded *student action*) described what students did physically  
25  
26 in interacting with an exhibit – effectively, how to make it 'work'. Examples include: 'You  
27  
28 pull a rope, yeah' (*Leaf School, Heave Ho*) and 'We've taken it in turns to spin the thing and  
29  
30 then we was pressing the button' (*Redwood School, Hydrogen Rocket*).  
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34 Although the above two types of statements (*exhibit appearance* and *student action*)  
35  
36 were made quite often by students when discussing exhibits, statements in which students  
37  
38 described what they had observed at the exhibit – or what had 'happened' (coded *observed*  
39  
40 *phenomenon*) – tended to appear most frequently in the transcripts, regardless of the type of  
41  
42 stimuli used (photo or video), the exhibit being described and whether the interview occurred  
43  
44 shortly after the visit or weeks later. In addition, such statements appeared at least once – and  
45  
46 generally considerably more often – in every interview conducted. Typical examples were:  
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52 It floats and goes up and down with your hands. It's like you're pushing it,  
53  
54 but without touching it. *Sugaroak School, Bernoulli Blower*  
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3 It (the cork) shot up nearly all the way to the top and then came back down.

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5 *Chestnut School, Hydrogen Rocket*

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10 It went for ages. It started doing the circles, and then as it slowed down it  
11  
12 began doing the 8 shape. *Redwood School, Orbits*

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17 When you get it started it goes quite fast, and then when you try and stop  
18  
19 it, it's really hard. *Sugaroak School, Kugel*

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23  
24 While such statements are fairly straightforward descriptions of what happened at the  
25  
26 exhibits, the fact that it was such features that were recalled indicates that students are going  
27  
28 beyond a simple ontological description of its elements and can recall a sequence of events,  
29  
30 some of which were not actually visible in the stimuli on which they were commenting.  
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34 *Further Cognitive Engagement.* Despite the perceptual nature of most of the  
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36 statements students made when discussing their interactions with exhibits, some students did  
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38 spontaneously make statements that seemed to be further removed from what was  
39  
40 immediately perceptible. For instance, when asked what he would tell a friend that an exhibit  
41  
42 is 'showing', one student replied, 'That air can hold quite light balls in one sort of place'  
43  
44 (*Sugaroak School, Bernoulli Blower*). Our view is that this sentence is more generalised in  
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46 that it describes what air can do – this student having arrived at some sort of conclusion about  
47  
48 a property of air, rather than simply stating what he observed while interacting with the  
49  
50 exhibit.  
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55 In response to a similar question about what he had learned at Orbits, a student from  
56  
57 another school responded, 'Balls can't go in holes when it's all bendy' (*Chestnut School*).  
58  
59 Whilst such a statement contributes little to understanding the concept and idea underlying the  
60



1  
2  
3 exhibit, it does demonstrate an attempt to construct a generalised explanation and to go  
4  
5 beyond the phenomenon itself. Speaking about the Bubble Race exhibit, another student  
6  
7 explained that he found out that 'Air bubbles move faster through thinner liquids than thicker  
8  
9 liquids' (*Leaf School, Bubble Race*). And similar types of statements were made about other  
10  
11 exhibits, such as: 'Different pulleys can make it easier or harder to pull up six kilograms'  
12  
13 (*Leaf School, Heave Ho*) and 'Water can make things easier to push' (*Sugaroak School,*  
14  
15 *Kugel*).  
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19  
20 The above statements suggest that students were attempting to extract the underlying  
21  
22 properties or characteristics of balls and surfaces, of air bubbles and liquids, and of pulleys  
23  
24 and water. In all cases, this is a process that requires the ability to see beyond the descriptive  
25  
26 and a willingness to construct models of physical systems – features which suggest a greater  
27  
28 degree of cognitive engagement and reflection on their experience than just descriptive  
29  
30 accounts of what the exhibit is or what it does. As Table 5 shows, statements coded as *Fact* or  
31  
32 *Exhibit-focused fact*, while certainly less frequent than descriptions of the phenomena that  
33  
34 were observed, appeared at least once in 90% (57 of 63) of the interviews, suggesting that  
35  
36 stimulated recall techniques can prompt this greater level of generalisation or distance from  
37  
38 what is immediately perceptible. That such statements were elicited also highlights the  
39  
40 importance of scaffolding in order to make the most of these types of experiences. Unless  
41  
42 students are scaffolded to transcend the simple ontological questions of what the exhibit is or  
43  
44 what it does, to ask the causal question of how it works or the more general question of what  
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46 it shows, it is doubtful if the full educational experience of the interaction – and the visit –  
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48 will be exploited.  
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--- Insert Table 5 about here ---

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3 Cognitive engagement with what can be observed at an exhibit is also suggested by  
4 statements in which students attempted to provide a *causal explanation* for what they see. For  
5 instance, one student noted that the Kugel (a big granite ball resting on a thin film of water)  
6 was very hard to stop once it was spinning. In describing what happened, he explained that it  
7 was the water making it hard to stop 'because it's slippery.' (*Sugaroak School*). A classmate  
8 explained the same phenomenon by saying, 'You couldn't stop it because the water was  
9 underneath and still pushing it' (*Sugaroak School*).  
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20 Thus, revisiting the experience in an interview has stimulated the construction of an  
21 explanation, albeit scientifically incorrect. Likewise, students from another school tried to  
22 explain why one of the bags in Heave Ho felt heavier:  
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29 S1: That one's easiest.

30 S2: Because it has more pulley-things. (*Leaf School*)  
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36 While the above statement does not articulate *how* pulleys make something more  
37 difficult or easier to pull, it does indicate an attempt to describe the cause of what was  
38 observed. Other students provided more detailed causal explanations of observed phenomena,  
39 although these were not always correct. In the following excerpt, a student attempted to  
40 explain why the cork goes up in the Hydrogen Rocket exhibit:  
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50 I think it's like air pressure. And as it builds up inside that chamber then  
51 it... it kind of sucks up all the air pressure. And then it lets it out into the  
52 rocket shaped thing, and then that pushes up a cork and makes it go up.  
53  
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57 (*Redwood School*)  
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3 A student from another school provided a different, also incorrect, explanation: 'Water  
4 – it got bubbles into it a bit and they pushed it – and it would go really higher' (*Chestnut*  
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6  
7  
8  
9 *School*).

