# THE IMPORTANCE OF NATURAL EXHIBITS IN STUDENTS' LEARNING: A CASE STUDY IN ATTITUDES TO THE USE OF SCHOOL AND MUSEUM COLLECTIONS

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# Acknowledgements

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# The Importance of Natural Exhibits in Students' Learning: A Case Study in Attitudes to the use of School and Museum Collections

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***Abstract:***

*This work is a case study which builds on similar research previously carried out at the same school. It focuses on the use of real objects to enhance student learning within the formal school curriculum. A number of teaching activities are described which draw on the literature concerning informal learning in museums, where constructivist teaching with the help of individual objects and collections is commonplace. These activities form the basis of research into the attitudes of students and staff concerning the use of objects and displays in school teaching. The main points of interest are: the perceptions of pupils at key stages three and four regarding the frequency with which displays are used, their learning value and their enjoyment value; teacher perceptions regarding the use of displays; and the practicality of using objects as everyday teaching tools. As is common in case studies, a variety of research instruments were used and the results analysed using both quantitative and qualitative methods as appropriate. The research reveals that natural exhibits are indeed seen by both teachers and pupils to contribute informally to student learning and motivation, although there is a tension between this and the formal school curriculum, which tends to be content-driven due to pressures of the testing regime. This results in pupils perceiving displays to be infrequently used and, therefore, not fulfilling their potential as learning tools. Possible ways of overcoming this problem are discussed and a number of other practical issues raised during the course of this study are also addressed.*

# Chapter 1: Introduction

## The Rationale behind this Study

*"All of us are born with an interest in the world about us. Watch a human baby or any other young animal crawling about. It is investigating and learning things with all its senses of sight, hearing, taste, touch and smell. From the moment we are born we are explorers in a complex and fascinating world. With some people this may fade with time or with the pressures of life, but others are lucky enough to keep this interest stimulated throughout their lives."* (Durrell, 1982, on becoming a naturalist)

This research is designed to examine the use of hands-on resources in everyday teaching with the aim of harnessing and keeping alive within school pupils the innate interest to which Durrell (1982) refers in the quote above. It builds on earlier PGDES research into the use of classroom displays (Noone, 2004) which had been premised on the belief, advocated by Holt (1983) among others, that all children are adept at learning about the world around them, though not necessarily through the formal school context. This was coupled with my personal ideas as a biologist about the importance of wildlife conservation. Writers like Attenborough (2002) had pointed out that the most effective way to spread the conservation message was simply to make people more aware of the natural world and its many wonders, so I decided to harness the innate curiosity of students by creating a wide variety of displays with wildlife and conservation as their central themes. These included colourful posters **(1*)**, "Fact-of-the-Week" **(2)** and other stimulus displays, display cabinets **(3, 4)** full of stuffed specimens, shells, minerals and rocks, several tanks of animal life **(5, 6)** and a wide variety of plants **(7)**.

To assess the educational impact of these displays, and also to identify areas for further improvement, year 8 and 10 students were given questionnaires followed by interviews. An unexpected finding was that, as well as being enthusiastic about the use of displays to informally find out about wildlife and conservation, students indicated they would like to use the examination and interpretation of displays as part of their regular learning. This view is supported by the literature: whereas successive governments have regarded classroom displays as unimportant *"administration"* (DfES, 2003), constructivist researchers like Cooper *et al.* (1996) recognise the value to students not

* For ease of reference bracketed numbers in bold font will refer to pictures in Appendix I throughout this report.

only of making displays but also of using existing ones to stimulate enquiry. Gardner's theory of multiple intelligences (Gardner, 1999) would similarly suggest that the variety provided by the study of real objects, etc. is beneficial. It seems therefore that there is much scope for researching the use of displays and collections as learning tools in the everyday curriculum.

By the summer of 2004, the room in which the aforementioned displays were housed, Lab 5, was becoming increasingly congested and so I decided to acquire four new display cabinets to allow better presentation of the various specimens and, in time, rotation of themed exhibits. These were in place for the start of term in September 2004 and several members of staff pointed out at this time that the room was beginning to resemble a small museum. This led me to think it might be useful to examine what ideas if any could be successfully adopted from educational practice in museums, not least because there is a dearth of literature dealing with wall displays in the secondary school (Noone, 2004).

However, as is explained at the end of Noone (2004), I had originally intended to study mixed-ability for this MSc. The reasons for reverting back to classroom displays in December 2004 were manifold. Firstly my PGDES research was reasonably successful and had given me many ideas and indeed some firm plans for using displays as *active* learning tools in everyday curriculum delivery (they had previously been used to enable pupils to *informally* acquire largely extra-curricular information about wildlife and conservation). By the end of September 2004 some of these ideas were already being put into action (some are even mentioned as footnotes in Noone (2004)). Moreover, my work the previous year had stimulated such interest within the school that, during the first term, pupils and staff were bringing in useful objects (many of them living!) on an almost weekly basis. A third consideration was that of time, something which is at a premium in schools, as is shown by the government's workload agreement (DfES, 2003). Most of the displays I was planning in my mind did not involve simply sticking up student work but, rather, necessitated significant input on the part of teacher that went beyond the "wallpaper" which displays have all to often been dismissed as, according to Cooper *et al.* (1996) among others. As the year progressed the amount of time that would be needed to do this was becoming increasingly apparent and, as Hammersley (1993) points out, there are many other skills that teachers need to keep on top of besides inquiry skills. Finally, as with previous years, I knew I would be running a Wildlife Elective in the summer term, with funding that would enable me to buy resources which students could then set up and maintain within the Science Department. This combination of factors proved too strong to resist!

An advantage of this research is that both the literature on classroom displays (e.g. Cooper *et al.*, 1996) and museums (e.g. Hein, 1998) are based around a constructivist framework, so many of the ideas present in them will be relevant to current school practice. The Sc1 Attainment Target of the Science National Curriculum (DfEE/QCA, 1999b), with its emphasis on active learning, for example, is heavily reliant on constructivist thinking. This is also the case with the new 21$^{st}$ Century Science Curriculum (Millar and Osborne, 1998) and the Cognitive Acceleration in Science Education (CASE) project (Adey *et al.*, 2001), both of which are being introduced within my department over the coming year.

As well as being of interest to me, and comparable to the above-mentioned initiatives, studying the use of displays and collections in education is also important for my school, which already has strong links with the Oxford University Museum of Natural History, the County Museum and Begbroke Science Park. The increasing variety and size of the collections in Lab 5, developed over three years, mean that there is now much scope for their use by other members of staff in the science department and elsewhere, rather than just being confined to one room where only a minority of students benefit from them. I felt that a deeper understanding of how to use collections as a teaching tool would enable me to help staff borrowing these resources to use them to maximum effect as teaching tools. Indeed many staff who visited Lab 5 to teach certain lessons had already expressed a desire to know how their pupils' interest in the displays could be channelled productively so that it is not merely a distraction. The school's strategy of disseminating best practice will also mean that there is scope for helping other departments with similar resources.

# Chapter 2: The Literature Review

The literature on museum learning is extensive. Much of it is concerned with the history and philosophy of museum education (e.g. Pedretti, 2002; Rennie and McClafferty, 1996; Rennie and Stocklmayer, 2003), neither of which are directly relevant to this study. Equally a large quantity of references on the subject concern contexts vastly different from the science classroom. The interpretation of artwork in galleries or taking into account the points of view of many different cultures, for example, are both important topics, but not ones that are relevant here. Similarly, references relating mainly to management issues within the museum (e.g. Moffat and Woollard, 1999) are beyond the scope of this report. For these reasons, careful selection of the literature was necessary.

The first part of this review reports on the findings of Lock (1996) and Elliott (2000), two papers that add to Noone (2004), on which this study builds. The remainder of the chapter then looks at how museums use real objects as learning tools and what schools can learn from them. Here, I first examine whether or not there are any fundamental differences between the way people learn in museums and in schools by considering the literature on formal and informal learning. This section is followed by a discussion of the educational theories common to museums and schools in which I also critique current practices in the latter. In the final part of this literature review I get down to practicalities and examine in detail those aspects of constructivist museum practice which seem most directly transferable to the context of my science department. These include teaching with objects, the use of displays, using exhibit labels and using worksheets. For each of these, a description is given of how museums use them, their pros and cons are assessed and I speculate how they might be used in the classroom with reference to similar teaching activities that have already been tried in my lab and which are described more fully Chapter 4.

## 2.1: Lock (1996) and Elliott (2000) on Classroom Displays

Early in the literature search, while looking for references on museum displays, two papers on classroom displays (Lock, 1996; Elliott, 2000) were found which had been overlooked during my PGDES research (Noone, 2004). As noted in the latter there is a dearth of literature relating to the area of classroom displays. Capel *et al.* (2001) in their

465 page volume devote just over a page to it and with no reference to other literature. Cohen and Manion (1989) and Kyriacou (1998) acknowledge the fact that displays exist, but say little else. References that deal exclusively with the issue of classroom display are few and far between and many of those that do are simply "how to" guides with little or no reasoned discussion of the various techniques they espouse. Skaggs (1993), for example, simply describes 65 *"tried and tested bulletin board ideas"*. Moreover, both Lock (1996) and Elliott (2000) focussed on secondary education, whereas virtually all the literature previously examined related to the primary classroom.

Why though, the reader might ask, am I proposing to review a display-related paper here when my MSc research focus has moved on? There are two reasons. Firstly, my PGDES research arose out of personal interest in and enjoyment of the use of displays in my classroom – this hasn't changed and so I am naturally curious to examine any literature on the subject that is new to me. Secondly, the fact that my MSc builds on previous PGDES work means that any extra information relating to the latter can also, indirectly, inform current research. Lock (1996) and Elliott (2000) are useful reference points against which my previous work can be judged, although I will only review the latter here as Lock's paper is simply a list of interesting ideas presented in a "how to" fashion.

Elliott (2000) gives us a wide ranging examination of the visual environment in which secondary science is taught and starts his paper with a necessarily brief overview of the literature on classroom display. In a similar manner to Noone (2004) he points out that most of the secondary school literature gives scant attention to classroom *displays*, dealing instead with the physical and emotional factors associated with the classroom *environment*. He then goes on to mention the literature on primary classroom display. In common with Noone (2004) he quotes the work of Greenstreet (1985), Cooper *et al.* (1996) and Jackson (1993) but omits Phelps (1969) and Corbin (1970). Perhaps a conscious decision to ignore older literature was made but I feel that this is a mistake. While the curriculum content of school displays will no doubt have changed since 1969, there is still much to be learned from older literature about the nature of display methods, etc. Elliott's omission seems all the more unusual given the aforementioned dearth of literature on the subject. Although primary school studies are mentioned by name, Elliott makes no attempt to describe or evaluate them. This is unfortunate as Cooper *et al.* (1996) in particular base their methods closely on constructivist theories of learning. These are relevant across the age range and so much of what Cooper *et al.* advise could validly be transferred to the secondary school, curriculum differences aside. As will be seen in sections 2.3 to 2.6 below, much of the educational practice in museums is also based on constructivism and museums deal not just with primary pupils but with adolescents and adults as well!

While Elliott's introduction is broadly similar to that of Noone (2004), albeit shorter, his research is very different and there are a number of methodological problems with parts of the questionnaire he used. Despite this difficulty, those sections of the report dealing with truly categorical data provide some interesting information. Some of this is highly predictable: we are told for example that there is a link between the subject specialisms of teachers and the content of their displays. More interestingly, of the 21 categories of display material, only six – commercially produced posters, unmarked pupils' work, safety guidance, reference books, codes of conduct and laboratory equipment – occurred in more than 50% of rooms. Although it is not pointed out by Elliott, almost none of these categories would contribute to constructivist learning as described by Cooper *et al.* (1996), assuming that only the *use* (as opposed to *display*) of reference books and laboratory equipment would lead to learning. Elliott does point out, however, that there will be variation within categories. Some commercial posters can be visually stimulating and informative while others, due to their design, are merely wallpaper. Sadly, very few of the display categories liked by students in Noone (2004) were present in more than 25% of rooms studied by Elliott, although he mentions that interactive teachers' work is more common (24%) than non-interactive teachers' work (16%). Only 14% of laboratories used more than 12 of the display types listed.

All this suggests that classroom displays in secondary schools are not only under-researched but under-valued. This is reflected in the Government's Workload Agreement (DfES, 2003) which classes displays as an administrative task, confirming the fear expressed in Noone (2004) that, while the potential for the serious use of displays as an effective learning tool is immense, the pressures of an over-prescriptive National Curriculum (DfEE/QCA, 1999a) and ill-informed Government policies (DfES, 2003) mean that displays are undervalued. It would seem, therefore, that the value of my research could be greatly increased if, as well as examining pupils' perceived learning from and enjoyment of objects and classroom displays, the practicality of their use from the teacher's point of view was also examined.

## 2.2: Formal and Informal Learning – Are They Compatible?

Before contemplating the adoption of museum practices in schools we must consider what, if any, is the fundamental difference between education in these two contexts? The answer, at first sight, appears to be straightforward. A plethora of references seem to make the distinction between formal learning, which occurs in schools, and informal learning, which occurs in museums (e.g. Lucas & McManus, 1986; Lucas, 1991; Re'em, 2001; to name but a few). However, as Hofstein and Rosenfeld (1996) point out, there is no clear agreement in the literature regarding the definition of formal and informal science learning. Writers with a museums background (e.g. Feber, 1987; Hein, 1998) tend to see formal education as something that typically takes place in schools. These are relatively dull, are governed by rules and have a set, content driven, highly didactic and hierarchical curriculum. In informal settings, by contrast, the learner is seen to be self-directed, there are no attendance rules, no hierarchical curriculum, there is a respect for all learners and learning typically involves the use of real materials. Thus, formal and informal are seen principally as terms that describe the administrative attributes of educational settings. This view of Hein (1998) among others, where formal schools are portrayed as being diametrically opposed to informal museums, seems to me to be very judgemental, even stereotyped. While each educational setting has a different mode of working, they can both to be said to be successful. Perhaps it would be more appropriate to consider formal and informal learning as a continuum with schools tending to occupy one half and museums the other, but with neither clumped at opposite poles.

However, Hein (1998) does acknowledge that both formal and informal settings can have learning through the use of objects, respect for learners' interests, education including discovery and/or the construction of meaning and a sense of students taking responsibility for their own learning, so they are not mutually exclusive. Classrooms in progressive primary schools, for example, may look very much like a science museum discovery gallery. It is also important to note that formal education will always be important. As McManus (1992, p165) points out, despite the restrictions formal education imposes on the individual, *"formal education institutions are very efficient, admirable means of communicating knowledge through societies for the benefit of those societies and the individuals within them."* The challenge is to find an appropriate balance between both types of learning.

Many people equate science learning with the formal school curriculum. Indeed Feber (1987) points out that, as science and technology have permeated our lives, they have become less accessible informally. This is in contrast to the mid-1800's where the popular science culture led many amateurs like Mantell, Faraday and Darwin to become more deeply involved in natural studies and, from there, to make great scientific advances (Gribbin, 2002). Yet, according to Wellington (2000) much, if not most, of children's learning about science still occurs outside the confines of the timetable and the school today. He sees informal learning in science is an under-used and under-studied area that could enrich science education and the work of classroom teachers. This view is backed by Maarschalk (1986) who sees informal science teaching as a condition for, and outcome of, scientific literacy.

Informal learning can take place in almost any context. Jarman (2005), for example, examines the potential of scouting as a context for informal science education. When Tunnicliffe and Reiss (1999) studied sources of pupil learning about animals they found them to include, in order of importance, home (63%), direct observation (30%), TV/Video/CD (25%), school (17%) and books (15%). While it is encouraging that so much extra-curricular learning seems to be taking place, it is disheartening that this enthusiasm is not being harnessed to a greater extent in schools. Wellington (2000: p251) identifies a wider range of informal learning sources that impinge on school science education:

- everyday experiences, such as slipping on ice; riding on a bus or lift; eating, drinking, cooking; gardening; sweating; boiling a kettle, etc. – the list is endless;
- the media: television programmes, some deliberately educational, some providing 'accidental learning'; radio; newspapers;
- access to multimedia at home, either via the Internet, CD-ROM, or other platforms;
- visits to museums, science centres, workplaces, etc.

One of the problems with formal learning identified by Millar and Osborne (1998) is that too many students who complete their compulsory science education with apparent success still lack any familiarity with the scientific ideas they are likely to meet outside school, in contexts such as the above. Moreover, it is claimed that the scientific 'understanding' achieved does not equip pupils to deal confidently with scientific information in everyday situations.

It appears that the type of informal learning used in museums could be used to at least partially address some of these problems in the classroom. Both Wellington (2000) and

Hofstein and Rosenfeld (1996) advocate the use of informal learning activities to supplement the formal curriculum. Conversely, Fehir and Rice (1985) point out that there is an element of formality in school visits to museums, even though the setting is apparently informal. Sabar and Shamir (1988) explored this interface between formal and informal learning by used focussed learning activities (FLA's) with students visiting the Museum of Jewish Diaspora in Israel. This effectively meant that they were using a semi-formal learning style with exhibits designed for informal learning, a situation similar to my intended use of informal objects and displays as part of the formal science curriculum in school. 87% of students found the FLA's interesting or very interesting, 77% said they would like to know more about the topic and 75% indicated they would like to revisit the museum. These results appear to be encouraging to say the least and would suggest that some elements of informal museum practice could be adopted within the classroom.

To summarise, it appears that there is indeed a clear distinction between informal and formal learning. Moreover, despite being successful overall as noted by McManus (1992), the latter does seem to pose some problems for science education in schools. In particular, it seems evident from Millar and Osborne (1998) that there is some disparity between the knowledge pupils acquire formally in schools and the informal situations in which they may have to apply that knowledge. Wellington (2000) believes there is much scope for the adoption of some elements of informal learning to help with science education in schools and he includes visits to museums among these. I will focus on learning in museums for the remainder of this chapter, examining firstly what educational theories underpin their work, comparing these with science teaching in schools, and then looking at what actual teaching practices could be adopted for use in the classroom.

## 2.3: The Educational Theory behind Informal Learning in Museums

One of the potential advantages of adopting some teaching strategies from informal museums is that educational theories, including constructivism, can be applied to both. Indeed, as will be demonstrated below, these educational theories actually arose in the school context and from there spread to museums. However, museums have very different resources to schools and so, having considered the educational theories themselves, I will then move on in following sections to consider the teaching strategies employed by museums and what schools can learn from them.

Hein (1998) describes a model of museum learning that consists of three components: a theory of knowledge, a theory of learning and a theory of teaching (or pedagogy). This model is not a description of learning but rather a set of theories that represent a well thought out philosophy of education. There are two main theories of knowledge (or epistemologies) described by Hein (1998, 1999) and these can be represented on a continuum. The first is the realist view, dating back to the time of Plato, that ideal forms exist independent of the learner and that learning consists of arriving at knowledge through an intellectual process. Conversely, the British philosopher George Berkeley advocated the view that knowledge only exists in the mind of the knower.