10 Although statements such as these were not as frequent as the observations  
11 themselves, that 12% of cognitive statements did reflect attempts to provide some sort of  
12 causal explanation for an observed phenomenon would seem to be noteworthy. The  
13 appearance of such statements shows the potential that re-visiting exhibit interactions afford  
14 as a means of encouraging students to think more deeply about what has been observed and to  
15 begin to construct explanatory models – something which is central to the nature of science  
16 itself. Moreover, students made this kind of statement in 94% (59 of 63) of interviews and  
17 such statements occurred in the context of interviews which primarily attempted to elicit what  
18 students might remember about their science centre visits. It remains an open question how  
19 much better teaching and learning experiences which attempted specifically to exploit the  
20 potential of such nascent memories for learning science might be.  
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36 *Using Prior Knowledge.* Finally, some students not only tried to provide causal  
37 explanations for what they observed, but went a stage further by attempting to bring their  
38 existing science conceptions or understandings to bear as they tried to interpret, explain, or  
39 make sense of interactive exhibits. For instance, in describing what the Bernoulli Blower was  
40 attempting to show, one student explained, 'It's, like, overpowering, well, it's not  
41 overpowering gravity, but it equals gravity. So, it's the up-thrust, it was gravity, so it lets it  
42 float.' He then went on to state: 'You can equal, like, the force of gravity with another force –  
43 usually you can't just make a ball float in the air' (*Leaf School*). This student did have some  
44 difficulty in articulating his interpretation of the exhibit (which is not entirely accurate).  
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60 Nevertheless, he attempted to apply the scientific concepts of force and gravity (or his  
understanding of them) as he tried to explain what he had observed.

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3 Another student also referred to gravity as she attempted to explain Heave Ho: 'I think  
4 probably what I learnt from it was that it was probably showing us that probably the heavier a  
5 thing is, the greater gravity pulls down on it' (*Leaf School*). In this case the student missed the  
6 point of the exhibit and may not have noticed the pulleys at all. However, she had noticed that  
7 different bags seemed to weigh different amounts (in that some were easier or harder to lift)  
8 and attempted to draw upon a familiar science concept she connected with weight – gravity.  
9 Later statements reflected that her understanding of gravity was not as sophisticated or  
10 accurate as the above comment might suggest, but the important point here is that it  
11 demonstrates an attempt to utilise her science knowledge to explain what she has observed.  
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24 In describing what they learned from their interactions with the exhibit Kugel, students  
25 from another school also referred to science concepts:  
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31 S1: Trying to stop it, it's like friction with the water and the ball in your  
32 hands.  
33

34 S2: It's like water pressure a bit, but not. Well, you're trying to push it  
35 and the water's moving it... making you not, cos it's getting  
36 slippery. (*Sugaroak School*)  
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46 The second comment, in particular, illustrates the student drawing on his  
47 understanding of a range of science concepts, as he struggled to find the term that would  
48 adequately explain what he had observed.  
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52 In another instance, two students refer to gravity, as well as thrust, in attempting to  
53 explain Hydrogen Rocket:  
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57 S1: It's like the rocket going up in space.  
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3 S2: Yeah, because when it goes up, it's really hard because you need all  
4  
5 them rocket fuel and all that to burn and the thrust to push it up.  
6  
7

8 S1: Because the thrust pushes the rocket up. And when it gets up...

9  
10 S2: Well, it sucks it down again.  
11

12 S1: Yeah, because of the gravity. (*Chestnut School*)  
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18 Although such statements did not appear frequently in the transcripts, that they  
19  
20 occurred at all is of interest because they highlight the way in which students were attempting  
21  
22 to make sense of their experiences in the visit by drawing on their existing understanding of  
23  
24 scientific concepts. That these '*science conception*' statements appeared at least once in 83%  
25  
26 (52 of 63) of the interviews again indicates the potential of utilising stimulated recall in  
27  
28 interviews to encourage reflection on underlying science principles. From a constructivist  
29  
30 perspective (Hein, 1995; Osborne & Wittrock, 1985), such a finding is also not surprising as it  
31  
32 illustrates children attempting to make sense of the unfamiliar in terms of their pre-existing  
33  
34 concepts. It also reinforces the importance of science centres utilising students' common  
35  
36 conceptual frameworks – that is, the ideas they are likely to be familiar with from school and  
37  
38 everyday life – as a starting point from which they can help students develop their knowledge  
39  
40 and understanding from their visit experiences.  
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46 We do not suggest that students would have spontaneously reflected on these exhibits,  
47  
48 either during the visit or subsequently, nor that they would utilise their existing science  
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50 understandings without being prompted. Nevertheless, the interviews do provide evidence,  
51  
52 consistent with previous research (e.g., Stevens & Hall, 1997; Stevens & Martell, 2003) that  
53  
54 interactions with science centre exhibits can provide opportunities for reflection and deeper  
55  
56 engagement with science concepts and processes after the visit itself, even after considerable  
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58 delay. Such reflection and engagement can serve as building blocks for the development of  
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3 future understandings. Moreover, that using video (or photos) to re-visit these experiences  
4  
5 following a school trip can be cognitively demanding suggests that there is educational value  
6  
7 to incorporating such media in follow-up activities, a practice that teachers may find relatively  
8  
9 easy to implement, given how many take photos or even video during school trips (Kisiel,  
10  
11 2006).  
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14  
15 *Students' Views of the Function and Purpose of Exhibits.* The interview data not only  
16  
17 provided evidence of the way in which re-visiting their exhibit interactions could engage  
18  
19 students with underlying science content, but also showed that students seemed to view the  
20  
21 visit as a 'learning experience' – they were often able to articulate answers to questions about  
22  
23 what they thought particular exhibits were supposed to show. Their interpretations were not  
24  
25 always correct, indeed rarely so, but students clearly seemed to appreciate – and expect – that  
26  
27 the exhibits they encountered had a purpose, generally related to science. For instance, when  
28  
29 asked about the purpose of Hydrogen Rocket, students responded:  
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36 S1: It's to show how high it can go.

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38 S2: It's showing the power and the electricity and mixing the liquids, so like  
39  
40 science, all part of science. (*Chestnut School*)  
41  
42  
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46 That students did connect these experiences with learning science is not only reflected  
47  
48 by the purposes they ascribed to the exhibits and their attempts to utilise existing science  
49  
50 understandings to interpret observed phenomena, but is also suggested by their frequent use of  
51  
52 science terminology (such as *gravity*, *friction*, and *pressure*). Nearly all students used such  
53  
54 terms as they talked about exhibits they had encountered during their visits, with these terms  
55  
56 appearing in 87% of interviews. Some students, albeit fewer, even described how they used  
57  
58 science skills – such as fair testing – in their exhibit interactions. For instance, in discussing  
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3 what he had done at the Bubble Race exhibit, one student said, 'But to make it a fair test, you  
4 have to wait until they [bubbles] were all equal at the bottom' (*Leaf School, Bubble Race*).

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8 Another reported, 'I did a big spin. And I did it twice to make the test fair. Because, like, if  
9 you did it once and you didn't exactly get the right answer, do it again to make it get the right  
10 answer, if it is the right answer' (*Leaf School, Bubble Race*).

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15 Nevertheless, although students at various times used scientific terminology, referred  
16 to science process skills and drew upon their prior science knowledge in the interviews, they  
17 rarely made connections explicitly to what they had learned in school.

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21  
22 *Stimulus Type and Interview Timing.* As Table 3 reflects, the patterns of statements  
23 students made when discussing their interactions with exhibits were broadly similar, with a  
24 predominance of observational statements, whether presented with a photograph or a video as  
25 a stimulus for recall. These general patterns were also found regardless of when the interview  
26 was conducted (Table 4). That is, most statements were descriptions of aspects of the exhibit  
27 itself, what students did with it or the phenomena that could be observed. However, some  
28 students were able to speak more generally about properties, and could provide causal  
29 explanations for some of the phenomena they observed, sometimes even utilising their  
30 existing science understandings in doing so. What is of interest is that this overall pattern  
31 seemed to hold regardless of stimulus type or of the timing of the interview. Why might this  
32 be? Is it possible that 3 months, even with an intervening summer holiday, was simply not  
33 long enough for differences to appear? Or is it a fact that the dynamic nature of the video  
34 makes little difference as a stimulus to recall when one is able to recall the whole episode and  
35 mentally replay it in the mind? If so, it would suggest that the impact of the visit had been  
36 significant, creating a memory that was sustained even several months after the visit – and a  
37 memory which only required a small prompt to bring it to the fore again.

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3 Although the general patterns of statements reflecting the cognitive dimension of the  
4 visit were similar across stimulus type and interview timing, students seemed to refer to their  
5 conversations with other students more often when looking at a video rather than a photo.  
6  
7 This could be because the element that videos do capture is the dynamic interaction between  
8 students and the exhibit where conversation is often central. Hence the video may stimulate  
9 recall of conversation which a still photograph may fail to do. However, it should be noted  
10 that the sound was not of particularly high quality and students' comments did not always  
11 directly refer to talk heard in the recording.  
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22 *Differences Among Exhibits?* The distribution of the types of statements was also  
23 generally consistent across the various types of exhibits in this study. Table 6 reflects that in  
24 discussing any exhibit students tended to describe the phenomena that they observed. They  
25 provided more generalised comments and causal explanations less frequently, but such  
26 statements – as well as those in which existing science knowledge was brought to bear – were  
27 made in reference to all six exhibits used in this research.  
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43 --- Insert Table 6 about here ---  
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55 One difference worth mentioning is that, when discussing the Bubble Race exhibit,  
56 there were fewer instances of students bringing science concepts to bear, but they often  
57 referred to the science process skill of fair testing. The nature of the exhibit – with a clear  
58 comparison to be made and an intuitive way to repeat the test or comparison – seems likely to  
59 have contributed to this difference.  
60

The only other difference found in the data is that a smaller proportion of students' cognitive statements for Orbits were causal explanations, compared with cognitive statements they were making about the other exhibits. That the exhibit failed to stimulate causal



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2  
3 explanation may also be why students frequently described Orbits as 'just a game'. This  
4  
5 would suggest that it is erroneous to think that exhibits can speak for themselves with minimal  
6  
7 or no interpretation. Indeed many science centre exhibits are accompanied by either no or  
8  
9 very limited explanatory text. In addition, centres are often not able to provide sufficient staff  
10  
11 to facilitate interactions with exhibits. Visitors are often simply left to construct, for  
12  
13 themselves, an explanation. The result is an emphasis on the phenomenon as opposed to the  
14  
15 explanatory theory it illustrates. Yet it is theories of science that are the 'crowning glory of  
16  
17 science' (Harré, 1984). While it can be debated as to whether increasing visitors'  
18  
19 understanding of canonical theoretical explanations of phenomena is an appropriate or  
20  
21 reasonable goal for science centre visits, the data from this research reinforce that the goal of  
22  
23 supporting any development of science concepts is unlikely to be achieved without  
24  
25 scaffolding, either during or after the visit.  
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### 30 31 *The Visit as an Affective Experience*