The next components of Hein's model are theories of learning and these are also described by Hooper-Greenhill (1999), who refers to them as *"theories of communication"*. Here also we find two dichotomous ideas that can be represented at opposite poles of a continuum. The first is transmission, the traditional view that students are *"little vessels .... ready to have imperial gallons of facts poured into them until they were full to the brim"* – (Dickens, 1868). Thus, learning is seen as being incremental, adding to a *tabula rasa*. In this theory of communication, the learner, whether in the museum or in the classroom, is seen as being cognitively passive and often experiences mental discomfort, a feeling of personal inadequacy and a feeling of being out of place. The second theory of learning is the cultural theory which sees communicators as being mutually active in the process of making meaning because they find it relevant and interesting.

The two continua described above can be juxtaposed on each other orthogonally to create four domains, each of which represents a particular type of educational theory. This combination provides the theoretical background for Hein's (1998, 1999) model and is illustrated in Figure 1 below. This diagram is a helpful reference point and I will use it as a basis for critiquing both science learning in schools and the potential for adoption of more informal museum practices to enhance this learning.

The four educational theories that arise out of Hein's (1998) combination are didactic learning, behaviourist learning, discovery learning and constructivist learning. The first two of these are both based on the transmission approach to learning. Didactic learning is where the teacher organises a lesson based on a subject's structure and presents information to students in a rational sequence. The "teacher" in this case could be a person or even text, a programmed instruction or a museum exhibit. This approach led

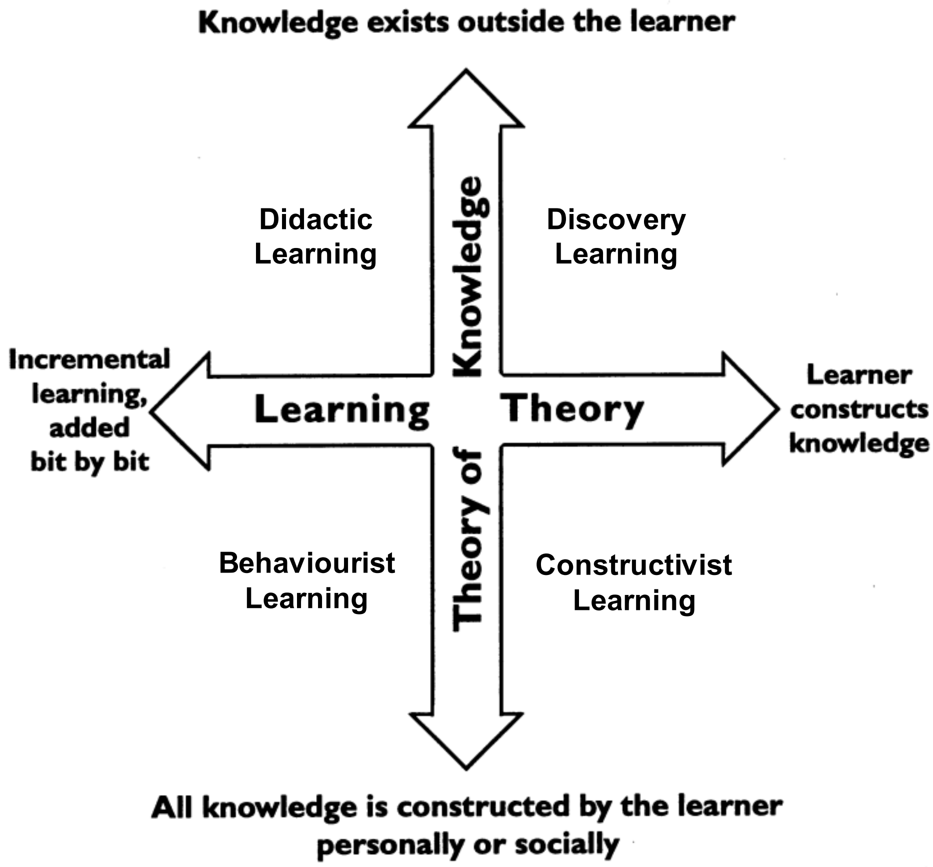


*Figure 1: Combination of Theory of Knowledge and Learning Theory continua, showing four possible Theories of Education – adapted from Hein (1998).*

to the development of learning hierarchies such as those of Gagné (1970) and Bloom's (1964) *Taxonomy of Educational Objectives* (both cited in McManus, 1992) which is still advocated by some educationalists today.

With behaviourist learning, the educator is concerned solely with method of instruction. Learning is seen as incremental and arises from a pattern of stimulus-response encouraged by reinforcement (e.g. Watson & Rayner (1925) in Gross *et al.*, 2000: p95). However, the idea that one-way transmission of information alone can form the basis of effective teaching is now thoroughly discredited according to Kirk (1987). Nevertheless, while schools recognise that other learning strategies may be more effective, the testing regime means that teachers often feel they are forced to adopt an over-didactic approach characterised by relatively restricted and traditional approaches to teaching and learning. This is what Broadfoot (1996) calls *"diploma disease"*, where superficial rote learning is encouraged at the expense of true understanding.

Many of the problems outlined in Millar and Osborne's (1998) review of the science curriculum are related to the transmission approaches to learning. For example, secondary science fails to sustain in students a sense of wonder and curiosity about the natural world, leading to disappointing uptake of science subjects at A-level. The authors put this down to an over-emphasis on content which means that science can seem to be a 'catalogue' of discrete ideas lacking coherence or relevance. Another reason is that science assessment is based on exercises and tasks that rely heavily on memorisation and recall, and are quite unlike those contexts in which learners might want to use science knowledge or skills in later life. As Rennie and Stocklmayer (2003) point out, deficit models of science understanding have little value because students simply do not understand science on science's terms, but on their own.

## 2.4: Learning Theories Based on Construction of Knowledge

The next two educational theories in Hein's (1998) model, discovery learning and constructivist learning, are both based to varying degrees on the idea that learners construct knowledge in their own minds. Although their ideas are constantly under review, the key learning theorists in this area are still Piaget, Bruner and Vygotsky (Burton, 2001). While, space does not permit me to give a detailed evaluation of their work here (for this the reader is directed to Pollard (2002), Burton (2001) and Bennet & Dunne (1994) to whom I referred while writing the following two paragraphs), I nevertheless feel it is important to briefly outline their theories before discussing the implications of their work for discovery learning and constructivist learning.

Constructivism developed from the work of Piaget who suggests that people learn through an interaction between thinking and experience, and through the sequential development of more complex cognitive structures. Children encountering a new experience *"accommodate"* their existing thinking to it and *"assimilate"* aspects of the experience. In this way their thought is restructured and so, gradually, children come to construct more detailed, complex and accurate understandings of the world about them. Piaget proposed four stages in the successive development of these mental structures and two of these relate to students of secondary school age:

- the concrete operations stage (approximately 7 – 12 years)
- the formal operations stage (approximately 12 years onwards)

In the concrete operations stage the student's direct experience is very important. A child using concrete operations to describe an ecosystem, for example, would describe simple food chains. During adolescence, however, there is a shift towards formal operational thinking, a gradual increase in the ability to use forms of logical reasoning. This could, for instance, allow a student to understand the dynamic equilibrium of multiple variables in an ecosystem. While Piaget's stage theory has been hotly debated, it still seems useful in thinking how students progress.

The ideas of Bruner and Vygotsky have come to be called social constructivist theories as they place more emphasis on the social context of learning. Vygotsky argued that children's intelligence is determined not only by their capacity to learn but also by their capacity for being taught. Thus, learning can be enhanced by interacting with others who have a greater degree of competence. These "others" can be teachers or even higher-attaining children, although pupils are more likely to learn from collaboration that involves an adult. Vygotsky called this cyclical process of learning through self-help with assistance from others the "zone of proximal development". Bruner elaborated on this concept, using the term "scaffolding" to describe the process by which a teacher can employ a series of step or questions to help students think in the right direction.

We now come back to Hein's (1998, 1999) two educational theories based on construction. The name discovery learning has been used to refer to refer to any situation where the learner is actively doing something (either physically or mentally). However, it should be noted that, according to Hein, discovery learning is much more restrictive than is commonly perceived, combining as it does the notion of active learning with a realist position on knowledge. Thus there are inherent difficulties with the approach as it suggests that learners can learn by actively constructing knowledge, but that they must reach conclusions arrived at by others! This would mean, for instance, that students given a few bits of string and weights to make a pendulum should independently arrive at the laws of pendular motion, something which had eluded scientists for centuries before the discoveries of Galileo. It is unlikely that students would pay attention to those areas of the topic necessary for arrival at the appropriate conclusion. To know what is relevant, such as the "obvious" way to use science apparatus, often requires that the learner already has the knowledge the situation is intending to impart. Of course, information can be structured to lead to the desired outcome, but is an experiment an experiment if the results are effectively pre-determined?

According to Hein (1998, 1999) true constructivism requires three separate components. The first of these is active participation of learners who are encouraged to think, deduce, hypothesise, criticise, speculate, evaluate, imagine, create, etc. This in turn leads to qualities of independence, initiative, resourcefulness and judgement plus a sense of learning how to learn, or "metacognition". Secondly, Hein (1998) argues that the conclusions of the learner should not be validated against external standards of truth but whether they make sense within the constructed reality of the learner. This means that different people can take very different meanings from the same objects depending on their background and experience. A religious fundamentalist looking at fossils, for example, may understand them to be life-like patterns in rocks whereas a scientist will regard them as being evidence for prehistoric life. Constructivists talk not of misconceptions but of naïve, personal or private conceptions – "mistake" and "error" are terms concerning conclusions not corresponding to the evidence to hand. A further characteristic of constructivism, noted by Kirk (1987), is that students learn at their own pace and that, while pace may differ between students, this does not mean that there is a limit to their learning. This has also been shown by Hart *et al.* (2004) who describe a number of instances where people who performed poorly in selection tests at the age of 11 went on to achieve at a high level in various walks of adult life. Thus there is a tension between constructivist theories of learning and the current school curriculum with its emphasis on knowledge acquisition and testing. While it would be naïve for me or any other researcher to think that current teaching styles could be completely replaced by constructivist-based ones in the near future, it is nevertheless apparent that the application of constructivist thinking to the use of objects and displays in the classroom could be a useful supplement to the formal curriculum.

Constructivism developed within educational circles and so, for many years, the curious situation existed where the constructivist approach to learning was used in the museum education room but the traditional transmission approach was used for museum display spaces (Hooper-Greenhill, 1999). This dislocation was regarded as unhelpful and has been overtaken by a more wholly constructivist approach where museum education and museum learning are seen as synonymous. Hooper-Greenhill (1987) argues that there has been a definite shift from abstract learning to learning from concrete experiences, and the process of knowing has become more important than the accumulation of knowledge. This increasing emphasis on constructivism in museums is important to the present research due to the fact that Burton (2001) among others describe science as being the subject area in secondary schools most strongly influenced by constructivism.

Therefore, any ideas gleaned from the museum context are particularly likely to be generalizable to science classroom practice.

According to constructivist theory the teacher's role is to facilitate learning by: designing learning experiences that allow pupils to investigate processes and outcomes; encouraging pupils to be actively involved with tasks and to take responsibility for their own learning; and allowing and valuing pupil's own descriptions and hypotheses of what they have learnt. Constructivism has led to important work on thinking skills in science across the age range and not just in museums. Adey *et al.* (2001) argue that cognitive acceleration in science education (CASE), which challenges secondary school pupils to examine the processes they use to solve problems, allows them to enhance their thinking. Being aware of the latter, a process called *"metacognition"*, should allow students to become better able to take control of their own learning. Another school application of constructivism is the use of concept cartoons (Naylor and Keogh, 1999) which force students to examine the very core of their conceptions.

Unfortunately, society has yet to fully accept the significance of learning from experience and critics will still argue that education is exclusively about "learning" facts. Hein (1998) reports that no role is seen for museums in the "back to basics" education movement. This view is typified by writers like Shortland (1987) who questions the learning value of science centres: *"... children have fun participating in a series of 'experiments', but they learn little science and may acquire a good many misconceptions which at the very least fail to match those offered in the captions. No one can doubt the success of these centres in drawing visitors .... However, what can be questioned – and surely must be investigated – is whether any appropriate science is being acquired."*

It seems to me that strict and exclusive adherence to any one of the four types of learning identified in Figure 1 could restrict student achievement. There also appears to be a tension between the traditional knowledge-transfer that is necessitated by curriculum pressures and the slower but deeper learning from experience advocated by constructivist learning theory. While recognising that it is both undesirable and improbable that constructivism will "take over" in schools, I nevertheless feel that it can be an important supplement to more formal learning styles and one that could be harnessed in using objects and displays to enhance the curriculum. In the remaining sections of this review I will examine how museums apply constructivist learning in practice and assess what aspects of this practice, if any, could be adopted for school science teaching.

## 2.5: Pedagogies – Completing the Model of Museum Learning.

The combination of theories of knowledge (epistemologies) and theories of learning/communication, with their associated theories of education, provides the theoretical background for Hein's (1998, 1999) model. However, a third component, pedagogy, is needed if we are to apply these theories in practice. Constructivism in particular needs detailed elaboration of the pedagogic activities appropriate to it.

Learning from real things and places, talking, handling, discussing, reviewing, comparing, recording and presenting are all methods used by museum teachers. Thus there is a reservoir of experience in museum education that could be of great use to the educational world in general. As Hooper-Greenhill (1987) points out *"techniques of using material things to teach from have been developed in museums for a very long time and are well tried"*. She sees it as unfortunate that museum education is rarely included in teacher training. McManus (1992, p179) reports that when student teachers were taken to museums as part of a planned course they became aware of a range of museum resources and services, came to understand the learning experience involved in handling artefacts, gained worthwhile experience of group work and developed confidence and skills. This bodes well for the present study, suggesting that there is much to be learned from museums and that teachers benefit from doing so.

The irony is that, while schools are compulsory, they are hopelessly impoverished in comparison with museums, which are often what Kirk (1987) calls an *"almost embarrassingly rich repository of resources."* Museums focus on the "stuff" of the world and so should become central to any educational effort when focus shifts from the written word to learners' active participation through instruction with objects, according to Hein (1998). Constructivist theory presupposes adequate learning resources, which schools tend to lack. Books undeniably constitute one type of resource but there are many others, some of which offer even greater scope for fruitful educational activity by pupils than books. In the next section I will discuss what it is museums actually do to bring about constructivist learning.

## 2.6: Museum Teaching Strategies Applicable in the Classroom

In this section I will look at how museum curators create a constructivist learning environment and consider which of these techniques could be applied in the classroom. This section will be illustrated where appropriate with examples of how the learning activities I trialled (discussed more fully in Chapter 4) and how these incorporate various types of museum practice, or could be adapted to do so.

### *2.6.1: Handling Objects*

According to the constructivist model, using objects enables students to develop skills of making links and connections, of close observation, questioning, discussion, talking, documentation, and comparison. In doing these, students inevitably draw on their own knowledge and build bridges between this and the new things they are looking at. Hooper-Greenhill (1987) points out that this happens almost unconsciously in the struggle to find meaning. Sabar and Shamir (1988) recorded this type of learning in their study of formalised learning activities in museums. Students were reported to gain enormous satisfaction from finding answers and they particularly enjoyed *"finding similarities between the exhibit and school material"*, showing that they were building bridges between new and existing learning. Similarly, Martin *et al.* (1991) found that children related their observations to everyday objects or organisms: fossil trilobites were compared to woodlice, for example. It would appear that students gain most from seeing objects they have learned something about beforehand.

Hooper-Greenhill (1987) suggests that true internalised understanding that is genuinely felt and incorporated into the existing knowledge and experience of the learner is more likely to occur in concrete situations. According to Schools Council (1972) it is also important that students should get a feel for the inherent qualities of the object, rather than it just being used to illustrate some specific fact or theory. This allows each pupil to have a personal response to each exhibit, although the class as a whole may be examining a particular theme. The teacher can act as a facilitator by helpful and discreet questioning rather than transmitting knowledge. Thus, learning from objects is process-oriented in the best constructivist tradition, rather than being content oriented.

An important point noted by Hein (1998) is that any activity involving the use of objects must be meaningful if learning is to take place. Some museums have taken "hands-on" to mean pressing buttons or opening flaps to find answers, without necessarily involving the mind. There is now a recognition among writers (e.g. Rennie and McClafferty, 1996) of the need for activities to be *"minds-on"* as well as *"hands-on"*. Some science centres have been criticised for failing to recognise this. Shortland (1987), for instance, dismisses some of their activities *"as simply play, as innocent entertainment"*. Feber (1987) addresses this issue, explaining that exhibits should be neither fixed (cases/cabinets) nor simply reactive (push-button). They should, however, be designed to stimulate conversation (either internally or externally) and, in this way, interactive environments can be set up that are very different to the traditional linear narrative of older museums (or classrooms). The research of Stevenson (1991) would suggest that truly interactive exhibits do indeed have a positive impact on learning. He conducted a series of follow-up interviews several months after visits to the Launch Pad exhibit at the Science Museum in London and found that visitors' recall was vivid and that a large proportion of visitors' thoughts were *"accurate or appropriate"*. While this would seem to contradict the worries of Shortland (1987), Stevenson (1991) does not make clear his definition of accuracy or appropriateness of thought and so it is difficult to make meaningful comparisons between his study and the more formal school context.

Allowing sufficient time for students to engage with artefacts is a prerequisite for constructivist learning. Hein (1998) points out that consideration of pupil comfort can have considerable benefits and he suggests that, in schools, it might be advisable to sit students in groups with objects, changing around at intervals, circus-style. This might help make lessons more purposeful and reduce the likelihood of some students just wandering around aimlessly. In busy museums such approaches can conflict with the need to push visitors through, but this is not such a problem in school, where timetabling means such issues can be planned for carefully in advance.

Feber (1987) and Durbin *et al.* (1990) found motivation to be an important factor when it comes to the use of objects. Things can be learnt with or without artefacts but, when the latter are used, it seems that ideas are absorbed more easily and with greater enthusiasm, remembered for longer and generate an enthusiasm to know more. Randler and Bogner (2002), for example, compared the use of taxidermic specimens and slides for the teaching of bird species identification skills. While both methods of instruction resulted in increased learning, retention of information was better over a long period with taxidermic specimens, due to the element of variety they provided for students. A similar case is described by Borun *et al.* (1983). Regardless of the type of cognitive measure employed, their data unequivocally supported the hypothesis that students visiting a museum exhibit scored significantly higher on a test of science content than students in a class situation. Museums were perceived by the students to be far more enjoyable and interesting than the classroom and they wanted to learn more. According to Perry (1992) there are six factors to take into account when planning motivating displays:

- Curiosity – pupils are surprised and intrigued.
- Confidence – students have a sense of competence.
- Challenge – students perceive there is something to work towards.
- Control – pupils have a sense of self-determination and control.
- Play – pupils experience sensory enjoyment and playfulness.
- Communication – students engage in meaningful social interaction.

The important thing about each of these is that they relate to students' intrinsic motivation. Kyriacou (1998) defines this latter as the extent to which pupils engage in an activity for its own sake, rather than to meet external ends like favourable exam results or praise. It is interesting to note that the components of intrinsic motivation – challenge, control, curiosity and fantasy – are also naturally present in play (Child, 1997) and are part of the constructivist framework, whereas extrinsic motivation relies heavily on behaviourist learning (see Figure 1 above).

Objects can be relevant at many different levels of knowing and Hooper-Greenhill (1987) reports that museum teachers become skilled at predicting the specific aspect of an object that will suit the needs of particular learners. A reservoir of knowledge about collections and artefacts enables a response to wide-ranging questions from learners. Martin *et al.* (1991) found that children perceived museum activities more valuable and/or enjoyable and tended to stay at it for much longer when a demonstrator was present. Similarly, Schools Council (1972) advises that listening to an enthusiastic expert is an experience enjoyed by most students. They recommend a short introduction as this allows pupils to move on to examine the exhibits and generate their own questions.

For school teachers who may be less familiar with objects, careful reference to syllabus content in schemes of work and level descriptors in the National Curriculum (DfEE/QCA, 1999b) can be a useful source of information both on the object and on how they might differentiate for pupils when teaching with it. Durbin *et al.* (1990) feel this latter should be easy. Whereas the reading and writing attainment within a class can divide it across a very wide spectrum, the range of formal attainment in dealing more informally with objects should divide them much less. Durbin *et al.* think that using objects effectively removes a barrier to learning, allowing every pupil to succeed.

In the past, the use of museum objects for education has been frowned on by curators. However, museums are now moving on from the days when the collection of objects and their careful conservation was seen as an end in itself. Of course, wear and tear of some exhibits is inevitable but, given the extensive nature of museum resources outlined in the previous section, this seems a poor excuse for restricting student access to artefacts. For school-based collections, the Schools Council (1972) recommends simply putting an instruction label by relevant objects. Indeed, examples are given of cases where children use almost all the objects in their room and nothing is locked away.

### ***2.6.2: Displays***

Students can often find museum displays difficult to relate to due to the specialist nature of the knowledge they represent. As Hooper-Greenhill (1987, p40) points out *"merely putting on show the sample of the collection that the curator happens to like best, or know most about ... only serves to confuse"* and this is something school teachers should also be wary of. Theme based displays or those designed around everyday subject matter are more accessible. Students should be enabled to make relationships with their experience so one important function of displays is to stimulate conversation about particular events. Pupils can also be involved in bringing in objects and making their own contribution, something which has been happening a lot with my displays in Lab 5 in the last year.

Hein (1998) suggests two interrelated ways of making displays more accessible for learners. The first is to incorporate familiar objects. For instance, in my year 11 fossils practical **(17)**, modern seashells were included so that they could be compared with the fossilised shells. Another example would be the inclusion of coins in photographic displays to give a sense of scale. Hein's second method is to actually use familiar rather than exotic objects in the displays. In this way students are enabled to concentrate on the principles and phenomena underlying the activity, rather than being confused by the display exhibits themselves. The plants used to teach about adaptation **(7)** were in my lab throughout the year so, when learning from them, students were confronted with familiar objects which they simply had to interpret in a new way. This was also the case with many of my other resources, including the live animals.

This last example leads nicely to another recommendation of Hein's (1998), that of open storage. This is where extensive collections are put on view but with minimal interpretation (few labels, etc.). Most of the objects stored in Lab 5 are in glass cabinets or on table tops. This means that, as well as being used during particular topics, the exhibits are present throughout the year where they can be seen and where students can enjoy learning informally from them (this was one of the aims of Noone, 2004).

One final issue worthy of consideration in this section is that of learning modalities. Hein (1998) suggests that a combination of text, photos, sound, smell and touch should be used as much as possible to accommodate different types of learners. While the theories of Gardner (1999) have been largely discredited (Coffield, 2004; White, 1998) there is little doubt that increasing the variety of learning modalities enhances learning, if only by reducing monotony and boredom. Research in the Boston Museum of Science (Hein and Mello (1993) cited in Hein, 1998), for example, has shown that the use of exhibits with a multi-sensory approach doubles visitor time and that they demonstrate richer learning after such exhibits. There are, however, practical limitations to such an approach in schools. The noise of crickets singing in Lab 5 drove many students to distraction and experience has shown that the multi-sensory opportunities created by a three inch cockroach running loose in the lab tend to be nullified by the time students spend evacuating the area!

### *2.6.3: Exhibit Labels*

One of the objectives outlined in Noone (2004) that was not fully achieved in the past year was the extensive addition of labels to the displays in Lab 5, although the stuffed birds exhibit was labelled and stimulus questions added **(31)**. This is probably just as well, as the literature on museums has much to say about labelling displays. The Schools Council (1972) emphatically states that labels in display cases tell us relatively nothing. In the study of Martin *et al.* (1991) there was little attempt by visitors to read labels and the authors use this fact to underline the importance of exploration and discussion in learning at an informal setting. Perhaps, however, the way that labels seem to fall by the wayside in informal settings has more to do with the large number of alternative novel experiences available, rather than inherent problems with the labels themselves.

The view of Hooper-Greenhill (1987) is more moderate. While pointing out that labels are often not helpful to students, she also describes how the Children's Museum in Boston successfully uses labels with three levels: adult with a little knowledge; child; parent to read to child. Perhaps a similar strategy could be employed in Lab 5 with selected objects or groups of objects in permanent displays having a three-tiered label. Figure 2 shows a potential label for the stuffed cuckoo **(31)**.

**CUCKOO**

**Vertebrate; Bird**

Has same colour as a **predator** – an **adaptation** for protection.

A brood parasite. Females learn where to nest through **social learning**.

*Figure 2: Potential style of labelling for use in Lab 5. The name of the object is given first followed by information relating to Key Stages 3 (in green), 4 (in red) and 5 (in blue). Key words are highlighted in bold.*

Information overload could result if all exhibits were labelled, so perhaps it might be better to label selected objects each month so the information switched around and pupils' interest is aroused by novelty. Hein (1998) also seems to think that labels have their place. Although visitors seldom read them in a formal manner, he notes that components of label text appear in their conversations at the end of museum visits. This is similar to the finding of Noone (2004) that students pick up information from wall displays around them but without consciously learning it.

### *2.6.4: Group Work and Worksheets*

In schools, the use of objects and displays is often coupled with some form of group work that requires a written record to be kept so I decided it would be informative to see what the literature says about the use of student grouping and worksheets in museums. Many students find that working in groups not only motivates them but helps their learning. Uzzell (1993) for example describes how, when completing a worksheet, students that worked in pairs did better than individuals, a difference that was not attributable to modelling. Group work allows learners to go beyond individual experience and extend their own knowledge and even their ability to learn. This is comparable to Vygotsky's "zone of proximal development" (Burton, 2001) and links with the concept of "cooperative learning" in formal education.

Worksheets are a commonly used resource in schools and Robins and Woollard (2003) point out that, when visiting museums, teachers tend to encourage students' independent study through the use of drawing activities and worksheets, with the teacher acting as facilitator. Museum educators, by contrast, are more likely to lead groups around and use focus learning through the use of direct, verbal questing. Schools Council (1972) warns that worksheets may inhibit pupils such that a potentially fruitful experience becomes merely a treasure hunt. Indeed, information may well be simply taken from a series of labels rather than from the objects themselves. There is also the danger that teachers can over-direct students. However, Durbin (1999) argues that worksheets, if well designed and carefully piloted, can structure a museum visit in terms of space used, time spent, knowledge gained and objects looked at, all of which are essential. I will here use my year 11 fossils practical to illustrate Durbin's suggestions for improving worksheets **[iv[*]]**.

The first thing Durbin (1999) considers is practicality. It is important that students are spread around the room, know where the answers are to be found and know what sorts of answers are required. For the fossils practical this was achieved by dividing the objects into three sets of questions (A-C) with students starting at different points, giving matching numbers to objects and questions, and providing dotted lines to give pupils a rough idea of how much writing was required. The level of vocabulary was quite high, but then the activity was being used with year 11. Durbin next considers the level of thinking required to answer each question, suggesting that a mix of low- and high-level questions is best. I feel this was achieved with my worksheet, some questions merely requiring a description of the objects (Q1) whilst others asked students to link knowledge learnt in class to the exhibits (Q3). A sense of the whole topic was provided by briefing students before the activity and going through the answers with them afterwards and, of course, the work was set in its curriculum context. The main way my

[*] For ease of reference Roman numerals in square brackets and bold font will refer to resource samples illustrated in Appendix II throughout this report.

worksheet would fall down, in Durbin's eyes, is its lack of variety - all the answers required a free written response. This could be overcome by, for example, asking students to make annotated diagrams (for Q1 and Q2) and take size measurements (for Q3). It might even be possible to produce a student record sheet, with the bulk of the text being presented on laminated cards beside the exhibits, although there could then be a risk of students taking the information from labels and ignoring the objects themselves.

## 2.7: Implications for Classroom Research

What then, in summary, has the literature told us? Firstly, Elliott's (2000) paper gives us an idea of the limited extent to which classroom displays seem to be used in school. However, Noone (2004) found classroom displays to be both enjoyable for students and effective tools for informal learning. If displays are not being routinely used and yet enhance learning, it would seem that an examination of the practicalities of using classroom displays is merited, so that any problems, real or perceived, which prevent their use can be overcome. Secondly, the wealth of literature on learning in museums suggests that adapting informal museum practice to the formal school context is indeed desirable. Moreover, the fact that schools and museums share a common set of educational theories would suggest that it is valid to do so. Museums rely heavily on the constructivist approach to learning, as does the literature on classroom display (Noone, 2004), and writers like Burton (2001) and Adey et al. (2001) tell us that constructivism has had a particularly strong influence on secondary science teaching. However, while there is much literature explaining how students react to the use of resources in museums, it is less apparent how students feel about the use of informal museum practices within schools. This will be the main topic of consideration throughout the rest of this report.

# Chapter 3: Research Questions

It should now be clear to the reader that the present research is strongly based on a previous study (Noone, 2004) where classroom displays were used to help students informally acquire information about wildlife and conservation. This approach was found to be highly effective, suggesting that there is great potential for the integration of both displays and hands-on collections into formal classroom teaching. Indeed, pupils themselves have pointed this out. There is a wealth of literature about the use of displays and objects in museum education which can be used to give this research a solid grounding in educational theory. Literature based on the constructivist approach is particularly comparable to my previous work on classroom display in the science department concerned.

While the literature review had provided a justification for the use of natural objects and displays, as well as many ideas for their future development, the effectiveness of these techniques in the classroom context still needed to be assessed. Many references were found that assess the effectiveness of informal techniques (or, indeed, formal ones) in museums but I needed to find out if they were appropriate in schools. Based on my reading, the following research questions would appear to be both answerable and useful:

**1.** In what ways and to what extent do pupils perceive the use of displays and collections to contribute to their motivation and learning?

It has already been found that students acquire information from wildlife displays due to their innate curiosity and desire to learn (Noone, 2004). Can this enthusiasm be maintained when displays and objects are used in the more formal context of a lesson? If so, will it have a positive or negative impact on learning compared with previously used teaching methods?

**2.** Which sorts of display-related activity do science colleagues think are best for teaching and learning in this department?

The literature has provided many examples of successful teaching methods in various contexts. However, it will be important to identify which approach or combination of approaches works best within the science department concerned and why staff think this is so.

3. What are the practical constraints of using displays and collections in everyday teaching and how can they be overcome?

While there may be some overlap between this question and the previous two, it is important that practicalities be given special consideration, especially if others are to make use of this research at a later date. The expected benefits of using displays will have, for example, to be balanced against the constraints of a curriculum where there is an emphasis on performance in tests. Equally some practical constraints could be overcome by improving teaching materials.

# Chapter 4: Choice of Research Strategy

## 4.1: Strategies Adopted

This research is primarily a case study although, as will be discussed below, it also has an element of action research. Robson (2002) defines a case study as being a strategy for doing research which involves the empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. It therefore involves the development of detailed knowledge about a single case or set of cases using a range of data collection techniques. This is particularly appropriate for my research because case studies are a common approach used in the literature on museum education. The collection of papers in Ambrose (1987) are a case in point. Over half of them use anecdotal descriptions of museum experiences and a number describe full case studies.

Yin (2003) identifies three types of case study:

1. exploratory – where the study is used as a pilot for other, larger-scale investigations;
2. descriptive – where the study is used to provide a narrative account;
3. explanatory – where the study involves the testing of theories.

My study does include descriptions – in order for the reader to understand my research, narrative descriptions of the classroom activities are given in section 4.2. Overall, however, it is largely exploratory: my case is how objects and classroom displays are perceived by pupils to contribute to their learning and motivation along with the practicalities of using them as part of everyday teaching. This research will not in the main be explanatory as it does not examine the use of objects and displays in a large number of schools, like Elliott's (2000) work on classroom displays.

Some authors see case studies as being essentially qualitative. Stake (1995), for example, makes the interesting point that the constructivist view of learning would suggest that the writer of a case study report should include lots of narrative description so that the reader has good raw material for their own generalising. He recommends that emphasis is placed on the things that readers would ordinarily pay attention to – places, events, people and so on. Yin (2003), however, says that case studies can include both qualitative and quantitative elements of data collection and he discusses examples of both in detail. These include a number of research instruments used in this study, including physical artefacts, interviews and participant observation but not questionnaires. Hooper-Greenhill (1999) sees these latter as an essential addition to museum case studies as they are useful in showing overall patterns of museum use. Both qualitative and quantitative methods will be discussed in more detail in Chapter 5.

Yin (2003) has pointed out a number of problems with the case study approach and these have led to it being stereotyped as a weak sibling among the social science methods. Some authors regard it as being less scientific than, for example, the experimental approach which can also be used for exploratory studies. However, an experiment would be inappropriate here as there are too many variables for the investigator to effectively control in the busy reality of the classroom. It should also be remembered that the experimental approach was designed primarily to deal with agricultural research (Hopkins, 1993). As Robson (2002) points out, the case study is not a flawed experimental design but a separate research strategy in its own right. Additionally, museum researchers point out that their research has moved from the laboratory model to a more sociological or ethnographic mode, which uses naturalistic settings and a more open-ended research agenda (Hein, 1998).

The possibility of researcher bias is also a problem for case studies. Hammersley (1993), for example, asserts that understanding educational phenomena in their wider context may be difficult for those closely associated with them. However, he also accepts that most of his arguments about the bias of teacher researchers have equally valid counter arguments. It could be argued, for instance, that teachers have a deeper understanding of their own behaviour than an outsider ever could. Yin (2003) sees the problem of case study researcher bias as being comparable to the bias which can enter more readily accepted research strategies like the conduct of experiments or the design of survey questionnaires. It is a mistake of which the researcher must be wary, but not a factor that could render the case study strategy itself invalid.

Another issue with case studies is that of generalizability or “external validity” (Robson, 2002). This is the extent to which research undertaken can be applied elsewhere. My research is unlikely to be empirically generalizable due to the very specific context outlined in section 4.2. Despite this, the literature review should allow other teachers to gain a thorough grounding in the educational theory underlying it. Additionally, one of my principal aims has always been that my work should be internally valid, providing lots of helpful information for use within my science department. While this should be possible, *Gomm et al.* (2000: p109) warn against making generalisations based on single classes or even year groups. These often vary from year to year and from subject to subject so it is important to sample as wide a cross-section of the school as possible. The careful description of my methods and photographs in section 4.2, coupled with the theoretical justification in the literature review, will hopefully give readers a clear enough understanding of my work for them to decide which displays and activities could be adapted to their school. These steps should hopefully enable what Gomm *et al.* (2000) call "naturalistic generalisation" or "transferability".

While this research is primarily a case study it also includes some elements of action research. Thus, my choice of strategy is tailored to the situation being investigated rather than falling into the trap of being "strategy driven". Elliott (1991) defines the aim of action research as being the improvement of practice rather than the production of knowledge. According to Scanlon (2000) action research often involves a number of cycles: practice is examined in the first cycle, improved and then studied in its modified form in the second cycle. As mentioned above, this study builds on earlier PGDES research into classroom displays (Noone, 2004) and so this year could be viewed as a second round in which I will be implementing many improvements to my displays. However, this is not strictly action research as I am now using objects as well as classroom displays with the aim of improving formal classroom teaching rather than just providing opportunities for informal learning. Thus, rather than merely trying to refine previously researched practice, I am also changing my emphasis to a new topic. Moreover, Gomm *et al.* (2000: p4) point out that action research can be seen as a case study which has been created by the actions of the researcher. This is the case here as I am studying the development of my own displays and collections.

## 4.2: The Case – A Narrative Account

It will be clear to the reader from the introduction that the focus of this research evolved during the latter part of 2004, rather than being firmly planned from the start. Moreover, numerous unpredictable contributions were made by colleagues and outside agencies throughout the year. For this reason a significant proportion of the display activities developed were used before any systematic literature review or data collection had taken place, although they were still informed by the findings of Noone (2004) as well as professional "instinct". In the interests of clarity, therefore, I will here describe all the classroom displays and exhibits used as the basis of this research so that the context will be clear to the reader in subsequent sections. The activities used with key stage four are described first as these were, for the most part, designed in the earlier part of the year to fit in with the examinations timetable. Key stage three exhibits and displays, by contrast, were mostly used during the summer term of 2005. For ease of reference, Table 1 also gives a résumé of which classes did which activities. Many of those described were also used by other staff in the science department and so, in the final part of this section, I describe how information about resources and their use was disseminated across the department.

### *4.2.1: Activities used with Key Stage 4*

The first display was designed to help year 11 students understand plant adaptation **(7)**, an idea gleaned from Cade (1988). The structure is adapted from a display pictured in Jackson (1993: p17) and was initially developed for purely pragmatic reasons – the shelving allowed the window behind it to be opened wide for ventilation but without the risk of a student falling out! The plants were passed around after the class had seen an introductory video on the desert environment (Attenborough, 1984) and students were asked to identify (a) the characteristic features of the plants and (b) how these features were adaptive. This display was present throughout the year as *"open storage"* (Hein, 1998), partly for pragmatic reasons and partly to act as a reference point for year 11 and attract the interest of many students. It was also used to teach a year 10 group at the end of the year, by which time it had been enhanced so that the pebble plants were realistically camouflaged **(8)**. In addition, two smaller displays were used that recreated a rainforest tree branch **(9)** and showed an aquatic plant **(10)**.

Carnivorous plants **(11)** were used to liven up the nitrogen cycle, a topic which pupils have found to be quite dry. These plants grow in peaty soils devoid of nitrates so they live by catching and digesting protein-rich insects (Attenborough, 1995). It was hoped the extreme lengths they go to to get nitrogen would fascinate pupils and underline the importance of the nitrogen cycle. Another dramatic plant was the desert *Euphorbia* (the tall plant on the right of illustration **7**) used to teach about adaptation in the "Environment" module and evolution in the "Inheritance and Selection" module. This was intended to introduce an element of cognitive conflict as, despite looking like a cactus, the desert *Euphorbia* is actually in the same family as spurges, common garden weeds in the UK [see illustration **xiv**], and the familiar, red Christmas *Poinsettia*.

Year 10 also saw real plants to make plant structure lessons more stimulating. Many plant types were placed around the lab and students were asked to examine each and find (a) roots, (b) stems, (c) leaves and (d) flowers. While this might sound easy, many of the plants used had unusual structures (e.g. ferns and cacti). Driver *et al.* (1994, p24) have also pointed out that students are bad at thinking about the "whole plant".

The year 11 curriculum offered the opportunity for a number of animal specimens to be used. The first was a tank of large goldfish **(12)** one of which was of particular interest. "Gummy" had a large benign tumour on the side of his head **(13)** which made him a great talking point when it came to teaching year 11 about mutations. Next came some stick insects **(14)** who reproduced asexually, the resulting offspring being clones. Learning about this, coupled with the chance to hold some of the insects, provided some light relief from written work in the middle of a lesson. Thirdly, a set of stuffed finches **(15)** were obtained on semi-permanent loan from the Oxfordshire County Museum. These were used to visually demonstrate variation in beak size while teaching about evolution and they fitted in quite nicely with existing worksheets **[i]** and videos.