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34 While the findings described above suggest that the visit was memorable and offered  
35  
36 potential as a building block on which further understanding could be scaffolded, the trips  
37  
38 were also positive, enjoyable experiences for the students. When asked to rate how interesting  
39  
40 they had found the visit, 83% (107 students) ranked it as 'very interesting' and 15% (20  
41  
42 students) as 'interesting'. (The remaining two students claimed it was 'neither interesting nor  
43  
44 boring'). Similar patterns were seen whether students were interviewed shortly after the visit  
45  
46 or later, although a greater proportion of students considered it to be 'very interesting'  
47  
48 immediately after the visit (90%) compared with those who were interviewed 10-12 weeks  
49  
50 later (76%). Although the reason for this difference is unclear, it may be that after more time  
51  
52 had elapsed, the memory had faded somewhat and muted the students' recollection of how  
53  
54 interesting the trip had been.  
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3 Students were also asked to justify their ratings, and gave a variety of reasons. Some  
4  
5 students found their visit to be interesting because it offered multiple opportunities for  
6  
7 exploration and interaction with exhibits. According to one, 'I never knew you could do so  
8  
9 much stuff there, and do experiments and stuff' (*Leaf School*). Others considered it to have  
10  
11 been very interesting because they felt they had learned something. For instance, one student  
12  
13 claimed, 'You learnt loads of things on the different exhibitions' (*Chestnut School*).  
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15

16  
17 Some students went further, describing the experience as something that had  
18  
19 combined both fun and learning. For example, 'It was interesting because you're having fun  
20  
21 and still learning science at the same time. So I quite liked it' (*Leaf School*).  
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23

24  
25 Students also frequently contrasted their experience of the visit with school,  
26  
27 particularly their experience of science in school.  
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31 S1: Cos we went to Technquest it's kind of changed the way we think about  
32  
33 science.  
34

35  
36 S2: So then, so next time we do about air, we're going to think 'Oh I remember  
37  
38 from Technquest we did that.'  
39

40  
41 S1: But then it will seem boring because we'll have memories of Technquest  
42  
43 being really fun, and then you go into the lesson and you're like, 'Oh this  
44  
45 is really boring.' (*Sugaroak School*)  
46  
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50 It makes science fun and that doesn't usually happen a lot. Because at  
51  
52 school everybody thinks science is boring, but it's not there. (*Redwood*  
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60  
*School*)

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62 In addition to providing reasons why they had found the visit to be interesting,  
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64 students were also asked to select which exhibit they had found to be most fun and which had  
65  
66

1  
2  
3 been most interesting for them and why. Although no one exhibit was chosen consistently, the  
4  
5 reasons students gave for choosing the exhibits they had were quite consistent. Students  
6  
7 frequently found exhibits to be fun or interesting because they allowed hands-on interaction.  
8  
9  
10 As one put it, 'They're all interesting 'cos you pull on one and then the other one you like  
11  
12 chuck it in the air and it floats. That one you've got to spin it around' (*Sugaroak School,*  
13  
14 *about Heave Ho, Bernoulli Blower and Kugel, respectively*). Similarly, another said, 'We  
15  
16 were, like, turning the handle...' (*Maple School, Hydrogen Rocket*).

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20 Students also spoke positively of exhibits which offered multiple opportunities for  
21  
22 exploration or interaction. For instance, the Kugel was liked because 'you have loads of  
23  
24 different ways and then you just spin it in loads of ways' (*Sugaroak School*)

25  
26  
27 What this suggests is that the opportunity to manipulate the material world remains a  
28  
29 key point of engagement for individuals – particularly in a society where such opportunities  
30  
31 are diminishing (Greenfield, 2009; Tapscott, 2009). When manipulating an exhibit, students  
32  
33 have an identifiable goal of comprehending how it works and possibly, as well, the  
34  
35 explanatory rules that govern its behaviour. Thus the exhibit poses a challenge permitting the  
36  
37 visitor to become engaged. In addition, interactive exhibits offer a sense of control –  
38  
39 something which the normal formal educational experience rarely affords (Paris, 1998).  
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44 Not surprisingly then, exhibits which did not seem interactive or controllable to  
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46 students were perceived as less fun or interesting. One student remarked, 'That one, you can't  
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48 touch the water inside' (*Maple School, Hydrogen Rocket*). Likewise, those that offered only  
49  
50 limited possibilities for exploration were viewed negatively: 'The rocket one, all you do is  
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52 turn the handle' (*Maple School, Hydrogen Rocket*).

53  
54  
55 However, a feature of exhibits that did engage many of the students was that they  
56  
57 offered an opportunity to collaborate with others. A different student praised the same exhibit  
58  
59 by saying, 'You had to help each other and everything' (*Redwood School, Hydrogen Rocket*).  
60

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3 In addition, the novelty of exhibits would also seem to contribute to engagement as  
4 students were intrigued by, or enjoyed, exhibits that were novel or contrasted with their  
5 previous experiences. In the words of one student, 'But with the blower one I found really  
6 interesting because I've never seen something like that' (*Leaf School, Bernoulli Blower*).  
7  
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11 Although novelty can detract from learning (Anderson & Lucas, 1997; Falk & Balling, 1982;  
12 Falk, Martin, & Balling, 1978), statements such as the previous suggest that novelty can also  
13 make experiences memorable.  
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19 Many students recounted the phenomenon that could be observed at an exhibit as  
20 justification for selecting it as fun or interesting, implying that the phenomenon itself was  
21 somehow of intrinsic interest (for reasons not entirely clear), while some students would go  
22 further to explain that its value lay in the fact that they had found out or learned something: 'It  
23 was very fun finding out that it [the bubble] would move faster through the oil' (*Leaf School,*  
24 *Bubble Race*). Some students also stated that they appreciated exhibits which were perceived  
25 as cognitively challenging: 'It's like a puzzle, which was quite hard' (*Sugaroak School,*  
26 *Kugel*). Thus, these data suggest that some, and possibly all, students would value a visit  
27 which, whilst permitting 'hands-on' manipulation, would also offer them the opportunity to  
28 learn.  
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44 Notably, however, students' perceptions of which exhibits were most fun or  
45 interesting varied and no distinctive pattern of engagement emerged. That is, one student may  
46 have preferred a particular exhibit because it offered an opportunity to learn, while another  
47 might have found it fun because it offered multiple opportunities for exploration. And yet  
48 another student may have disliked the same exhibit because she found it offered a limited  
49 repertoire of activities. Centres which offer a wider diversity of exhibits and potential  
50 activities are, therefore, more likely to engage a wider set of young students.  
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## Discussion

Looking across types of stimuli (photos and video), interview timing (shortly after the science centre visit or weeks later) and exhibit types, the interview data suggest that their visits provided highly memorable experiences for students. The way they interpreted or described the stimuli frequently went beyond what was observable in the photo or video. Students' statements ranged from fairly elaborate descriptions of the observable phenomena at the exhibits, to more generalised and even causal explanations of these phenomena or the science that students believed underlay the phenomena. Moreover, the data also demonstrate that these interactions with exhibits were positive, enjoyable, often social experiences for the students, and experiences from which they expected to learn.