During the past two years a wide variety of fossils had been gathered. Some of this collection had been put on display at the start of the year **(16)** but, for a year 11 practical, it was divided into nine groups which were placed around the room so that students could handle the fossils **(17)**. Each group had appropriate labels with illustrations from sources such as Hayward *et al.* (1996) and NHM (1983). In the past a worksheet had been developed to accompany a display about corrosion of various metals [**ii,** for example of accompanying display see **iii**] and a similar format was used for the fossils practical sheet **[iv]**. Although the latter required a greater degree of literacy, this was felt to be appropriate for year 11.

The final activity I will describe in this section is more a hand-on display than an exhibit. When I first taught the "Environment" module in 2002, it was immediately apparent that many students lacked the background knowledge that is assumed in the syllabus (AQA, 2000). Food chains, which show which organisms eat other organisms, are a good example of this. For instance, *oak leaf → caterpillar → blue tit → sparrowhawk*, means that caterpillars eat oak leaves, blue tits eat caterpillars and so on. This may seem very straightforward to the average adult but how can any adolescent grasp this apparently simple concept if they don't know what a blue tit is? Gardner's (1999) theory of multiple intelligences suggests that, without such background details, visual and kinesthetic learners are effectively being excluded from the lesson. In order to overcome such problems I developed a pack of twenty-four "food web cards" **[v]**. These showed pictures of organisms commonly found in woodland/hedgerow habitats along with various details about their lifestyle. A "pond life" version was also developed for use with KS3 classes **[vi]**. Students worked in pairs, initially using the cards to play "top trumps". This was designed to be fun, but it also enabled pupils to become familiar with what various plants and animals look like, as well as to pick up facts about them. This worked for at least one year seven student who, when doing pond-dipping outdoors later in the day, innocently asked, *"Sir, is that beetle with the bubble on its bum Hyphydrus ovatus?"* In year 10 some more perceptive students decided that, in the case of "pollutants", bigger numbers would loose you a card as this was a negative trait. The first year 10 class to trial this activity was given sticky labels so that students could construct a food web in their books. This proved to be too fiddly and subsequent classes used a matching worksheet **[vii]** and diagram **[viii]** to focus their work instead. As well as being used for food chains and webs, the cards were also reused throughout the rest of the module as their information also made them suitable for learning about pyramids of numbers, pyramids of biomass and bioaccumulation of pollutants. This allowed a degree of continuity throughout the module and students soon became used to getting out the cards and using them.

### *4.2.2: Activities used with Key Stage 3*

It had originally been intended that all the resources used in this research be biological in nature. However, the science department was given the opportunity to use some geology-based exhibits during the summer term with KS3 pupils and so it was decided to include these in this research as the samples used were similar in nature to the fossils activity trialled with year 11. As Hooper-Greenhill (1987) points out *"Working with real things, it is soon clear how arbitrary are our existing subject boundaries."*

The first of the two non-biological resources was a collection of rock samples and a "rocks mat" **[ix]** loaned by the Oxford University Museum of Natural History. This activity had been developed by the museum in collaboration with Oxfordshire LEA and the school had been asked to trial it with year 8 students **(18)** studying rocks and the rock cycle. The resources consisted of the large (8'x12') rocks mat **[ix]**, a selection of rocks samples, an illustrated rocks information card for each sample **[x]**, two sets of rocks name cards (level 3-6 and level 5-7), two sets of rock cycle statement cards **[xi]** (again, level 3-6 and level 5-7) and some accompanying worksheets **[xii]**. A CD of all the printed resources was also provided to allow them to be adapted if required. The resources could be used for a wide selection of differentiated activities at a number of points throughout the two modules and some staff used them repeatedly to allow for continuity.

The other non-biological resource was a set of lunar samples **(19, 20)** and meteorites loaned for one week by the Particle Physics and Astronomy Research Council (PPARC). The samples were incorporated into a lesson in which teachers circulated among the students, supervising them and discussing the samples with them **(21)**.

We now come back to biological exhibits. I have previously described, in Noone (2004), the acquisition of a tank of live Madagascan hissing cockroaches **(6)** and students' enthusiastic response to these. This collection was increased during the course of the year. Stick insects **(14)** and fish **(12)** have already been mentioned above. After months of being implored by students to get something small and furry, I acquired "Roz" the Chilean rose tarantula **(22)**. While she has to be kept in her tank for welfare/safety reasons, she moulted shortly after taking up residence and her skin, which is identical to the living animal **(23)**, has been used to terrify students and staff alike ever since! Less problematic was my other carnivorous acquisition, an African emperor scorpion **(24)**. She was used to teach students about the electromagnetic spectrum (scorpions fluoresce under a UV lamp, **25**).

Prior to obtaining these new animals the Wildlife Elective students, who helped to set up their tanks and subsequently look after them, went with me to the Oxford University Museum of Natural History for an interactive talk about caring for insects and other arthropods, given by one of the entomological curators **(26)**. We were also given two new types of cockroach, including death's head cockroaches **(27)** and some giant spiny stick insects to take back to school. Coupled with crickets and locusts **(28)** this meant that the science department now had quite a varied selection of live invertebrates to show students. Pupils taught in my room, Lab 5, were used to seeing these exhibits and many students from other classes came of their own accord to see them at lunchtimes. Nevertheless, the insects were also used in a more formal way during lessons on classification, taught to year 7 and some year 8 classes. This was done by teacher demonstration, with the more harmless insects being passed around for students to hold. I also taught some lessons for colleagues, both about classification and how to care for animals. Such an approach is recommended by Tunnicliffe and Reiss (1999) who found the teaching of classification by rote learning to be less successful than the use of and discussion about real animal specimens.

Use was also made of the school's collection of pickled animals in jars **(29)**. This was added to and the jars were numbered before being placed around the room. Pupils then had to examine them, deciding (a) what the animal was, (b) V or I ? (vertebrate of invertebrate), (c) which group it belonged to (mammals, fish, mollusc, insects, etc.) and recording this information in a table.

Two other classroom activities were used with year 7 pupils studying the environment. The first, food chain cards **[vi]**, has already been described with its KS4 equivalent above. The other was simply an extension in the use of an existing resource. Two years before, the Wildlife Elective had set up a large fish tank containing pond life from the school's nature reserve **(5)** and I allowed students who had been pond dipping in class to add some of their specimens to it. This stimulated extra interest in the tank and several students even named "their" dragonfly larvae. Unfortunately, the class concerned was not being taught the morning one of these spectacular insects hatched out **(30)**.

### *4.2.3: Training of Staff to use the Displays*

Reference to Table 1 will show that many of the activities described above were also used by colleagues. The degree of other-staff training varied from activity to activity. Some of them were simply adaptations of previous practice. The pickled animals in jars, live cockroaches and stick insects are all examples of this. Most staff had been using them to varying degrees for the past year and they had simply been modified slightly, so little or no extra training or discussions were needed.

Other activities, however, required a greater degree of attention. The rocks mat, for example, was completely new to all staff, including myself. In order to overcome this, I took a student teacher and fifteen year 8 students to the University Museum for an afternoon. There, we watched the Museum's education officer teach our students with the new resources (the students also got the chance to do other activities within the museum). We then took the materials back to school and demonstrated during a department meeting. This was much more effective than circulating a piece of paper

| Activity | Year Group(s) Activity Used With | | | | |
|---|---|---|---|---|---|
| | *7* | *8* | *9* | *10* | *11* |
| Food chain cards | ✓* | | | | |
| Live insect classification | ✓* | ✓ | | | |
| Animals in jars classification | ✓* | ✓* | | | |
| Rocks mat and samples | | ✓* | | | |
| Lunar samples and meteorites | ✓* | ✓* | ✓* | ✓* | ✓* |
| Generic plant structure | | | | ✓ | |
| Food web cards | | | | ✓* | |
| Plant adaptations to deserts | | | | ✓ | ✓ |
| Carnivorous plants – nitrogen cycle | | | | ✓ | ✓ |
| *Euphorbia* – desert evolution | | | | | ✓ |
| "Gummy" the gold fish – mutations | | | | | ✓ |
| Stick insects – asexual reproduction | | | | | ✓* |
| Stuffed finches – evolution | | | | | ✓* |
| Fossils practical | | | | | ✓* |

*Table 1: Summary of classroom activities used with each year group. ✓ denotes activity used by the writer. * denotes activity also used by other members of staff.*

because staff could actually see the resources and a useful discussion ensued about how best to use the mat. The lunar samples were also discussed during department meetings. Many staff observed the Head of Department and I teaching with them too – this quick training was necessary as we only had the samples for four days and we wanted to maximise their use. Another resource I demonstrated in department meetings was the year 11 food web cards. This was important because, although I had a very clear idea in my own mind about what to use them for, other staff needed to see them to grasp what they were about. Everyone was very enthusiastic about them and several useful suggestions were made which I acted on, including the development of a matching worksheet and a KS3 version that could be used in conjunction with pond dipping.

Information about some activities, particularly subject specific ones like the fossils practical and stuffed finches, was simply passed on by word of mouth. This avoided wasting time for other colleagues and worked quite well as the staff within my department work as a friendly and close-knit team. Indeed, one member of staff took the finches **(15)** with him to a (successful) interview! The transmission of knowledge about other activities, particularly those relating to plants was less effective. This is because they tended to be quite short teacher demonstrations and there were so many of them it was difficult to keep track of which plant is used to explain which topic. An obvious way to overcome this problem in the future would be to write the plants into schemes of work and label or number their pots so that the technicians can find them easily. This could be done in the coming year as preparations are made for the new 21st Century Science GCSE Syllabus.

# Chapter 5: Research Methodology

## 5.1: Data Collection Methods

As this was a case study a number of methods of data collection were used to address the research questions outlined above. These included the use of informal staff discussions, informal class observations, questionnaires with pupils, semi-structured interviews with teachers/students and a research log with photographs. In this section I will discuss how and when they were used, along with the practicalities of doing so. Table 2 summarises how data collection methods matched the research questions.

### *5.1.1: Informal Discussions with Staff*

Disseminating my ideas across the department was one of the main objectives stated at the end of Noone (2004). The three main reasons for this were that (a) previous research had shown that students liked the displays in Lab 5, (b) having spent much time developing various activities it seemed wasteful not to give other staff access to them and (c) Lab 5 was starting to reach saturation point and spreading new ideas and the use of objects and displays around the department seemed the obvious next step. Thus, the main difference in terms of methodology between this research and Noone (2004) is that it is less personal and so the expertise of other members of staff within my department was harnessed to a greater extent for answering research questions two and three. Initially staff were informally asked to comment on my ideas for classroom activities prior to their first use. This had the twofold effect of familiarising staff with the activities and also helping me to use the resources concerned to maximum effect. Action points resulting from these discussions were noted in the data log.

### *5.1.2: Observations*

Wilkinson and Birmingham (2003: p116) define observation as being *"research characterised by a prolonged period of intense social interaction between the researcher and the subjects, in the milieu of the latter, during which time data, in the form of field notes, are unobtrusively and systematically collected."* It can allow researchers to understand much more about what goes on in complex real-world situations than they could ever discover by asking questions of participants, no matter

| Research Question | | Methods of Data Collection |
|---|---|---|
| **1.** | In what ways and to what extent do pupils perceive the use of displays and collections to contribute to their motivation and learning? | • Informal peer observations while objects and displays were being used.<br>• Student questionnaires followed up with semi-structured interviews. |
| **2.** | Which sorts of display-related activity do science colleagues think are best for teaching and learning in this department? | • Discussions with teaching staff prior to trialling a new activity.<br>• Informal peer observations while objects and displays were being used.<br>• Semi-structured interviews with members of staff. |
| **3.** | What are the practical constraints of using displays and collections in everyday teaching and how can they be overcome? | • Student questionnaires followed up with semi-structured interviews.<br>• Informal discussions with teachers, technicians and teaching assistants recorded in research log.<br>• Informal peer observations while objects and displays were being used.<br>• Semi-structured interviews with students and members of staff |

*Table 2: Methods of data collection for the three research questions.*

how probing those questions might be. Wilkinson and Birmingham (2003: p118) list a number of instances where observations can be employed. These include:

- when the context of the event you are researching is important;
- when observation can be a useful supplement to other research instruments;
- when a flexible approach to research is needed.

Due to the fact that my research is a case study, all three of these points are highly relevant. I used observations to help answer research questions 2 and 3. In particular, they helped with the construction of appropriate questions for use in the interviews.

Bleach (1999) identifies three main types of observation: open-ended (a qualitative view of generic teaching qualities); criteria-based (a detailed, quantitative focus) and pupil-centred/participatory (where the researcher takes part in the lesson). The latter was utilised here as it avoided the pitfall of observing the teacher rather than the students' learning. The observations examined both pupils' responses to, and the practicality of, using displays and collections in everyday teaching and formed the basis of a series of short teacher interviews. Yin (2003: p93) does not see observation as a useful source of quantitative data due to observer bias but notes that the detailed knowledge gained does allow more accurate narrative description. There are a number of roles the participant researcher can adopt whilst observing. I probably correspond to what Robson (2002) calls the "participant-as-observer" because, as well as playing an active role in the lessons I observed, it was made clear to classes that I was there to help with a particular activity. This gave me the freedom to ask students about what they were doing in a natural way rather than maintaining the stance of a detached assessor.

Brown and McIntyre (1993; p36) highlight the importance of the shared understanding that results from observations prior to interviews, pointing out that observations *"reinforced the point that the focus of the research was on what actually happens in classrooms ... [and] ... constrained the teachers to concentrate on real and shared events rather than imagined reconstructions"*. Wilkinson and Birmingham (2003) additionally point out that, when a variety of data collection methods are in use, observations can be used as a basis of interview questions. They can also ensure that the researcher is aware of certain events or activities which, because they occur regularly or appear mundane, could be overlooked.

The main constraint with observations was that they took up a large amount of time, both for me and other staff. It had been hoped that, with careful planning, this would not be an insurmountable obstacle. The school was developing a system of peer observations at the time and my department was at an advanced stage of implementing the process. Despite this, time pressures meant that, while many observations were used, they did not offer comprehensive coverage of the class activities I was interested in. For this reason, the information gleaned from the observations was used to further inform the development of class activities, to supplement the research log and to help structure questions used in the staff and pupil interviews. Because of this, their results will not be discussed in Chapter 6 in their own right.

### *5.1.3: The Student Questionnaire*

Much of the methodology for answering research question one was, for consistency, similar to that used in Noone (2004) who started by using questionnaires. My principal aim in using student questionnaires this time around was to answer research question 1 about students' perceptions regarding the learning value and enjoyment value of using objects and classroom displays. Authors like MacBeath *et al.* (2003: p12) and Wilkinson (2000) describe a number of advantages to the questionnaire approach. They are, for example, effective with pupils who do not like extended writing or are shy about participating in teacher discussions. According to Oppenheim (1992) they are also quick to use and complete, easy to organise and analyse and offer a broad overview of opinions.

The student questionnaires (see Appendix III) were designed to find out three main things. Firstly, I wanted to know (a) how often students perceived they used objects and displays, (b) how much they felt they learned from them and (c) how much they enjoyed their use. These questions were addressed in section 1 of the questionnaire. Here, students were given a list of ten classroom activities which included classroom displays and they had to rank them (1-10) in order of preference. Ten were chosen as Oppenheim (1992: p250) says this is the maximum number of choices participants can readily deal with in such a task. Ranking was done under three headings:

**A:** How often was this activity used in lessons?

**B:** How well did you learn from this activity?

**C:** How much did you enjoy this activity?

The reason students were also asked to rank nine non- display activities was that I wanted to get an idea of how they felt about displays relative to other classroom activities. I also felt that whimsical or random responses were less likely if students had to make concrete comparisons. The ranking approach avoids invalid assumptions concerning data linearity which Oppenheim (1992) points out are often concerned with scaled responses. This problem had been experienced by Noone (2004) and I wanted to avoid it here.

On close examination of the questionnaires in Appendix III, the reader will see that different classroom activities are contained in the questionnaires given to classes in key stages 3 and 4. This is because it was felt that, in order for the questionnaires to be meaningful for students, the activities on them should closely reflect what they actually do in class. To achieve this a list of all those activities used within the science department was compiled during a department meeting and the resulting information was used as the basis of a short, tick-box questionnaire given to all science staff. This asked them to indicate which activities they most commonly used at each key stage. The nine most commonly chosen activities in each key stage were added with classroom displays to the student questionnaires, although their wording was sometimes modified for reasons of space and to avoid student confusion. It is noteworthy that seven out of the nine activities chosen by staff were the same for each key stage, the two differences being researching a topic and doing tests (KS3) and working in pairs/groups and exercises (working examples) (KS4).

Next I wished to explore the reasons underlying students' perceptions of the learning and enjoyment values of displays. This was done in section 2 of the questionnaires. In this, the first two questions related to student learning. For question 1, pupils had to look back at section 1 and explain why they had given displays the rank they did in column B (learning value). They were then asked, in question 2, how they thought displays could aid their learning. Questions 3 and 4 followed a similar pattern although the emphasis this time was on student enjoyment of displays (column C in section 1).

The last thing I wanted to find out was how students thought the use of objects and classroom displays could be improved. This related to research question three and was treated by question 5 at the end of section 2. It simply asked students how they would make the displays they used better.

Questionnaires have their limitations. As Munn and Drever (1990) point out, they tend to describe things rather than explain them and the information yielded can often be superficial. Indeed, Noone (2004) found that written responses typically consisted of one word only, even with older students. To overcome this problem, in section two, it was stated that students were to write at least two bullet points per question. This worked and, while the questionnaire took longer for younger students in particular, there was a huge increase both in the amount and quality of information yielded.

The reader will notice that throughout the student questionnaire, objects and wall displays are referred to collectively as displays. This was done to keep student instructions short and direct. However, the term displays was defined in an introduction at the start of each questionnaire. This was written anew for each year group and included a brief overview of the activities which those students had undertaken. This introduction was read and discussed with students before they started working on the questionnaire so that they had a shared understanding of what they were writing about.

In Noone (2004) a quota (two entire year groups) had been sampled after a smaller pilot study. As the intention here was to use the maximum number of displays in as many areas of the curriculum as was physically possible, students in a number of year groups had to be included this time around (Table 5 on p60 shows the numbers of students completing questionnaires in each key stage and class). It was necessary, therefore, that opportunity sampling be used as different years did different amounts of display work and at different times of the year, depending on the curriculum and the science department's teaching orders. Initially, some thought had been given to using questionnaires immediately after doing one of the classroom activities. However, this was impractical due to the fact that many classes did more than one activity. Instead, all the questionnaires were administered in the last two weeks of the school year. To facilitate discussion of the questionnaire introduction, all questionnaires were supervised by the class teacher of the students concerned. To ensure consistency, the questionnaires were discussed in a department meeting and each member of staff was given detailed instructions on their completion (see Appendix III). Where possible, I also tried to go into their lessons and help.