Indeed, such an expectation may partially account for why students attempted to use their understandings of science to explain the exhibits. For, if they believed the trip to the science centre had to do with 'learning science', it is perhaps not surprising that students concluded that the exhibits themselves were meant to demonstrate something about science, and consequently, attempted to apply their understanding of science in interpreting their observations. Such expectations also reinforce recommendations made by researchers (e.g., Griffin & Symington, 1997) that teachers should emphasise to students that a visit to a science centre does have to do with learning science and that they should expect exhibits to demonstrate science concepts and principles.

That students participating in this research also found the experience of visiting a science centre to be enjoyable means that such visits provide an opportunity which can be exploited by teachers for student learning. Put differently, that a visit is so memorable, engaging, enjoyable and considered to be connected to science highlights the opportunities afforded by 're-visiting' the experience to build students' science knowledge. However, although students often tried to bring their science understandings to bear in interpreting the

exhibits, they were often incorrect, confused or inappropriate. Hence, such opportunities will only really be exploited by providing an occasion after the visit to reflect and re-engage with the phenomenon when their understanding can be developed and scaffolded.

For instance, the following conversation occurred between two students (and the interviewer) while looking at a photograph of themselves at the Heave Ho exhibit:

I: So, what can you tell me about that one and what you were doing with it?

S1: They're all the same. It's weird cos I think they're all the same kilograms, but they all feel heavier.

I: Mmm. So they feel...

S2: They're different.

I: Yeah. They feel different.

S1: Maybe it's because, like, you've tried one which is the lightest, then you go on to another and pull it again and lift your arms.

S2: Well, it might be something to do with the actual thing

S1: The rope's heavier.

S2: There are those things that you can pull engines up easy.

S1: Yeah, and the rope might have been heavier to pull and, like

S2: It might've been a longer rope and it might have been a bit more heavier. (*Sugaroak School*)

In the above excerpt it is apparent that the students noticed that the sensation of lifting the sacks suggested that they contained different weights, although they were labelled with the same weight. They offer two explanations of what they have observed – one concerning muscle fatigue and the other the weight of the rope. The second student also notices the

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3 pulleys ('these things that you can pull engines up easy'). Unless student thinking is then  
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5 challenged, it is unlikely that their scientific understanding will be developed further. In this  
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7 case, the salient feature is that the ease of lifting is correlated with the number of pulleys.  
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9  
10 Once this factor has been identified as the significant observation, the issue becomes one of  
11  
12 how the numbers of pulleys account for the observed difference in heaviness among the sacks.  
13  
14

### 15 Conclusions and Implications

16  
17 In summary, the data from this exploratory study suggest that students were  
18  
19 cognitively and affectively engaged by the process of reflecting on their interactions with  
20  
21 science centre visits. From a cognitive standpoint, most of the students' statements were  
22  
23 descriptive. However, their comments did extend to attempts to provide causal explanations  
24  
25 and to use their science understandings to explain the phenomena they observed. In the  
26  
27 interviews students also reflected on the affective dimension of their visit, discussing what  
28  
29 made particular exhibits – and the visit as a whole – fun and interesting. Perhaps not  
30  
31 surprisingly, such factors included students' perceptions that exhibits were interactive or  
32  
33 hands-on, were novel, offered multiple opportunities for exploration, allowed collaboration  
34  
35 and combined fun and learning.  
36  
37  
38  
39

40  
41 It is important to recall that these reflections on the visit did not occur in a vacuum.  
42  
43 They were stimulated by the photos and video clips and were elicited by interviewer  
44  
45 questions. Thus, the findings would seem to highlight the role of mediation in encouraging  
46  
47 these kinds of reflections which may, in turn, help students get the most out of their  
48  
49 interactions with exhibits as it is such mediation that may help scaffold students' developing  
50  
51 understandings of science concepts.  
52  
53

54  
55 It can be challenging to provide such mediation during a science centre visit.  
56  
57 Anecdotally, the visits which formed part of the current research were not unlike what Paris  
58  
59 (1998) describes:  
60



1  
2  
3 Most of them raced from one exhibit to the next, spending less time than a minute at  
4  
5 most and less than 20 seconds at many. They turned handles, pushed buttons, pulled  
6  
7 ropes, and sped to the next exhibit. Their motivation displayed free choice but their  
8  
9 behavior seemed directed at 'making things happen' or, at best, understanding *how* to  
10  
11 make each exhibit work rather than *why* it operated as it did. Some may call this a  
12  
13 performance goal; others may call it a procedural, as opposed to conceptual orientation  
14  
15 to exhibits. Still others might say it is an expected response pattern when you turn loose  
16  
17 a class of students with limited time to see many interesting exhibits. Regardless of the  
18  
19 reason, all three factors diverted children's motivation from understanding, and  
20  
21 exploring, and learning about the exhibits (p.23).  
22  
23  
24  
25  
26

27         Such behaviour is likely to be attributable, at least in part, to the novelty of the setting.  
28  
29 A challenge for science centres is to balance the varying impacts of novelty. While science  
30  
31 centres often want to maximise the (cognitive) learning potential of visits, this is unlikely to  
32  
33 occur if students fail to go beyond the experience of simply sampling one exhibit after  
34  
35 another. Many centres also want to support the affective engagement elicited by the novelty of  
36  
37 the experience. Mediation, we would contend, is essential to achieving this balance. Whilst  
38  
39 students need to experience the excitement of freely exploring novel exhibits, they also need  
40  
41 help to identify the salient features of those exhibits. Undoubtedly, mediation can occur  
42  
43 during the visit and some students' statements reflected this possibility:  
44  
45  
46  
47  
48  
49  
50

51                 When you have people with you, you can talk about what weights are  
52  
53 which. And when you just go on your own, you just pick it up and drop it,  
54  
55 then pick it up and drop it and then there's no one to say 'What did you  
56  
57 find out about it?' (*Sugaroak School, Heave Ho*)  
58  
59  
60



1  
2  
3 She [the teacher] was asking the question of which one would be travelling  
4  
5 the fastest and she was saying that, well, the motor oil was, cos it's a lot  
6  
7 thicker liquid, that the bubble would travel slower. (*Leaf School, Bubble*  
8  
9 *Race*)  
10  
11

12  
13 Without the direction given by the teacher in the statement above, students may easily  
14  
15 miss the important scientific and technological aspects illustrated by the exhibit. Nevertheless,  
16  
17 an important implication of this study is that such mediation can *also* occur away from the  
18  
19 exhibit itself, when viewing video recorded at the exhibit. That this should be the case is not  
20  
21 surprising, given previous research which used video recordings to stimulate visitors'  
22  
23 reflection in informal learning environments (Stevens & Hall, 1997; Stevens & Martell,  
24  
25 2003). This study is significant, however, in showing the kinds of reflection that can be  
26  
27 prompted by such stimuli away from the science centre, even months after the visit.  
28  
29

30  
31 Photographs and video thus offer a means by which can students can engage with both the  
32  
33 content and processes underlying exhibits in a way that could support or scaffold the further  
34  
35 development of science concepts, particularly when mediated by a teacher. Moreover, in  
36  
37 discussing video clips and photos, students may make their interpretations and understandings  
38  
39 more explicit – and as such, these reflections can in turn be used as a tool to construct  
40  
41 meaning from their experience.  
42  
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45

46  
47 To extend the learning potential of the visit, science centres could even make clips of  
48  
49 exhibit interactions available on their web sites. Alternatively, modern mobile phones permit  
50  
51 students to readily collect short clips of phenomena or exhibits they consider significant, and  
52  
53 many clips are publically available on YouTube. Informal conversations with teachers whose  
54  
55 classes participated in the current study indicated that such clips (even of other individuals)  
56  
57 would be a welcome and useful classroom resource to use either as an advance organiser to  
58  
59 help point out key features to observe or as a prompt to further discussion after the visit. The  
60

1  
2  
3 data from the interviews conducted for this study indicate the kind of discussion that such  
4  
5 stimuli can generate. Moreover, photographs or video will enable students to re-visit a  
6  
7 positive experience, as well as supporting the kind of engagement and reflection useful in  
8  
9 building further science concepts. Such actions could, in turn, help maximise the potential of  
10  
11 science centre visits for learning. If the boundary between learning in formal and informal  
12  
13 contexts is to be dissolved, it is essential for museum educators and teachers to make use of  
14  
15 such media which will enable the value of the experience offered by the science centres and  
16  
17 experiences outside the classroom to be exploited as an educational resource for learning  
18  
19 inside the classroom. The findings of this study have, we hope, suggested one step to  
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21 achieving this goal.  
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## References

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51  
52  
53  
54  
55  
56  
57  
58  
59  
60
- Anderson, D. (1999). *The development of science concepts emergent from science museum and post-visit activity experiences: Students' construction of knowledge*. Unpublished Ph.D., Queensland University of Technology, Brisbane, Australia.
- Anderson, D., & Lucas, K. B. (1997). The effectiveness of orienting students to the physical features of a science museum prior to visitation. *Research in Science Education*, 27(4), 485-495.
- Anderson, D., Lucas, K. B., Ginns, I. S., & Dierking, L. D. (2000). Development of knowledge about electricity and magnetism during a visit to a science museum and related post-visit activities. *Science Education*, 84, 658-679.
- Anderson, D., & Nashon, S. (2007). Predators of knowledge construction: Interpreting students' metacognition in an amusement park physics program. *Science Education*, 91(2), 298-320.
- Ash, D. (2003). Dialogic inquiry in life science conversations of family groups in a museum. *Journal of Research in Science Teaching*, 40(2), 138-162.
- Bamberger, Y., & Tal, T. (2007). The long term effect of a class visit to a science center. *Paper presented at the 2007 annual meeting of the National Association for Research in Science Teaching. New Orleans, Louisiana.*
- Bamberger, Y., & Tal, R. (2008). Multiple outcomes of class visits to natural history museums: The students' view. *Journal of Science Education and Technology*, 17(3), 274-284.
- Borun, M., Chambers, M. B., Dritsas, J., & Johnson, J. I. (1997). Enhancing family learning through exhibits. *Curator*, 40(4), 279-295.
- DeWitt, J. (2008). What is this exhibit showing you? Insights from stimulated recall interviews with primary school children. *Journal of Museum Education*, 33(2), 165-174.