The questionnaire was piloted with three year 11 classes. No major problems were experienced although a number of minor alterations were made to the format and administration of the questionnaires as a result. Some students had thought they were being tricked into giving a high mark to classroom displays in section one, where this activity was placed top of the list. To avoid biases caused by this, classroom displays was placed sixth in all subsequent questionnaires. Future ones were also presented in landscape format on A4 coloured paper so they looked less forbidding to students and allowed me to colour-code different samples. I supervised the year 11 classes while doing the questionnaire and this opened my eyes to many student pitfalls. For example, some individuals started completing section one as if it required scaled responses rather than ranks. Such experience was a great help when it came to giving instructions to other staff later on.

### *5.1.4: Student and Teacher Interviews*

It has already been pointed out that questionnaires tend to describe things rather than explain them and the information yielded can often be quite superficial (Munn and Drever, 1990). Wilkinson and Birmingham (2003) make a similar point, stating that, while other research instruments tend to focus on the surface elements of what is happening, interviews tend to give the researcher more of an insight into the meaning and significance of what is happening. While students definitely gave more lengthy answers to this study's questionnaire than they did for Noone (2004) it was still felt necessary to conduct a set of semi-structured interviews after preliminary questionnaire analysis. This meant that students could be probed for more interesting additional information and encouraged to elaborate their ideas.

Quota sampling was used to obtain a representative sample of the school population (Robson, 2002). Two pairs of students each from years 7, 8 and 10 were chosen. Year 11 had already started exam leave and I had not taught year 9 that year so neither of these groups was interviewed. Mixed-gender pairs were used because MacBeath *et al.* (2003) among others point out that students can feel intimidated by one-to-one discussions with a teacher and are more likely talk openly in the presence of a peer they know reasonably well. The students were chosen by their class teachers and for each year group one pair of high / medium attaining students and one pair of medium / low attaining students was selected. Staff were asked to send me pairings consisting of students whom they thought could get on together and who were likely to talk freely.

The interviews lasted for about 15 minutes each and they were taped (a) to provide an accurate record for later transcription and (b) so that I could converse naturally with the students and concentrate on probing interesting points raised by them. I explained to pupils why a tape recorder was used, emphasising that nobody else would hear the tape and that it would be anonymous, and they all seemed quite happy with this. The location was Lab 5 as this was the room with most displays in it to act as stimulus material should the need arise.

The key questions asked during the interview are summarised in Table 3. As preliminary data analysis had already been done on the year 11 questionnaire by this time, and other questionnaires were being similarly treated as they came in, I have also included with some of the questions my rationale for asking them. The KS3 interviews

| Interview Question | Rationale for Question |
|---|---|
| **1.** What do you think of when we use the word display in school?<br>**2.** Which displays have you used before and what did you do with them. | The written responses in section 2 of the year 11 questionnaire mainly concerned wall displays. I wanted to see if the interviewees thought this and, if so, why? I also wanted to establish exactly which activities they had done so our discussion was based on a common understanding. |
| **3.** The questionnaire suggested people don't get the chance to use displays very often. Do you agree?<br>**4.** Why do you think this is so? | Students had not been asked to explain on their response to column A (frequency of use) on the questionnaire as the latter concentrated on their personal preferences. |
| **5.** Many students thought they got to do practicals more often than displays – what's the difference between a practical and a display (or is there one)? | Students given questionnaires clearly saw practicals as separate from even active displays – why? |
| **6.** What sort of things have you personally learned from displays?<br>**7.** What is it about a display that helps you learn? | To explain in more depth responses to questionnaire questions 1 and 2. |
| **8.** Do you ever find out things from displays that are around you but you haven't used in lessons (even if they're from another class)? | Do students learn from the "open storage" of display items? – a continuation of Noone (2004). |
| **9.** What makes displays fun (or are they)? | To explain in more depth responses to questionnaire questions 3 and 4. |
| **10.** What is the worst thing about displays?<br>**11.** How could you make them better and what other science topics could you use them in? | I wanted to make students think really hardly and honestly about how the displays they used could be improved. Further informed questionnaire question 5. |

*Table 3: The main questions asked of pupils during the interviews. The rationale for each question is also given.*

| Interview Question | Rationale for Question |
|---|---|
| **1.** What types of display have you used? | Used to check we had a common understanding of what was to be discussed. |
| **2.** What made you do so?<br>**3.** Did students benefit from this display work? How and why? | I wanted to see if teacher rationale for using displays had any similarities with that of museums. Informs research question 2. |
| **4.** Were there any practical constraints with using displays? How could they be overcome? | To inform research question 3 on overall practical constraints. |
| **5.** How would you have improved the displays themselves? | This question looked at individual displays, rather than the practical constraints of displays in general. |
| **6.** What was the worst thing about the displays you did? Could this problem be overcome? | This prevented staff from being too "helpfully" positive in their answers! |
| **7.** Is student behaviour an issue when it comes to the use of displays? | Interviewed students had surprised me by commenting on the poor behaviour of some of their peers – did teachers think this was a general issue or one linked with using displays? |
| **8.** Are there any other areas of the curriculum you think might lend themselves to this type of work? | Having used displays this year, where did staff think we should go next with them? |
| **9.** Do you think it's worth spreading display expertise around the department and, if so, how do you think it should be done? | How should we achieve the above? Or are the methods already being employed to do this good enough? |

*Table 4: The main questions asked of teachers during the interviews. The rationale for each question is also given.*

followed the pattern of questions quite closely, although students nevertheless talked at length. Year 10 student answers, however, tended to carry the interview forward so they needed less prompting.

Teacher interviews were conducted in the first week of the summer holidays 2005. This was because everyone was very busy and tired towards the end of the year and I felt that interviewing during term time would be unreasonable, especially considering all the support colleagues had already given me with trialling displays and student data collection. Three staff were selected who had used a particularly large number of my objects and classroom displays during the year. Two were biology specialists and one a physicist. Questions asked, and the rationale behind them, are shown in Table 4. Interviews were conducted singly and taped for transcribing.

### *5.1.5: Other Methods of Data Collection*

Photographs were also used to conveniently and accurately convey a wealth of detail. Whilst in Noone (2004) all photographs were taken by the writer, in this study it was intended to use the pupils as photographers. Schratz and Steiner-Löffler (1998), Prosser (1998) and MacBeath *et al.* (2003) suggest this as an effective way for students to convey their preferences and Groundwater-Smith and Kelly (2003) adopted their approach, seeming to provide a visual version of the "pupil voice" research described in Ruddock *et al.* (1996). Unfortunately, curriculum pressures, time and the limited availability of the school camera equipment prevented any systematic use of this technique and so it was abandoned in favour of teacher-record photographs (see Appendix I) to supplement the research log.

## 5.2: Ethical Issues Concerning Data Collection

Robson (2002: p69) identifies ten questionable practices in social science research and these are dealt with in more detail by BERA (2004). The BERA report identifies ethical guidelines for educational studies under a number of headings and the most important of these to this research is "Responsibilities to Participants".

The participants here were my colleagues and the students. In some cases these latter were passively part of the context (e.g. in observations I observed methods of learning, not individual pupils) but sometimes they were required to take a more active role in the research (e.g. through questionnaires and interviews). Voluntary informed consent and right to withdraw are requirements of the guidelines. Staff were given this opportunity to agree to their participation at the outset. This was not deemed to be necessary when students were part of the context or doing short questionnaires as a class, as these were normal classroom activities and observations and surveys are part of the everyday school routine. However, students and staff were kept informed of the purposes of the research at all times by, for example, adding an explanatory paragraph to questionnaires (see Appendix III). Those asked to take part in interviews were not expected to do so unless they felt fully comfortable about it and had volunteered.

The BERA guidelines also draw attention to the possible conflict between the dual role of teacher and researcher. My research was not detrimental to student learning as it was based on student opinions within the school, successful previous practice and a wealth of educational literature. Furthermore I did not engage in the dangerous practice of withholding benefits from some participants as the methods used to teach students before the introduction of displays was assessed by interviewing staff and examining past schemes of work. Indeed, more students benefited from my new resources than could possibly participate in questionnaires or interviews!

Articles 3 and 12 of the UN Convention on the Rights of the Child stipulate that children's best interests should be put first and their views taken into account. The BERA guidelines say this should apply to young people also and that the approval of guardians and responsible others should be gained. As this was a small, school-based study not covering any serious issues of welfare, I simply asked senior staff for their consent. The use of photographs within the school is already part of normal practice, and has been endorsed by parents, so no special provision had to be made for this issue. Nevertheless, the faces of pupils pictured in Appendix I are blurred and consent sought from the adults shown with them.

Participants have a right to privacy and anonymity. In Noone (2004) neither of the questionnaires used were anonymous. The reasons for this were twofold. Firstly, having pupil names allowed the researcher to look up information (e.g. year group) that had been left off accidentally, rather than excluding otherwise useful data. Secondly, it was useful to know names so that any particularly interesting opinions could be followed up at a later date. I continued in this fashion during the present study. However, no details of any individual questionnaire or interview were given to anyone else, in this report or otherwise. There was a possibility that negative perceptions of colleagues could have come to light during the course of observations or interviews. Such issues would have needed careful treatment but, thankfully, they did not arise.

One final issue is the ethics of school collections, especially the appropriate treatment of the increasing number of living animals. Careful preparation of living quarters was carried out before the acquisition of each species with the help of references like Baker (1999), Marshall (2001) and Willis (2003). Arrangements were also made for their maintenance during holidays. It was important to check the various species kept in Lab 5 are housed in accordance with health and safety regulations and animal welfare is also an issue (often of genuine interest to many students). On both these fronts I have consistently followed Institute of Biology guidelines (Reiss, 1996) and those of CLEAPSS (1992). In the case of the scorpion and tarantula, advice was also sought from Oxfordshire LEA advisers. All this information, coupled with my personal experience, was used to write a series of risk assessments for the various animals and plants in Lab 5 **[xiii]**. As well as fulfilling an LEA requirement, these serve as a set of instructions for other staff on how to take care of the animals in my absence and they also provide information on when and how to use them during lessons.

## 5.3: Data Analysis

### *5.3.1: Research Log, Informal Discussions and Observations*

These research instruments were collectively used for two main purposes. Firstly, they helped inform and keep an accurate record of the development of the displays upon which this research is based. This process has already been reported in Chapter 4 and so will not be given further consideration here. Their second use was to inform the development of the other research instruments, particularly the student questionnaire and interviews. This process has already been described in sections 5.1.3 and 5.1.4.

### *5.3.2: Analysing the Student Questionnaire*

In this section I will firstly consider overall treatment of the questionnaires and them move on to look at the analysis of sections one and two separately. Reference to Table 5 will show that 123 and 104 students completed questionnaire in key stages 3 and 4 respectively. The lower response rate in KS4 can be attributed to class 11C having less time to complete their questionnaire. Four year 7 classes were studied but only one year 8. The data for the latter seemed largely consistent with the younger groups, not least because this particular class had done a number of year 7 activities. For this reason, it was decided to treat the data for years 7 and 8 collectively as KS3 data. Similarly, years

| Key Stage 3 Groups | Number | Key Stage 4 Groups | Number |
|---|---|---|---|
| 7R | 24 | 10B | 19 |
| 7S | 23 | 10D | 22 |
| 7V | 27 | 11A | 27 |
| 7W | 27 | 11C | 14 |
| 8T | 22 | 11D | 22 |
| **Total KS3** | **123** | **Total KS4** | **104** |

*Table 5: Numbers of students completing the questionnaire in each key stage.*

10 and 11 were amalgamated into KS4. This was felt to be appropriate, despite the fact that year 11 were the questionnaire pilot group, because no significant changes were subsequently made to the questions asked, just to the format. The data for both year groups seemed to show similar trends and a number of student responses in the year 10 interviews reflected comments written by year 11 in questionnaire section 2.

In section 1 of the questionnaire students were asked to rank ten activities under three heading – (a) frequency of use, (b) learning value and (c) enjoyment value – by filling in three columns, A, B, and C, on the questionnaire. Table 6 shows the percentage of students who completed each of these columns correctly (some mistakenly treated it as attitude scale – see Oppenheim, 1992). There is remarkable consistency between the key stages, each column being completed correctly between 86% and 88% of the time. This demonstrates that the task was equally achievable for students of differing maturity.

The ranked data are ordinal in nature (Eagly and Chaiken, 1993) which means they lack intervals and so are unsuitable for parametric tests. For example, let us suppose a student gave displays a rank of 6 and practicals a rank of 2. All this tells us is that the pupil likes practicals more than displays – the data simply gives us an *order*. It would be invalid to assume that there are equal intervals (a scale) between the numbers on the rank – we cannot say that 2 is a third of 6 so the pupil likes practicals three times more than displays. Parametric tests (e.g. ANOVA) rely on the calculation of means, etc. (Grafen, 1994), something which cannot be done without interval scales. Thus, for this research, we must turn to nonparametric tests which make fewer assumptions and can deal with ordinal data. Was the use of ranking a mistake? No! As described in the data collection section it was necessary to get students thinking concretely about the differences between activities. Moreover, as Noone (2004) found out, the claim that alternatives like attitude scales are interval in nature is highly dubious (Oppenheim, 1992; Himmelfarb, 1993).

Two sets of tests were carried out on the data in section 1. Firstly I wanted to establish an overall rank order to see which activities students preferred under each of the three headings given. Sign tests (equivalent to the one-sample t-test – Grafen, 1994) were used to calculate the median (with upper and lower interval) for each classroom activity. From these I assigned crude ranks to the activities under each heading. These are shown in Tables 8 (KS3) and 9 (KS4) in Chapter 6. Wilcoxon signed rank tests, less wasteful versions of the sign test, were then used to test whether the median values for classroom displays differed significantly from the other activities.

The next set of tests looked for correlations between the data in each column (A with B; A with C; B with C) within each key stage. Before this could be done, data for any student who had not completed all three of the columns had to be excluded. This left 85% of KS3 pupils and 83% of KS4 ones (see Table 6). Student responses were first represented graphically (classroom display ranks for KS3 and KS4 are shown in Figures 7 and 8 respectively; all other activity ranks are shown in Appendix IV, Figures 15-23 representing KS3 and Figures 24-32 representing KS4). They were then tested for correlations between ranks using Spearman's Rank Correlation (Oppenheim, 1992; Grafen, 1994). The results for KS3 and KS4 are presented in Tables 10 and 11 respectively.

Comprehensive comparisons between age groups were not possible due to the fact that different activities had purposefully been listed on the questionnaires for each key stage. However, eight activities did overlap and it was decided to test for differences in pupil responses between KS3 and KS4. Spearman's Rank Correlation was not used for this due to differing amounts of data for these two samples. For this reason categorical data were created by counting the number of times each rank was given to each classroom activity. This resulted in twenty-four 2x10 tables (DF=9) which were used to perform a series of $X^2$-tests reported in section 6.1.5.

| Column | Key Stage 3 Responses | Key Stage 3 % Response | Key Stage 4 Responses | Key Stage 4 % Response |
|---|---|---|---|---|
| **A** | 107 | 87 | 91 | 88 |
| **B** | 106 | 86 | 90 | 87 |
| **C** | 107 | 87 | 90 | 87 |
| **All** | 104 | 85 | 86 | 83 |

*Table 6: Numbers and percentages of students in key stages 3 and 4 correctly completing columns (a) Frequency, (b) Learning Value, (c) Enjoyment Value and all three (a) to (c) in section 1 of the questionnaire (KS3, n=123; KS4, n=104).*

| Question Number | Key Stage 3 Responses | Key Stage 3 % Response | Key Stage 4 Responses | Key Stage 4 % Response |
|---|---|---|---|---|
| **1** | 102 | 83 | 91 | 88 |
| **2** | 103 | 84 | 88 | 85 |
| **3** | 93 | 76 | 81 | 78 |
| **4** | 87 | 71 | 84 | 81 |
| **5** | 76 | 62 | 65 | 63 |

*Table 7: Numbers and percentages of students in key stages 3 and 4 responding to written questions 1 to 5 in section 2 of the questionnaire (KS3, n=123; KS4, n=104).*

We have now covered the quantitative data in section 1 of the questionnaire and will turn to the written responses (questions 1-5) in section 2. Table 7 shows that progressively fewer students answer each question, reflecting the inevitable fact that not all students had time to finish the questionnaire. For all questions the percentage response is slightly higher for KS4 but a $X^2$-test did not show this difference to be significant.

Although differently worded, both questions 1 and 2 essentially asked students to indicate how displays helped or inhibited their learning. For this they were analysed together. Similarly, questions 3 and 4 (about the enjoyment value of displays) were combined. Thus, from Table 7, we can see that 84% and 88% of students in key stages 3 and 4 respectively made comments about the learning value of displays. The equivalent figures for enjoyment value are 76% and 81%.

To analyse the learning value data quantitatively a tally was made of reasons given by students for finding displays helpful or unhelpful. This was done using the computer package Atlas.ti, recommended by Coffey and Atkinson (1996). This program allows codes to be attached to pieces of data. These can then be retrieved, giving a count of how many pupil responses occur under each code. While Atlas.ti is not designed for tallying in this way, it was appropriate here due to the large number of questionnaires and their definite structure (similar treatment of data from the twelve pupil interviews would result in biases). For ease of comparability between key stages the counts were calculated as percentages, using the figures in Table 7. It was found that students tended to treat the use of objects separately to the use of classroom wall displays so data for the latter were separated out.

Figures 3 and 4 respectively show reasons given by students for learning well and poorly from displays. As individual students often made more than one comment, it will be found that the total of percentages in these and other similarly treated figures may exceed 100. The data from questions 3 and 4 about enjoyment value were similarly treated, Figures 5 and 6 respectively showing reasons given by students for learning well and poorly from displays. Finally, Figure 9 shows student suggestions for improvements (from question 5). Equivalent data for classroom wall displays are shown in Figures 10-14 (see Appendix IV). While these latter are both interesting and useful, they are strictly speaking beyond the scope of this report and space does not permit their further consideration in the discussion. One point that is worth mentioning here, though, is that the data for wall displays are highly consistent with those discussed in Noone (2004), perhaps suggesting equivalent reliability within the same context.

### *5.3.3: Analysing the Interviews*

In Noone (2004) interview quotations had tended to be used selectively to illustrate quantitative results. A more grounded and systematic approach was necessary here which allowed the data to speak for itself and so avoid misconceptions. After being transcribed, the interview data were qualitatively analysed using the computer package Atlas.ti. This was more convenient than some of the paper-based methods suggested by

Drever (1995). Robson (2002) outlines a number of advantages of qualitative data analysis computer programmes and these are certainly consistent with my experience:

- They provide an organised single location storage system for all stored material.
- They give quick and easy access to material (e.g. codes) without using cut and paste techniques.
- They can handle large amount of data very quickly.
- They force detailed consideration of all text in the database on a line-by-line basis.
- They help the development of consistent coding schemes.

There were disadvantages with using Atlas.ti but these were to do with the practicality of using it rather than the analysis *per se*. For example, transcribing the data, while it increased accuracy greatly, took a huge amount of work and time. As Drever (1995) points out *"one minute of talk may produce a page of transcript."* Proficiency in the use of qualitative data analysis computer programmes like Atlas.ti also takes time and effort (Robson, 2002).

# Chapter 6: Results & Discussion

Overall structure is given to this section by use of the research questions as a starting point. In this way data from the many different sources used in this case study can be drawn together in a coherent way. The results and discussion are given consideration simultaneously for ease of reference.

## 6.1: Research Question 1

*"In what ways and to what extent do pupils perceive the use of displays and collections to contribute to their motivation and learning?"*

### *6.1.1: Definitions – what do students understand the term display to mean?*

When filling in section 2 of the questionnaire, 45% of KS3 student comments concerned the learning value of objects and 46% concerned their enjoyment value. The remainder were to do with wall displays. The corresponding figures for KS4, however, were lower – 31% and 13%. Thus, there is a tendency for KS4 students to take the word display as meaning mainly wall displays, despite the explanatory paragraphs at the top of the questionnaire. Why was this?

Reference to Table 1 (p46) can probably provide us with part of the answer. If we look at the five display activities conducted with years 7 and 8 it can be seen that they all involve active learning. By contrast, only four out of the ten activities used with years 10 and 11 included active student involvement (lunar samples, generic plant structure, food web cards and the fossils practical). The others were essentially teacher demonstrations using materials that were present in Lab 5 as "open storage" for most of the year. To the student mind, these could have effectively been seen as wall displays to which the teacher may have referred for a few minutes in certain lessons. Indeed, one of the year 10 pupils interviewed commented *"you can also have objects on the wall"*. Moreover, given that wall displays surround students in most classrooms for most lessons, it is only natural that they should be referred to more frequently than objects which may have only been used formally in lessons for ten minutes or so.

Data from the interviews seems to confirm this explanation. Questions 1 and 2 were partly designed to elicit what pupils thought a display was (see Table 3). KS3 pupils made roughly equal numbers of comments about objects and wall displays, although their definitions of the latter were more succinct. Wall displays were seen as being pictures, poster and pupil work stuck to the wall. Definitions given of objects were more descriptive, indicating perhaps that students had never consciously considered them as displays before. This is illustrated nicely by the following comment:

> *"Because it's not ... like ... when you think about displays you mostly think about pictures, even though it's not just pictures, and then you don't really ... it's not obvious when you look at displays you don't always know that you're looking at a display."*

KS4 students made only one comment alluding to the use of objects (quoted in the previous paragraph). Apart from this their definitions of displays matched closely with those of the younger students.

Another confounding factor with KS4 was that the year 11 classes are re-organised in late November each year from mixed-attainment groupings to Foundation and Higher groups. This meant that the three year 11 groups sampled contained a number of students who had used few if any displays for active learning, an issue which many of these students raised while completing the questionnaires. Unfortunately, however, it was not possible to sample students in any other way (form time could not be used as even the original science groups differed from the forms).

Thus, the reader should be aware when considering the rest of this section that, although students of all ages think of displays as including the use of objects and wall displays, with KS4 there is an emphasis on the latter.

### *6.1.2: How frequently do students perceive displays to be used?*

Table 8 shows that key stage 3 pupils think displays are infrequently used – they are ranked joint seventh out of eight ranks. Wilcoxon signed rank tests showed that there was no significant difference between the frequency of use of displays and researching a topic. Displays were more commonly used than tests ($p \leqslant 0.000$) but students used more audio visual materials ($p \leqslant 0.023$), class discussion, practicals, teacher presentations, individual help from the teacher and teacher question-and-answer sessions ($p \leqslant 0.000$ in each case). Key stage 4 students ranked displays seventh out of seven ranks (see Table 9), feeling that displays were used less frequently than all the other activities ($p \leqslant 0.000$).

| Classroom Activities | A: Frequency of Use (n=107) | | | B: Learning Value (n=106) | | | C: Enjoyment Value (n=107) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Median | Interval (lower/ upper) | Rank | Median | Interval (lower/ upper) | Rank | Median | Interval (lower/ upper) | Rank |
| **Class discussion (teacher led)** | 2.00 | 2.00, 2.50 | **1** | 4.00 | 3.50, 4.50 | **2** | 5.50 | 5.00, 6.00 | **4** |
| **Practical work** | 3.50 | 3.00, 4.00 | **2** | 1.50 | 1.00, 1.50 | **1** | 5.00 | 1.00, 1.50 | **1** |
| **Teacher presentation** | 4.00 | 3.50, 4.50 | **3** | 5.50 | 5.00, 6.00 | **4** | 5.00 | 4.50, 5.50 | **3** |
| **Individual help from teacher** | 5.50 | 5.00, 6.00 | **4** | 4.50 | 4.00, 5.50 | **3** | 6.00 | 5.50, 6.50 | **5** |
| **Researching a topic** | 7.00 | 6.50, 7.50 | **7** | 6.00 | 5.50, 6.50 | **5** | 6.50 | 6.00, 7.00 | **6** |
| **Classroom displays** | 7.00 | 6.50, 8.00 | **7** | 6.50 | 6.00, 7.00 | **6** | 5.00 | 4.50, 5.50 | **3** |
| **Teacher-led question and answers** | 5.50 | 5.00, 6.00 | **4** | 6.50 | 6.00, 6.50 | **6** | 6.00 | 5.50, 6.50 | **5** |
| **Using audio visual materials** | 6.50 | 6.00, 7.00 | **6** | 5.50 | 5.00, 6.00 | **4** | 3.00 | 2.50, 3.50 | **2** |
| **Using handouts** | 6.00 | 5.50, 6.50 | **5** | 7.00 | 6.50, 7.50 | **7** | 7.00 | 6.50, 7.00 | **7** |
| **Doing tests** | 7.50 | 7.00, 8.00 | **8** | 8.00 | 7.00, 8.50 | **8** | 9.00 | 8.50, 9.50 | **8** |

*Table 8: Summary of key stage 3 pupils' responses to section one of the questionnaire. Medians shown are at 95% confidence.*

| Classroom Activities | A: Frequency of Use (n=91) | | | B: Learning Value (n=90) | | | C: Enjoyment Value (n=90) | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Median** | **Interval (lower/ upper)** | **Rank** | **Median** | **Interval (lower/ upper)** | **Rank** | **Median** | **Interval (lower/ upper)** | **Rank** |
| **Teacher-led discussion** | 4.00 | 3.50, 5.00 | **2** | 5.00 | 4.50, 5.50 | **3** | 6.00 | 5.50, 6.50 | **4** |
| **Practical work** | 8.00 | 7.50, 8.50 | **6** | 3.50 | 3.00, 4.50 | **1** | 2.50 | 1.50, 3.00 | **1** |
| **Presentation of topic by a teacher** | 3.50 | 3.00, 4.00 | **1** | 4.50 | 4.00, 5.50 | **2** | 6.00 | 5.50, 6.50 | **4** |
| **Receiving individual help** | 6.50 | 6.00, 7.00 | **5** | 4.50 | 3.50, 5.00 | **2** | 6.00 | 5.50, 6.50 | **4** |
| **Using handouts** | 3.50 | 3.00, 4.00 | **1** | 6.00 | 5.50, 6.50 | **5** | 7.00 | 6.50, 7.50 | **6** |
| **Classroom displays** | 9.00 | 8.00, 9.00 | **7** | 8.00 | 7.00, 8.50 | **7** | 6.00 | 5.50, 6.50 | **4** |
| **Using audio &/or visual equipment** | 5.50 | 5.00, 6.00 | **4** | 5.00 | 4.50, 5.50 | **3** | 3.50 | 3.00, 4.00 | **3** |
| **Teacher questioning** | 5.00 | 4.50, 5.50 | **3** | 7.00 | 6.50, 7.50 | **6** | 7.50 | 7.00, 8.00 | **7** |
| **Working in pairs / groups** | 6.50 | 6.00, 7.00 | **5** | 6.00 | 5.50, 6.50 | **5** | 3.00 | 2.50, 3.50 | **2** |
| **Exercises (working examples)** | 4.00 | 3.50, 4.50 | **2** | 5.50 | 5.00, 6.00 | **4** | 6.50 | 6.00, 7.50 | **5** |

*Table 9: Summary of key stage 4 pupils' responses to section one of the questionnaire. Medians shown are at 95% confidence.*

In the interviews most students in both key stages acknowledged that they had used displays but opinions as to the frequency with which they did so varied. Although the sample size is very small, it would appear that KS3 pupils actually taught in Lab 5 for a significant proportion of the year were more likely to think they used displays often. Students taught elsewhere acknowledged that they had done displays but felt they were a rare occurrence because *"they were spread out a bit.... seems like we didn't do it so much"*(Y8). This should have been true for all classes, but in Lab 5 there seems to have been an element of continuity as many of the displays were still present in the room both before and after having been used formally in lessons. It appears that students continued to learn from the objects around them in an informal manner, backing up the assertions of Noone (2004) and Wellington (2000), among others, that informal learning can indeed be used effectively within the school curriculum. One year 10 student actually commented that seeing the succulent plants at the back of the room helped when it came to the adaptations lesson in which they were used.

The KS4 students interviewed were very negative about the frequency with which practical tasks in general, and displays in particular, were used. They also had clear perceptions as to what caused this. They remembered doing *"absolutely millions of practicals"* at KS3 *"which was lovely but I guess like the GCSE course is more important"*. This reflects the views of writers like Broadfoot (1996) and Murphy (1996) who note with concern the extent to which the Government's reliance on summative assessment, league tables, etc. often works against the use of activities that can promote true learning.

### *6.1.3: How do students perceive displays to contribute to their learning?*

Despite their relatively infrequent use, students do have a slightly more positive view of the learning value of displays. KS3 pupils placed them joint sixth out of eight ranks (see Table 8). Wilcoxon signed rank tests found no significant difference between the learning value of displays, researching a topic, teacher question-and-answer sessions and using handouts. Students felt they learned less from tests ($p \leqslant 0.000$) and more from the use of audio visual materials ($p \leqslant 0.001$), class discussion, practicals, teacher presentation and receiving individual help from the teacher ($p \leqslant 0.000$ for each). KS4 pupils, by contrast, placed displays seventh out of seven ranks (see Table 9). They felt they learned significantly better from all the other activities listed ($p \leqslant 0.000$).

Students' written comments agree with these results. KS3 pupils expressed preferences mainly for practicals and classroom discussion. KS4 students did not compare other activities favourably with displays but both age groups preferred displays to written tasks (including tests) and reading from textbooks. These contrasting student perceptions of different learning activities are interestingly reminiscent of Hein's (1998, 1999) model (see Figure 1, p22). Pupils seem to perceive they learn better from active tasks like practicals and discussion, both of which can be associated with constructivist learning. By contrast, they think they learn less from approaches such as writing. While this latter can be creative and fun, Sutton (1992) notes that in science it often elevates doing above thinking and so can seem pointless or boring to students. However, it must be stressed that the above is just speculation as no student made any direct or indirect references to the *process* of construction.

As most science staff saw displays essentially as practicals, I was interested by the way students of all ages preferred practicals relative to displays (see Figures 7, 8, 16 and 25), and so probed students for their ideas on this in the interviews. The answers were remarkably consistent. Students took the word "practical" to mean "experiment". This latter was characterised by the use of equipment (particularly chemistry apparatus), excitement/fun (especially chemical reactions) and a greater element of control (both in terms of freedom of movement and manipulation of variables). With displays, by contrast, there was a sense of the work having been done for the students – they could not control the objects as such, and spent time merely looking at or handling them. Perhaps this distinction would have seemed less clear cut if curriculum time allowed students to really engage with objects, rather than using them largely to illustrate facts.

We now turn to what students said about how displays helped or inhibited their learning in section 2 of the questionnaire. A summary of reasons why students thought objects helped their learning is given in Figure 3. On this graph it can be seen that the opportunity for visual learning is an important factor. Students of all ages appreciated objects because they were real, allowing them to see how things worked rather than *"getting the wrong idea"* (KS3) from other sources. KS4 students also seemed to be "aware" that different people had different learning styles (presumably having covered the ideas of Gardner (1999) in PSHE), making comments like *"aids visual learners"*.

Active learning was the next most important factor. Students made it quite clear that what they meant by this was active use of the objects as opposed to having the

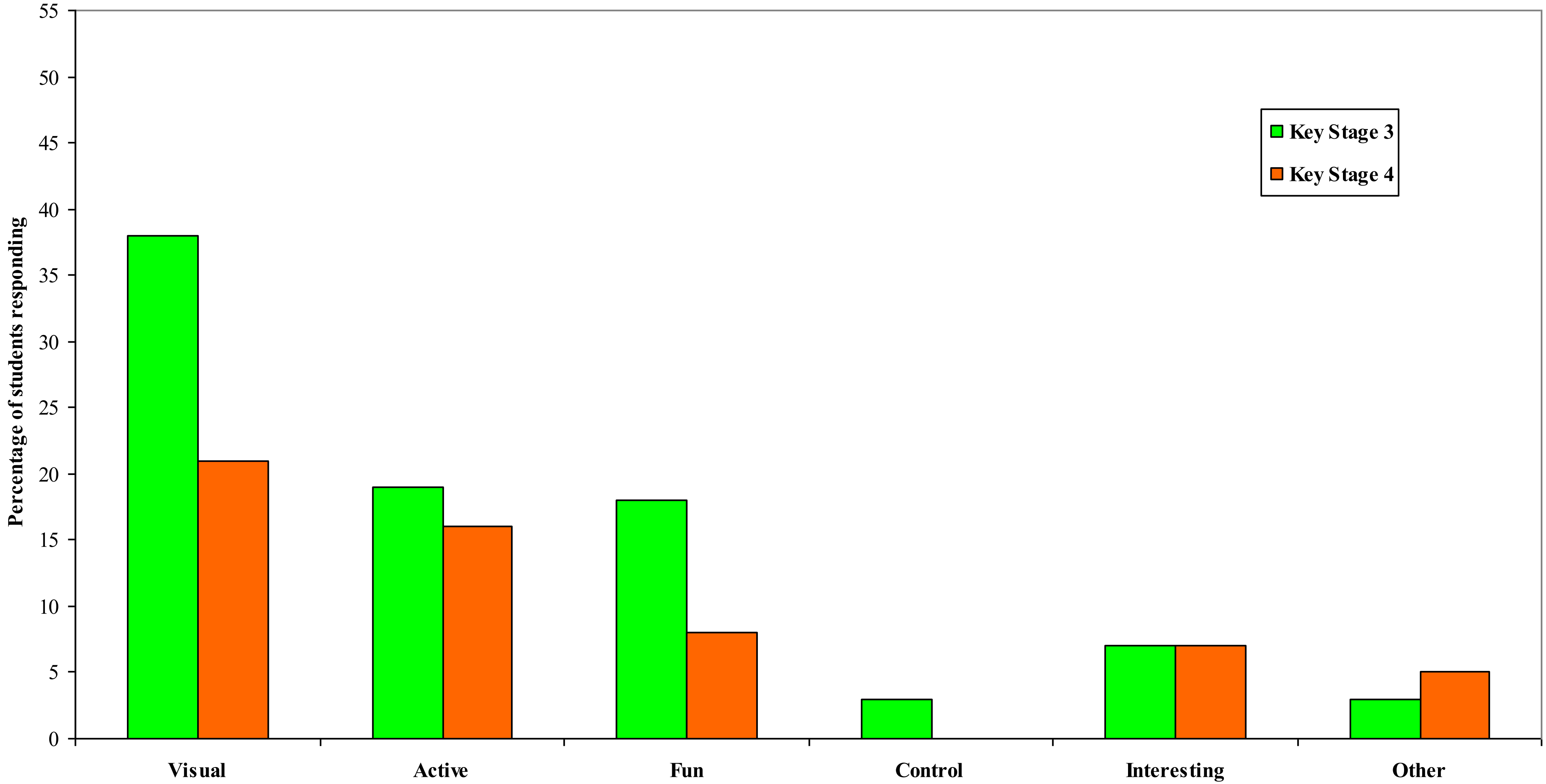


*Figure 3: Reasons given by students in key stages 3 and 4 for learning well from the use of objects.*

opportunity to circulate around the room. Despite this, very few pupils were able to articulate what it was about "hands-on" work that helped learning. However, as Hooper-Greenhill (1987) points out, learning to observe, compare make links, etc. using objects happens almost unconsciously in the struggle to find meaning. One student did come close to Child's (1997) writing about intrinsically-motivated learning: *"Helps you learn by playing with things, e.g. top trump cards* [food web cards]*"* (KS4).

Students of all ages thought objects could be fun and interesting. Key stage 3 students also commented positively on the fact that being able to walk around and look at exhibits gave them a sense of responsibility and control. This is something that Bleach (1998) and Perry (1992) have noted is often important to pupils. Students commented that they could learn at their own pace, they weren't put on the spot as much and that displays made them want to learn.

Figure 4 shows the reasons given by students for poor learning from classroom displays. The most common criticism of objects was infrequency of use. I had not expected this issue to come up under the "learning value" heading as students had already dealt with it in the "frequency" column of section 1 in the questionnaire. However, it was obviously of importance to pupils so it recurred. Most comments were not a criticism of objects *per se* but rather an expression of frustration at not having been able to use them more frequently. This was particularly the case at KS4 where over half of students indicated that they had given classroom displays a poor rank not because they weren't a good learning tool but because they were rarely used and so students hadn't learned much from them. Thus it seems that, rather than reflecting poorly on displays, the low rank given to them by year 10 and 11 students can at least partly be seen as a plea for greater temporal access to displays in the future.

An associated problem for the use of objects was physical access. This related to the fact that, with some displays, students could not actually handle the objects themselves, either due to display cabinets or tanks (e.g. the animals in jars) or due to large groups of other students making it difficult to share. Again, most of these comments seem to be directed not at the displays themselves but at classroom organisation.

Those students who stated that displays were boring or not helpful tended to give no explanation of why they thought this was so. All of those that did were KS3 pupils and they complained that, in using displays, they were revisiting topics that they had already

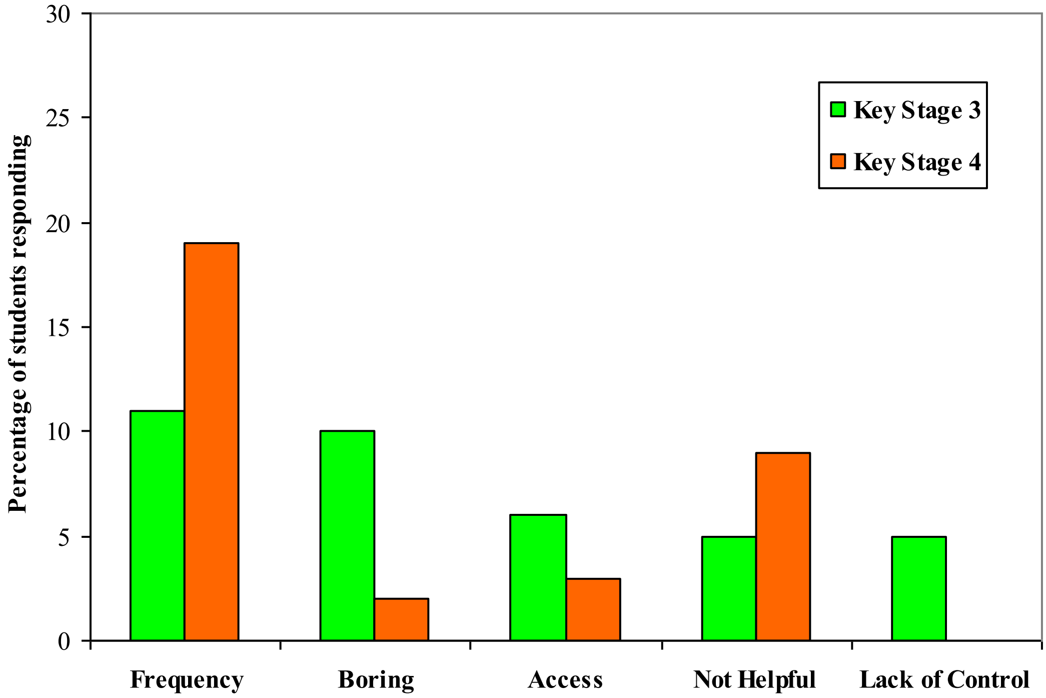


*Figure 4: Reasons given by students in key stages 3 and 4 for poor learning from the use of objects.*

studied in class – displays were seen as pointless repetition rather than useful reinforcement. While the sample size was only five, reference back to the original questionnaires showed that these students were all relatively high attaining. It is interesting to speculate that the reason they made such statements can be attributed to Piaget's stages of mental structure development (Burton, 2001). Students who had progressed from concrete operations to the formal operational stage (a process that happens at around age 12) should be able to assimilate information more readily from sources like books and so, for them, back-tracking to look at real objects may seem frustratingly easy or even patronising.