- 1  
2  
3 DeWitt, J., & Storksdieck, M. (2008). A short review of school field trips: Key findings from  
4  
5 the past and implications for the future. *Visitor Studies*, 11(2), 181-197.  
6  
7  
8 Falcao, D., & Gilbert, J. (2005). The stimulated recall method: A research tool applicable to  
9  
10 learning at science museums. *Hist. cienc. saude-Manguinhos*, 12 (suppl), 93-115.  
11  
12 Falk, J. H., & Balling, J. D. (1982). The field trip milieu: Learning and behavior as a function  
13  
14 of contextual events. *Journal of Educational Research*, 76(1), 22-28.  
15  
16  
17 Falk, J. H., & Dierking, L. D. (1992). *The Museum Experience*. Washington, D.C.:  
18  
19 Whalesback Books.  
20  
21  
22 Falk, J. H., & Dierking, L. D. (2000). *Learning from museums: Visitor experiences and the*  
23  
24 *making of meaning*. Walnut Creek: AltaMira Press.  
25  
26  
27 Falk, J. H., Martin, W. W., & Balling, J. D. (1978). The novel field-trip phenomenon:  
28  
29 Adjustment to novel settings interferes with task learning. *Journal of Research in Science*  
30  
31 *Teaching*, 15(2), 127-134.  
32  
33  
34 Falk, J. H., Scott, C., Dierking, L., Rennie, L., & Cohen Jones, M. (2004). Interactives and  
35  
36 visitor learning. *Curator*, 47(2), 171-198.  
37  
38  
39 Farmer, A. J., & Wott, J. A. (1995). Field trips and follow-up activities: Fourth graders in a  
40  
41 public garden. *Journal of Environmental Education*, 27(1), 33-35.  
42  
43  
44 Feher, E., & Rice, K. (1985). Development of scientific concepts through the use of  
45  
46 interactive exhibits in a museum. *Curator*, 28(1), 35-46.  
47  
48  
49 Greenfield, P. M. (2009). Technology and Informal Education: What Is Taught, What Is Learned.  
50  
51 *Science*, 323(5910), 69-71.  
52  
53  
54 Griffin, J., & Symington, D. (1997). Moving from task-oriented to learning-oriented strategies  
55  
56 on school excursions to museums. *Science Education*, 81(6), 763-779.  
57  
58  
59 Harré, R. (1984). *The Philosophies of Science: An introductory Survey* (2nd ed.). Oxford:  
60  
Oxford University Press.

- 1  
2  
3 Hein, G. (1995). The Constructivist Museum. *Journal of Education in Museums*, 20-23.  
4  
5  
6 Hein, G. E. (1998). *Learning in the museum*. London: Routledge.  
7  
8 Jarvis, T., & Pell, A. (2002). Effect of the Challenger experience on children's attitudes to  
9  
10 science. *Journal of Research in Science Teaching*, 39(10), 979-1000.  
11  
12 Jarvis, T., & Pell, A. (2005). Factors influencing elementary school children's attitudes toward  
13  
14 science before, during, and after a visit to the UK National Space Centre. *Journal of Research*  
15  
16 *in Science Teaching*, 42(1), 53-83.  
17  
18  
19 Kisiel, J. (2006). An examination of fieldtrip strategies and their implementation within a  
20  
21 natural history museum. *Science Education*, 90(3), 434-452.  
22  
23  
24 Leinhardt, G., Crowley, K., & Knutson, K. (Eds.) (2002). *Learning conversations in*  
25  
26 *museums*. Mahwah, NJ: Lawrence Erlbaum Associates.  
27  
28  
29 Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. London: Sage Publications.  
30  
31 Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip  
32  
33 in a natural environment. *Journal of Research in Science Teaching*, 31(10), 1097-1119.  
34  
35  
36 Osborne, J., & Dillon, J. (2007). Research on learning in informal contexts: Advancing the  
37  
38 field? *International Journal of Science Education*, 29 (12), 1441-1445.  
39  
40  
41 Osborne, R. J., & Wittrock, M. (1985). The Generative Learning Model and its Implications  
42  
43 for Science Education. *Studies in Science Education*, 12, 59-87.  
44  
45  
46 Paris, S. G. (1998). Situated Motivation and Informal Learning. *Journal of Museum*  
47  
48 *Education*, 22,(2 & 3), 22-26.  
49  
50  
51 Rahm, J. (2004). Multiple modes of meaning-making in a science center. *Science Education*,  
52  
53 88, 223-247.  
54  
55  
56 Rennie, L. J. (2007). Learning science outside of school. In S. K. Abell & N. G. Lederman  
57  
58 (Eds.), *Handbook of research on science education* (pp. XX-YY??). Mahwah, NJ: Lawrence  
59  
60 Erlbaum Associates.

- 1  
2  
3 Stevens, R., & Hall, R. (1997). Seeing Tornado: How video traces mediate visitor  
4 understandings of (natural?) phenomena in a science museum. *Science Education*, 81(6), 735-  
5 747.  
6  
7  
8  
9  
10 Stevens, R., & Martell, S. T. (2003). Leaving a trace: Supporting museum visitor interaction  
11 and interpretation with digital media annotation systems. *Journal of Museum Education*,  
12 28(2), 25-31.  
13  
14  
15  
16  
17 Stevenson, J. (1991). The long-term impact of interactive exhibits. *International Journal of*  
18 *Science Education*, 13(5), 521-531.  
19  
20  
21  
22 Tapscott, D. (2009). *grown up digital: how the net generation is changing your world*. New York:  
23 McGraw Hill.  
24  
25  
26  
27 Tofield, S., Coll, R. K., Vyle, B., & Bolstad, R. (2003). Zoos as a source of free choice  
28 learning. *Research in Science and Technological Education*, 21(1), 67-99.  
29  
30  
31 Tuckey, C. (1992a). Children's informal learning at an interactive science centre.  
32 *International Journal of Science Education*, 14(3), 273-278.  
33  
34  
35  
36 Tuckey, C. (1992b). Schoolchildren's reactions to an interactive science center. *Curator*,  
37 35(1), 28-38.  
38  
39  
40  
41 Tulley, A., & Lucas, A. M. (1991). Interacting with a science museum exhibit: Vicarious and  
42 direct experience and subsequent understanding. *International Journal of Science Education*,  
43 13(5), 533-542.  
44  
45  
46  
47  
48 Wells, G. (1999). *Dialogic inquiry: Toward a sociocultural practice and theory of education*.  
49 Cambridge: Cambridge University Press.  
50  
51  
52  
53 Wells, G., & Claxton, G. (Eds.). (2002). *Learning for life in the 21st century*. Cambridge:  
54 Blackwell Publishers.  
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## Appendix 1: Exhibits