***6.1.4: How do students perceive displays to contribute to their enjoyment/motivation?***

Enjoyment value is the category in which displays came out best. KS3 students placed them joint third out of eight ranks (see Table 8). There was no significant difference between student enjoyment of displays, classroom discussion and teacher presentation according to Wilcoxon tests. However, displays were liked better than receiving individual help, researching a topic, teacher questions-and-answers, handouts and tests ($p \leqslant 0.000$). Students only preferred practicals and using audio visual materials to displays ($p \leqslant 0.000$). Results for KS4 students were quite similar. They placed displays in joint fourth position out of seven ranks (see Table 9). Wilcoxon signed rank tests found no significant difference between their enjoyment of displays and teacher-led discussion, teacher presentation and receiving help. However, pupils preferred displays to handouts ($p \leq 0.002$), teacher questioning ($p \leq 0.000$) and doing exercises ($p \leq 0.018$). Only three activities were liked more than displays, these being practicals, audio visual materials and pair/group work ($p \leq 0.000$). In written responses, a small number of students in both key stages stated they preferred practicals and discussions to displays but liked bookwork and tests less.

Figure 5 show the reasons students gave for enjoying the use of objects, although there is hardly any data for KS4 due to the definition problems outlined in section 6.1.1 above. It is interesting to note that the fact that objects are visual is far less appealing to KS3 students than the fact that they involve active participation. This is a complete reversal of what is shown on Figure 3 (concerning pupil learning) and would appear to suggest that, although pupils find that the visual nature of displays helps their learning, this does not necessarily increase their enjoyment of using them. The nature of pupil comments concerning the visual and active categories was, however, entirely consistent with those of the learning value section above. Indeed, it is notable that virtually all pupil comments in the visual, active and fun categories related directly to the displays themselves. This would appear to support the view of writers like Child (1997), Norwich (1999), Perry (1992) and Wallace (1996) that children are mostly intrinsically motivated up to about the age of 14 (i.e. they like activities for their own sake).

Figure 6 shows reasons for student dislike of displays. The main perceived problems were infrequent use (which actually suggests that students like the displays themselves) and boredom (no students detailed why they felt this). These results can probably be explained by the fact that, while Lab 5 offers a number of opportunities for informal learning, this is not so much the case in other laboratories which are more traditional. As Lab 5 is one of six science teaching rooms, not to mention the landing area and stairs, it would appear that it has a relatively small impact on the student body as a whole, although this impact is presumably greater for those students regularly taught there. The obvious way to counteract this problem would be to move on from simply sharing classroom activities with other staff to offering them objects for permanent display in their teaching rooms, something which is becoming increasingly achievable as the collections stored in Lab 5 continue to expand.

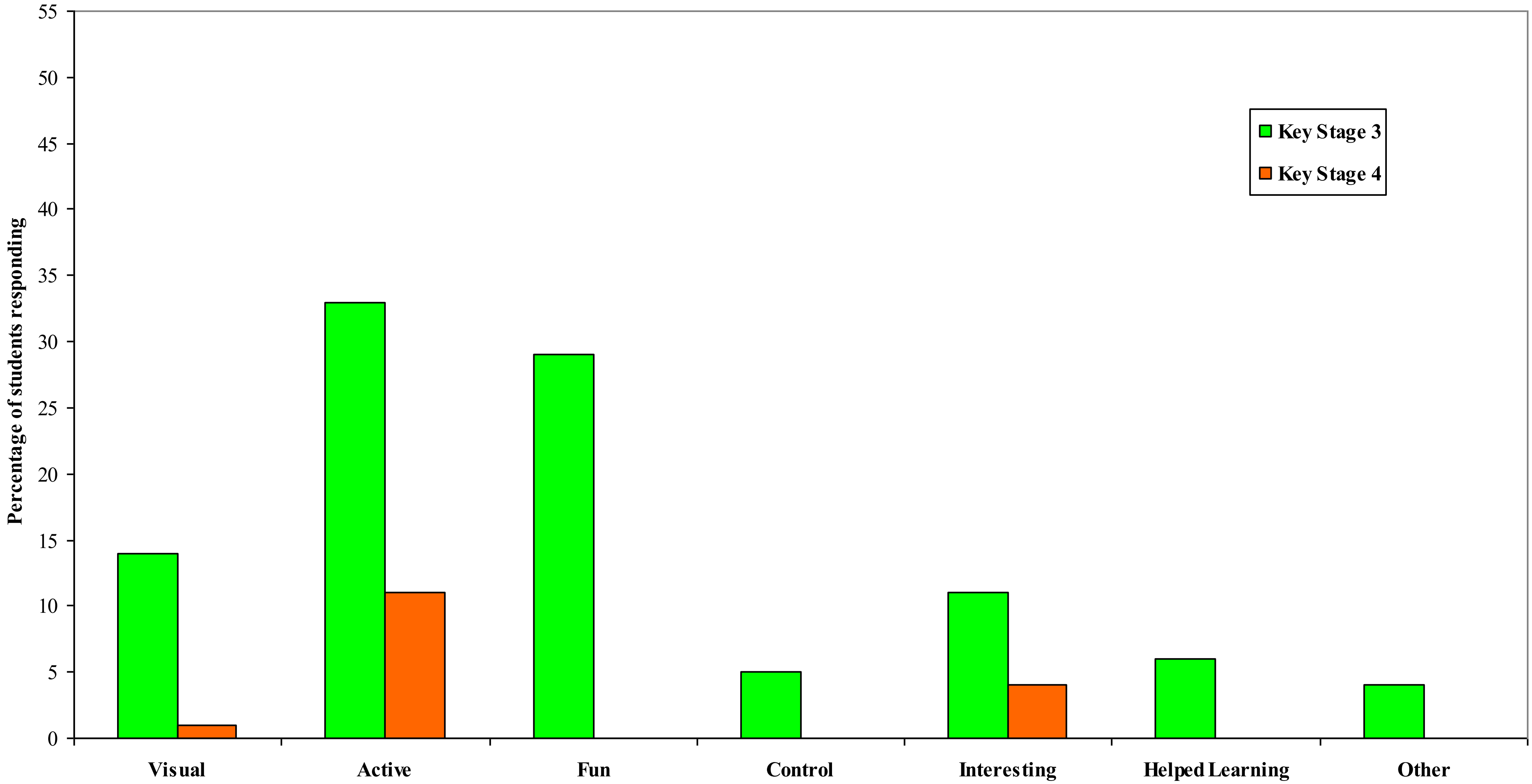


*Figure 5: Reasons given by students in key stages 3 and 4 for enjoying the use of objects.*

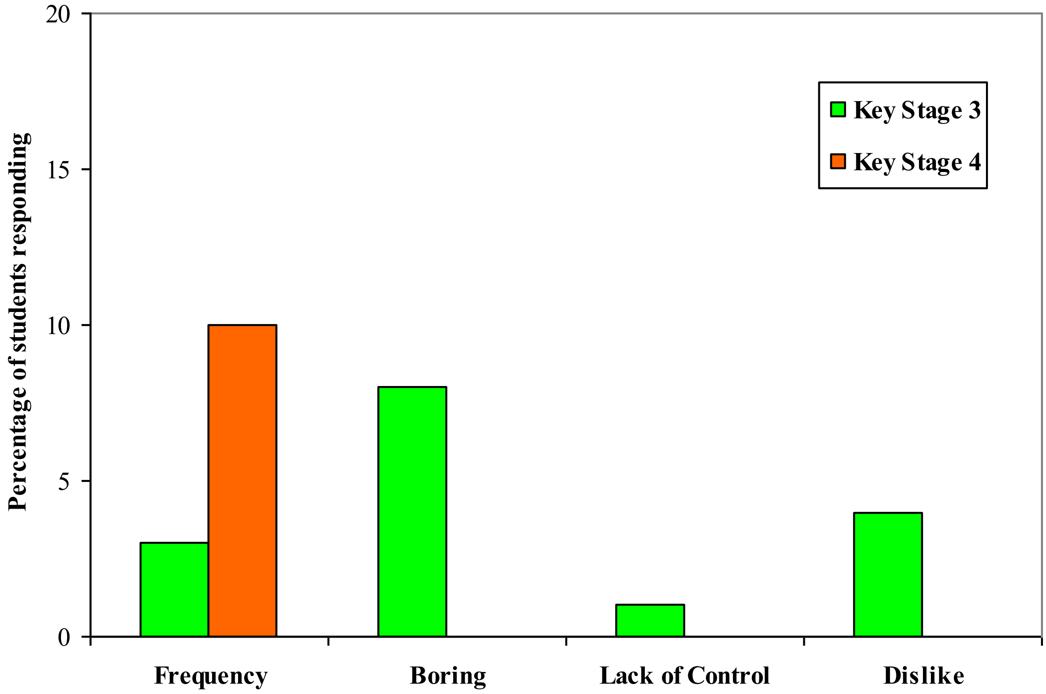


*Figure 6: Reasons given by students in key stages 3 and 4 for low enjoyment of the use of objects.*

#### *6.1.5: Were there any relationships between the frequency of use, learning value and enjoyment value of activities?*

Figure 7 shows the ranks assigned to classroom displays, under the headings frequency of use, learning value and enjoyment value, by students in KS3. At a glance, the ranks seem quite evenly spread, although a higher number of students (20% and 22%) seem to have assigned ranks 9 and 10 to frequency of use. This is reflected in the Spearman's Rank Correlation test results (shown in Table 10) which show significant correlations between frequency of use, learning value and enjoyment value. Classroom displays are one of only two activities (in either key stage) to show such a strong correlation between categories, suggesting that KS3 students may have been unsure what ranks to give them and so chose the ranks for displays more-or-less at random. Another explanation might be that younger students tend to be more overtly passionate about their opinions, resulting in a greater spread in the data. Alternatively, it could be that students were conscious of the fact that the questionnaire was about displays and so concentrated particularly hard on their responses to this activity, resulting in greater consistency across categories.

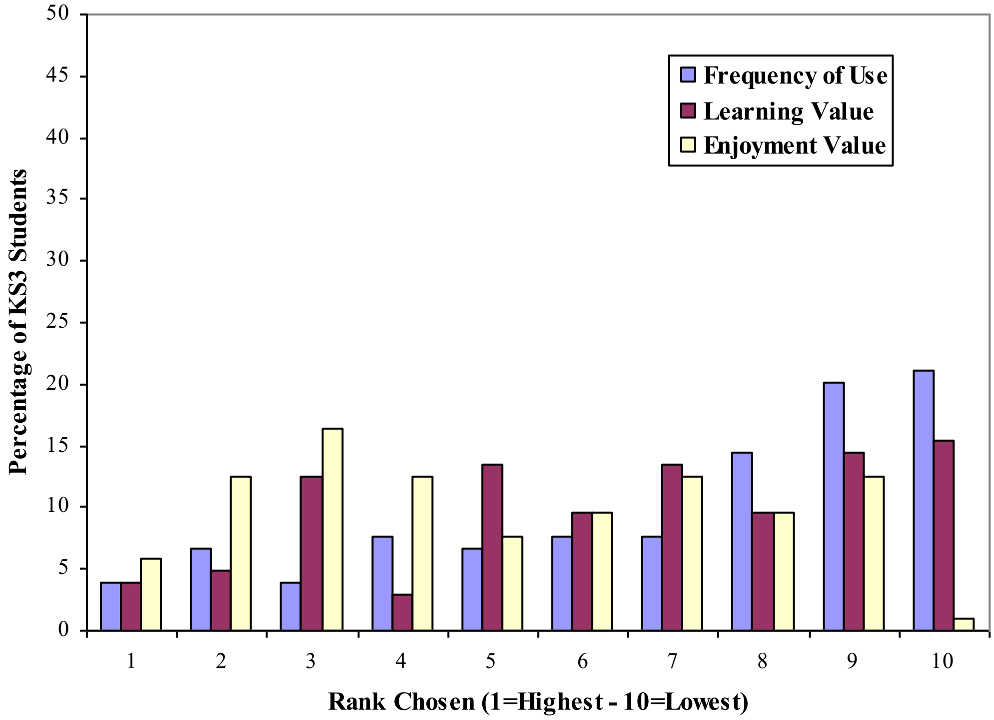


*Figure 7: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***classroom displays*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

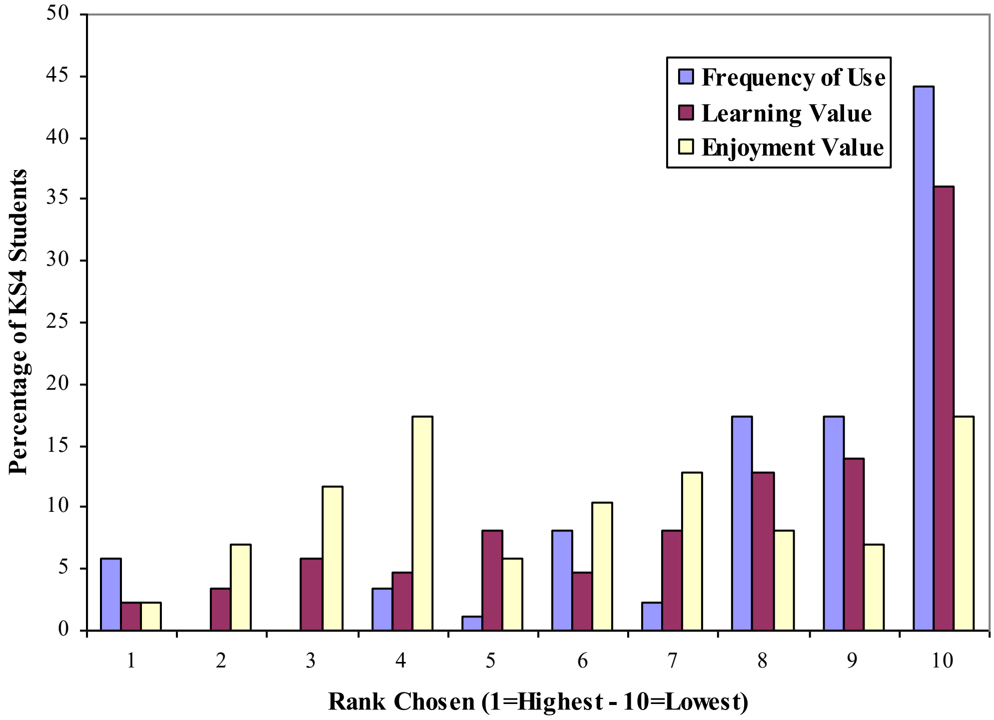


*Figure 8: Percentage of KS4 students (n=86) assigning each of ten ranks to* ***classroom displays*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

| Classroom Activities | A: Frequency of Use *with* B: Learning Value | A: Frequency of Use *with* C: Enjoyment Value | B: Learning Value *with* C: Enjoyment Value |
|---|---|---|---|
| Class discussion (teacher led) | | | 0.004 (0.283) |
| Practical work | | | 0.000 (0.650) |
| Teacher presentation | 0.020 (0.227) | | 0.001 (0.309) |
| Individual help from teacher | | | 0.001 (0.324) |
| Researching a topic | | 0.006 (0.269) | 0.000 (0.379) |
| Classroom displays | 0.048 (0.194) | 0.012 (0.246) | 0.000 (0.479) |
| Teacher-led question and answers | 0.023 (0.222) | | 0.000 (0.366) |
| Using audio visual materials | 0.001 (0.319) | | 0.000 (0.465) |
| Using handouts | | | 0.002 (0.294) |
| Doing tests | 0.000 (0.387) | | 0.009 (0.256) |

*Table 10: Correlations between the responses of Key Stage 3 pupils (n=104) concerning (a) the Frequency of Use, (b) the Learning Value and (c) the Enjoyment Value of ten different classroom activities. Numbers quoted are p-values (p≤.....) and Spearman's rho (in brackets).*

The results for KS4, shown in Figure 8, are clearer. In the data for both frequency of use and learning value there is a definite negative skew which $X^2$-tests showed were significantly higher than the KS3 data ($p \leq 0.000$ and $p \leq 0.044$ respectively). This shows up in Table 11 where there is a strong positive correlation between these two categories ($p \leq 0.000$; Spearman's Rho = 0.516), hardly surprising given the fact that students felt they used displays infrequently and learned poorly from displays due to this infrequency of use (see sections 6.1.2 and 6.1.3 above). The ranks for enjoyment value are more evenly spread and so do not correlate with frequency of use, although there is a just-significant positive correlation with learning value ($p \leq 0.047$; Spearnam's Rho = 0.215).

Graphs of ranks assigned to all the other activities are shown in Appendix IV where Figures 15-23 represent KS3 and Figures 24-32 represent KS4. The results of Spearman rank correlation tests for each activity are shown with those for classroom displays in Tables 10 (KS3) and 11 (KS4). While a detailed evaluation of all the non-display

| Classroom Activities | A: Frequency of Use *with* B: Learning Value | A: Frequency of Use *with* C: Enjoyment Value | B: Learning Value *with* C: Enjoyment Value |
|---|---|---|---|
| Teacher-led discussion | 0.001 (0.345) | 0.045 (-0.217) | |
| Practical work | | 0.029 (-0.236) | 0.001 (0.338) |
| Presentation of topic by a teacher | 0.024 (0.244) | | |
| Receiving individual help | | | |
| Using handouts | | | |
| Classroom displays | 0.000 (0.516) | | 0.047 (0.215) |
| Using audio &/or visual equipment | | | 0.007 (0.219) |
| Teacher questioning | | | 0.000 (0.477) |
| Working in pairs / groups | 0.000 (0.372) | 0.001 (0.360) | 0.000 (0.409) |
| Exercises (working examples) | 0.009 (0.280) | | |

*Table 11: Correlations between the responses of Key Stage 4 pupils (n=86) concerning (a) the Frequency of Use, (b) the Learning Value and (c) the Enjoyment Value of ten different classroom activities. Numbers quoted are p-values (p≤.....) and Spearman's rho (in brackets).*

activities is beyond the scope of this report, there are a number of patterns which are of interest.