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7 **Bernoulli Blower:** A stream of air is blown at an upwards angle out of a pyramid-shaped  
8  
9 base. The air flows over the top of a beach ball, creating lift and causing the beach ball to float  
10  
11 or hover in mid-air. (The ball must initially be held in the air stream and then released, in  
12  
13 order for the effect to be seen.)  
14

15  
16 **Bubble Race:** A wheel approximately three feet in diameter contains five tubes, each with a  
17  
18 different-coloured liquid. The wheel is mounted against a wall and can be rotated or spun.  
19  
20 When spun, air bubbles travel through the liquid from the bottom to the top of the tubes, with  
21  
22 their speed dependent on the viscosity of the liquid (water, motor oil, bubble bath, etc).  
23  
24

25  
26 **Heave Ho:** Three sacks of identical weight (6 kg) are suspended with rope from a metal  
27  
28 frame, but each rope is held by varying numbers of pulleys (one, two, or three) at the top. The  
29  
30 sacks are opaque, and each has '6 kg' printed on one side. Depending on the number of  
31  
32 pulleys, each sack is easier or more difficult to lift, when the rope is pulled. The exhibit is  
33  
34 intended to demonstrate the mechanical advantage afforded by varying numbers of pulleys.  
35  
36

37  
38 **Hydrogen Rocket:** Visitors spin a handle, causing gases to mix inside of a clear container.  
39  
40 Consequently, a small explosion (produced by the gases and accompanied by a 'pop') powers  
41  
42 a cork up a line, after which it falls back to its starting point.  
43  
44

45  
46 **Kugel:** A large granite ball, weighing one half ton, is covered in water, which enables it to be  
47  
48 rotated (when pushed) on a cement base.

49  
50 **Orbits:** Four golf ball-size balls can be spun or thrown across a surface. The exhibit itself has  
51  
52 an oval shape, but the surface slopes towards two holes. The shape of the surface causes each  
53  
54 ball to travel in a figure-8 shape, until eventually it spins around a single hole and drops in.  
55  
56  
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## Footnotes

<sup>1</sup>In this paper the term ‘exhibit’ is used to refer to a single interactive.

<sup>2</sup>A much shorter description of this work based on a few initial analyses of a subset of the data and some of the insights emerging have previously appeared in DeWitt (2008)

For Peer Review Only



Recollections of exhibits 1

Table 1

*Information about classes and visits*

School	Year group	No. students	Visit theme	Target exhibits	Interview timing
Leaf	Year 6 (age 10-11)	41 (19 interviews)	Investigate	Bernoulli Blower	Following week
				Heave Ho	
				Bubble Race	
Redwood	Year 6	17 (8 interviews)	Living in Space	Orbits	Following week
				Hydrogen Rocket	
Chestnut	Year 5 (age 9-10)	25 (13 interviews)	Living in Space	Orbits	10-12 weeks later
				Hydrogen Rocket	
Maple*	Year 5	6 (3 interviews)	Living in Space	Orbits	10-12 weeks later
				Hydrogen Rocket	
Sugaroak	Year 5	40 (20 interviews)	Forces	Bernoulli Blower	10-12 weeks later
				Heave Ho	
				Kugel	

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2  
3 \*Only six students from this school visited the science centre when scheduled, due to a last-minute change in scheduling for most of the students  
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6 in the class (involving a sports day).  
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For Peer Review Only

Table 2

*Types of student statements (all interviews)*

Code	Frequency of use
Exhibit appearance	17% (390 statements)
Student action	18% (418)
Observed phenomenon	31% (720)
Fact	5% (116)
Exhibit-focused fact	7% (157)
Causal	12% (275)
Science skill	3% (79)
Science conception	7% (163)

Table 3

*Types of statements made by stimulus type*

Code	Video clip	Still photograph
Exhibit appearance	16% (176)	15% (121 statements)
Student action	18% (202)	20% (163)
Observed phenomenon	30% (326)	30% (240)
Fact	4% (40)	5% (38)
Exhibit-focused fact	7% (79)	7% (57)
Causal	13% (133)	13% (104)
Science skill	4% (47)	3% (25)
Science conception	8% (82)	7% (58)

N.B., The number of statements represented in this table is smaller than in Table 4. This is because Tables 2 and 4 reflect all of students' statements receiving a cognitive code, including those not made in response to any stimulus (photo or video).

Table 4

*Types of statements by timing of interview*

Code	Shortly after visit	Delayed
Exhibit appearance	13% (102)	19% (288)
Student action	16% (127)	19% (291)
Observed phenomenon	29% (228)	32% (492)
Fact	8% (63)	4% (53)
Exhibit-focused fact	6% (44)	7% (113)
Causal	14% (105)	12% (170)
Science skill	5% (38)	3% (41)
Science conception	10% (77)	6% (86)

Table 5

*Interviews in which types of statements appeared at least once*

Code	Interviews
Exhibit appearance	95% (60 of 63 interviews)
Student action	100% (63)
Observed phenomenon	100% (63)
Fact	68% (43)
Exhibit-focused fact	76% (48)
Fact AND/OR exhibit-focused fact	90% (57)
Causal	94% (59)
Science skill	54% (34)
Science conception	83% (52)

Table 6

*Types of statements by exhibit type*

Code	Bernoulli Blower	Bubble Race	Heave Ho	Kugel	Orbits	Hydrogen Rocket
Exhibit appearance	8%	11%	21%	18%	13%	20%
Student action	15%	16%	18%	20%	22%	20%
Observed phenomenon	33%	22%	24%	31%	38%	28%
Fact	6%	13%	6%	3%	3%	2%
Exhibit-focused fact	7%	15%	5%	8%	7%	7%
Causal	17%	13%	12%	12%	8%	13%
Science skill	4%	8%	6%	1%	2%	3%
Science conception	10%	2%	8%	7%	8%	8%
Total number of statements	426	134	342	302	320	486