It is noteworthy that, for KS3, there is a significant positive correlation between perceived learning value and enjoyment value for every single activity (see Table 10), although this doesn't necessarily mean that all students really do learn. Nevertheless, this appears to reflect the fact, noted by Kyriacou (1998) and Child (1997) that younger students seem to be motivated intrinsically: they like learning for its own sake. However, as students become older, they find that they begin to receive extrinsic reinforcement (e.g. exam grades, parental rewards) for learning which they had previously just found intrinsically interesting. Thus, motivation shifts from being intrinsic to extrinsic, a process called overjustification (Child, 1997). Perhaps this explains the fact that, at KS4, there is no systematic link between the learning and enjoyment values of activities (see Table 11). Students of this age may have realised that doing activities they don't necessarily like will help them achieve exam success, etc. Such a trend is reported by Norwich (1999) and Wallace (1996) among others.

## 6.2: Research Question 2

*"Which sorts of display-related activity do science colleagues think are best for teaching and learning in this department?"*

The most striking, but perhaps unsurprising, thing about colleagues' answers to this question was the extent to which they mirrored both the literature on using objects in museums and pupil perceptions of their use in the classroom. They were seen as being useful learning aids because they were visual which meant that *"you could actually take each part of the concept and split it down quite simply ... [and this] ... allowed you to tier the amount of information you gave them [students]"* (Teacher, physics). They also offered *"a more kinaesthetic approach to learning which the students tend to enjoy and get more information from"* (Teacher, physics). Objects and displays were seen as a useful way of reinforcing prior learning and livening up *"what could be seen as a fairly dry subject"* (Teacher, biology). Moreover, all the advantages staff saw in using objects had elements of constructivist learning in them (see Figure 1), despite the fact that curriculum pressures meant that all of them were using the didactic approach to various extents. This is well illustrated by the following quotes:

> *"It was following through and reinforcing what had gone before and it's a great positive improvement on how we were teaching fossils previously. We didn't actually have any hands-on so it was excellent. And for them [pupils] to realise that there's ... they're around us here in Oxfordshire and that they're not just something that some weird archaeologist has found out somewhere in Africa. I think that's brilliant, absolutely brilliant."* (Teacher, biology)
> *"It immediately grabs their attention and draws them to think about it because it's visual ... and it can all fit together with the worksheets that we've got."* (Teacher, biology)

Teachers perceived that the use of objects assisted pupils because it was visual and active, enabling them to relate new learning to their own experiences and at their own personal level. They also perceived it was easier for the teacher to take each concept and break it down into manageable chunks. The reality and novelty of objects was seen as being more likely to stimulate pupil interest, particularly that of kinaesthetic learners or those who find literacy difficult.

## 6.3: Research Question 3

*"What are the practical constraints of using displays and collections in everyday teaching and how can they be overcome?"*

### *6.3.1: Student suggestions regarding display improvement*

*"I don't know – they are already good".* Encouraging thought the words of this KS3 pupil are I feel there is nevertheless some room for improvement. Question 5 at the end of the student questionnaire attracted fewer responses than any of the others but, having been present when most of the questionnaires were done, it is clear that this was largely due to the fact that slower students, or those who had become distracted, failed to finish.

32% and 19% of KS3 and KS4 students respectively made comments relating to the use of objects (as opposed to wall displays), suggesting that pupils had either forgotten the emphasis of the questionnaire by this stage, or that they were largely satisfied with the objects used. The improvements suggested for use of objects are shown in Figure 9. The main one for students of both age groups was to increase the frequency of use of displays. The KS3 students went into some detail as to how this could be done by, for example, having follow up discussions or doing further work on them in the next lesson *"to get the best out of them"*. The next most important thing to students was the use of animals. One student in each key stage expressed a dislike of the dead specimens. All the other comments advocated continuing to increase the animal collections.

Although access to displays is a minor category in Figure 9 this issue was discussed at some length by pupils in the interviews. For KS3 students the main problem seemed to be large numbers of pupils having to crowd around the objects, making it difficult for everyone to get a look in or write things down. This was particularly the case with teacher demonstrations and insects kept in tanks against the wall where *"you can only see one side of them"*. Students suggested having smaller, better-organised groups and one recalled how his teacher had once achieved this by splitting the class into two, where *"one half of us went to look at some stuff and the other half did some work with her [teacher], which was quite fun"*. More thoughtful grouping should also allow more collaborative learning (Uzzell, 1993). On the other hand, pupils liked the fact that

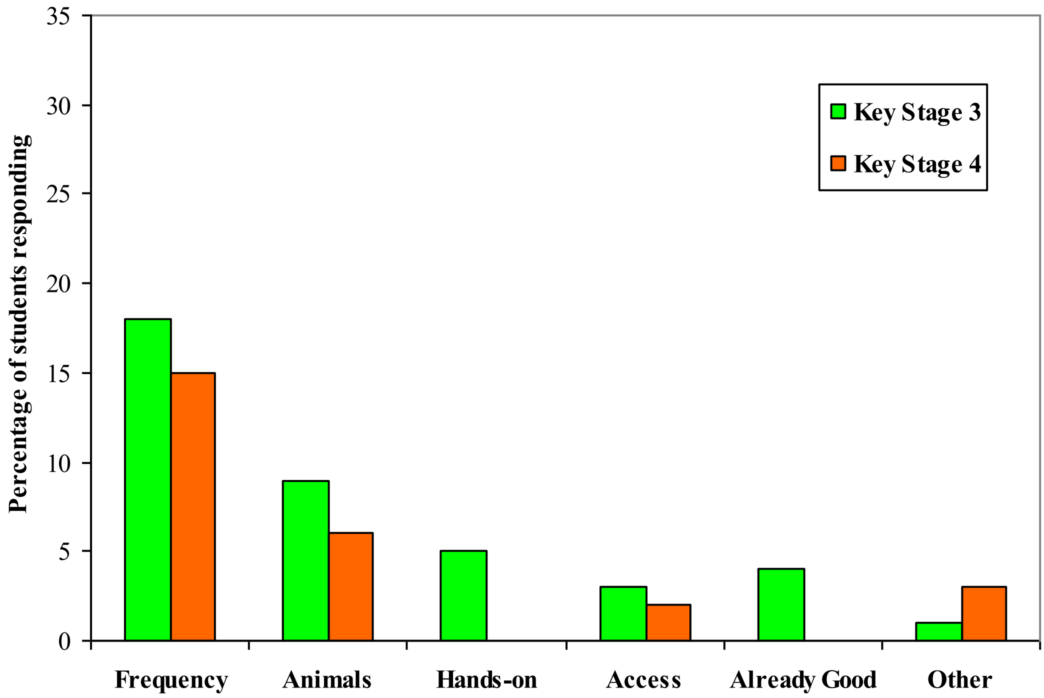


*Figure 9: Improvements which could be made to the use of objects in the classroom suggested by students in key stages 3 and 4.*

objects were placed around the room on benches when they were being used. This was better because many exhibits had to be stored high up when not in use and so were out of view of many younger students. It had originally been intended to buy lots of small tanks that live animals could also be put into for the duration of a lesson. In this way students could move around the room looking at them. However, there were insufficient funds at the time for this to happen and so it must remain a project for the coming year. Having objects on benches was also more comfortable for students when taking notes or doing worksheets because *"you can put your book there instead of having to lean on your knee or something"*. Such comments reflect Hein's (1998) idea that addressing issues of pupil comfort encourages learners to spend more time with objects, engaging with and learning from them. They also perhaps reflect Maslow's "Hierarchy of Needs" theory where physical well being, etc. are a prerequisite for effective learning (Capel *et al.*, 2001; Child, 1997).

While the views of KS3 pupils seemed to centre around classroom management issues concerning displays, those of KS4 students tended to focus on the objects themselves (apart from the frequency of use issue dealt with in sections 6.1.1 and 6.1.2). One of the most interesting suggestions was that more of the objects kept on semi-permanent display in Lab 5 should be labelled with names and short key facts. In this way, they could be used for reference throughout the year, rather than just being seen during a short teacher demonstration and then largely forgotten. One year ten student actually commented at some length on how she had learned from the labels on the succulent plants **(7)** and how this helped her learning about plant adaptations. Such an approach would allow the informal use of exhibits to spread beyond the confines of the individual lesson. It also conflicts with the negative picture of display labels in museums painted by the Schools Council (1972) and Martin *et al.* (1991), although it should be noted that not all museum writers share their views (e.g. Hein, 1998). More interestingly still, one of the main reasons given by students in both key stages for perceiving that they learned well from wall displays (see Figure 10 in Appendix IV) was that they could be used for reference and one of the main improvements suggested for wall displays concerned quality of information provided (see Figure 14 in Appendix IV). This closely reflects the findings of Noone (2004) concerning wall displays and perhaps this overlap of ideas can be put down to the fact that students perceive openly stored objects in cabinets to be similar in nature to openly stored information on walls.

### *6.3.2: Teacher suggestions regarding display improvement*

*"Nothing jumps out as being particularly horrendous. It was all relatively easy to execute"* (Teacher, biology). This statement exemplifies the staff response to using displays. All teachers felt that they stood up well in comparison to other activities and needed very little improvement. Indeed, many of the improvements suggested related to fine tuning for individual students or classes, something which is necessary for virtually all classroom activities. For example, one teacher experienced difficulty in grouping students for the preserved animals in jars activity and another felt the worksheet accompanying the fossils practical may be a bit text-rich for certain classes. Some comments, however, were more general.

One concerned the amount of time I had to put in to creating the activities, something which required a degree of effort many staff cannot mirror due to other commitments. Most colleagues found that getting the objects laid out around the room before pupils arrived could be a difficulty, especially with activities like the rocks mat which required the moving of furniture. They also noted problems with the size of objects (e.g. the lunar samples were very small) and their variety (e.g. the sample of preserved specimens in jars was skewed towards the vertebrates). Differentiation was another issue that came up. Whereas the rocks mat activity, for example, scored extremely highly in this respect, the classification activities used at KS3 did not. One possible solution given was accompanying each specimen with a label that had the answers in multiple-choice form. However, none of the issues discussed were felt to be insurmountable and it was suggested that activities could easily be evaluated and modified through discussion at department meetings.

### *6.3.3: New ideas for the use of objects*

This is a topic that both students and teachers were questioned about quite intensively during the interviews. I had been expecting lots of ideas relating to areas of the science curriculum in which objects are not already used but was surprised to find that this was not the case. Indeed only one teacher, when pressed, mooted the idea that a working model may assist pupils in learning about the electric motor. This would suggest that either interviewees did not have time to think through the issue carefully enough during short interviews or that they thought most of the topics to which the use of objects and displays could be practically applied had already been covered. The latter explanation would seem to be supported by the fact that pupils made comments like *"displays are best for environment and animals"* and both students and teachers merely suggested refinements of existing classroom activities.

Most of the new ideas related to the use of wall displays as a follow up to using objects. This would allow an element of continuity and permanence, as suggested by students in Section 6.3.1 above, and would particularly benefit classes taught in labs that do not yet have extensive collections like Lab 5. KS3 pupils suggested having a large maps of the school pond on which they could mark where they found each organism, as they had noticed differences in where these lived. Perhaps this could be achieved thought the use of labels printed with the images on the food chain cards **[vi]** and linked to data on environmental factor obtained using the science department's new electronic data harvest equipment. KS4 students suggested the use of colourfully labelled student photographs to remind them of work they had done and teachers advocated the use of wall displays to summarise complex topics like the reactivity series.

### *6.3.4: Classroom management issues*

Although rarely referred to and at no great length, issues of classroom management were noted consistently by pupils and so are treated separately here. On the questionnaires a small number of KS4 students noted that they saw off-seat activities as a chance to have a chat. Some students also referred to the food web cards as *"playing snap"*. This activity did involve playing a version of top trumps so that pupils became familiar with the facts and figures associated with various organisms but this beneficial effect may not have occurred if they were playing a more simplistic game. Alternatively, the students mentioning snap may simply not have been able to remember the name of the activity.

In the KS3 interviews a greater number of other classroom management issues were discussed. Here, there were some instances where "good" students felt that their access to displays had been restricted by the fact that *"some people in our form can't be trusted"* or were *"being silly"*, problems which can be associated with special classroom activities in general. Another problem was that some pupils disrespect the work of their peers: *"in history there were kind of like displays we did – weapons – and people just destroyed them – removed them, broke them. And that sort of thing's a worry"*. While no such comments were made with direct reference to the use of objects, this is obviously a potential issue. However, there have been no instances of damage to the exhibits in Lab 5, despite the fact that not all exhibits are stored in locked cabinets (e.g. plants **(7)**, fish **(12)** and fossils **(16)**). Perhaps this reflects the fact, noted by the Schools Council (1972), that pupils value objects for their novelty and so, while sometimes needing guidance on their use, nevertheless respect them.

Teacher comments reflected these views. Staff noted that the environment had to be well ordered and students trustworthy before they would consider any higher risk interactive activity such as the use of objects. Many factors such as time of day and the value of equipment to be used would affect their decisions about which classes to use displays with. Despite this, they felt that teaching groups for whom such issues would be a consideration were in the extreme minority. Such problems might be more likely to arise, it was felt, for trainee teachers or NQTs.

#### *6.3.5: Spreading best practice around the department*

Most colleagues seemed happy about the way new ideas were spread around the department in the past year. However, various comments nevertheless revealed that some staff had slipped through the net. One teacher, who pointed out that the year 11 environment module had few displays, obviously hadn't been made aware of the plant-related teacher presentations, for example. There was a consensus that carrying on with the dissemination on new ideas in department meetings was the best way forward as these provided a quick and convenient way to say *"Look, this is good ..."* (Teacher, biology). These also offer the opportunity to keep technicians fully informed. Other ideas suggested included writing new activities into schemes of work and adding them to a new "KS3 Ideas" notice board in the staff work room. More formal methods like lengthy written instructions were felt to be impractical.

# Chapter 7: Conclusions

In this conclusion I will discuss the key findings of my research and consider the main implications for future professional practice. Perhaps the most striking discovery for me was the low rank for learning value which students gave to displays. While this was also the case for frequency of use, as might be expected, it was in disheartening and seemingly inexplicable contrast both to the findings of Noone (2004) and to students' apparent enjoyment of displays throughout the year. However, closer examination of the qualitative data revealed that, far from disliking displays, pupils were simply frustrated at the infrequency with which they were used. As I analysed the student responses in questionnaires and interview transcripts it became increasingly apparent that, far from being bored by displays, students not only enjoyed them but saw in them many, if not all, of the benefits for learning which the literature on similar practices in museums would lead us to suspect they should possess. In particular, students seem to hone in on those aspects of constructivist learning theory espoused by writers like Hein (1998) and Hooper-Greenhill (1999) to name but a few, albeit probably unconsciously. In particular, pupils emphasise the visual qualities of objects, the way in which they can be actively engaged with and the fun and interest they provide. Moreover, the views of these students seem to be echoed by their teachers.

Does this mean that a school science laboratory can be turned into a museum? Do pupils think Lab 5 has been already? Or do my results suggest this should be done in the future? The literature certainly does seem to suggest that informal learning, such as that which takes place in museums, and the formal learning in schools are not mutually exclusive. Indeed, writers like McManus (1992) and Wellington (2000) seem to be very much in favour of introducing elements of informal learning into the classroom. What is equally apparent, however, it that few authors think it is either wise or achievable to try and replace formal curricula with a wholly constructivist approach. This tension was also evident in the responses of my pupils. While most students intrinsically enjoyed displays, and felt that they could learn from them, key stage four students in particular were concerned that such activities should be relevant to and useful for their GCSE's. As long as there is a testing regime in schools, students will be extrinsically motivated to learn via traditional styles and informal learning must be tailored to suit this need.

So did I manage to achieve this happy balance between formal and informal learning in my science department? The answer would appear to be, "partly". Students taking part in activities involving the use of objects generally enjoyed them and learned from them. For classes in most laboratories, however, this learning seemed fragmentary because objects were only seen for a short period of time. By contrast, for pupils taught mainly in Lab 5, the openly stored exhibits and materials used occasionally for activities seem to have acted as a reference point, informally reinforcing prior learning every time they are looked at. It appears, therefore, that the value of objects and displays lies not just in the short period of time for which they might be formally used in a lesson, but in their capacity for drawing the attention of students – who might otherwise just be unproductively walking by, or waiting to be given more work, or chatting with their peers – at a later date. Thus, objects are transformed from being instruments of didactic knowledge transmission to a part of the students' environment that can be engaged with constructively, supplementing and enhancing the learners' understandings of the world at their own pace.

All this would suggest that the display activities which have been implemented over the past year have indeed been successful. However, Lab 5 is distinct from a museum. While people in general, and teenagers in particular, may visit museums with relative infrequency – perhaps a couple of times a year at most – a given student will be present in a school science laboratory three or four times a week during term time. Thus, while pupils may not devote such an extended period of time to looking at school objects as they might to a dramatic museum exhibit, they probably see the former far more often, and its impact on their learning is likely to be greater, particular if an interested teacher, willing to answer impromptu questions, is present. It would seem, therefore, that while informal constructivist learning in schools is different to that in museums, it is nevertheless desirable to continue using natural objects and school collections both in lessons and displays.

What then are the practical implications of this research? An obvious starting point is the continued expansion and improvement of the objects and collections displayed in Lab 5. Enhancement of animal housing and labels is ongoing and plans are already being laid for the acquisition of new specimens later in the current academic year. Moreover, these materials should be spread around the department, so that more pupils can benefit from them, and used increasingly for pupil activities as well as teacher demonstrations, especially at key stage four. However, this must be done with consideration: while most staff are happy to embrace the use of displays, it would be an unreasonable burden to impose them indiscriminately on busy colleagues. The dissemination of best practice will continue through the use of department meetings, schemes of work, PGCE lectures, etc. During the course of this research, both students and staff advanced useful suggestions for the improvement of existing displays and the creation of new ones and these ideas should also be acted on. Indeed, a successful bid for funding to buy a digital camera for my department was recently made, based on the preliminary findings of this research. It will facilitate student ideas such as that discussed in section 6.3.3 concerning the photography of pupil activities for later reference. Above all, perhaps, the authors of the Workload Agreement (DfES, 2003) should be informed that, far from being a time-wasting administrative task, the creation and use of school displays and collections is a useful professional activity which pupils, staff and the relevant literature all perceive to be of great importance in students' learning.

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# APPENDIX I – Pictures of Objects and Activities Discussed in this Report


**Picture 1:** Some laminated insect identification charts brighten up a dull cupboard.


**Picture 2:** Fact-of-the-Week (centre) with other laminated displays.


**Picture 3:** Two new display cases, partially filled with bones and seashore items collected by year 8 pupils. It is intended that students will label the items during the coming year.

**Picture 4:** Lab 5's original display cabinet. The items are now better spread out for labelling and, ultimately, themed displays are planned.


**Picture 5:** The aquarium presentation beside the tank itself.


**Picture 6:** A run-down corner transformed by the Wildlife Elective for housing cockroaches and other insects.


**Picture 7:** A selection of cacti and other succulents. The plant on the right is a *Euphorbia* (more closely related to the Christmas *Poinsettia* than to cacti) and the stimulus question beside gets students thinking about convergent evolution.


**Picture 8:** The pebble plants camouflaged in their tray of pebbles – can you spot all seven of them?

**Picture 9:** A collection of orchids, ferns and bromeliads growing in hollowed-out branch to represent the plant community that lives hundreds of feet up in the rainforest canopy. How much of this habitat will be left in fifty years time?

**Picture 10:** A bulrush with its roots submerged in a large tub of water. Water lilies and other aquatic plants can also be conveniently grown in this way.

**Picture 11:** The carnivorous plants in the greenhouse. These were used in lessons on the nitrogen cycle

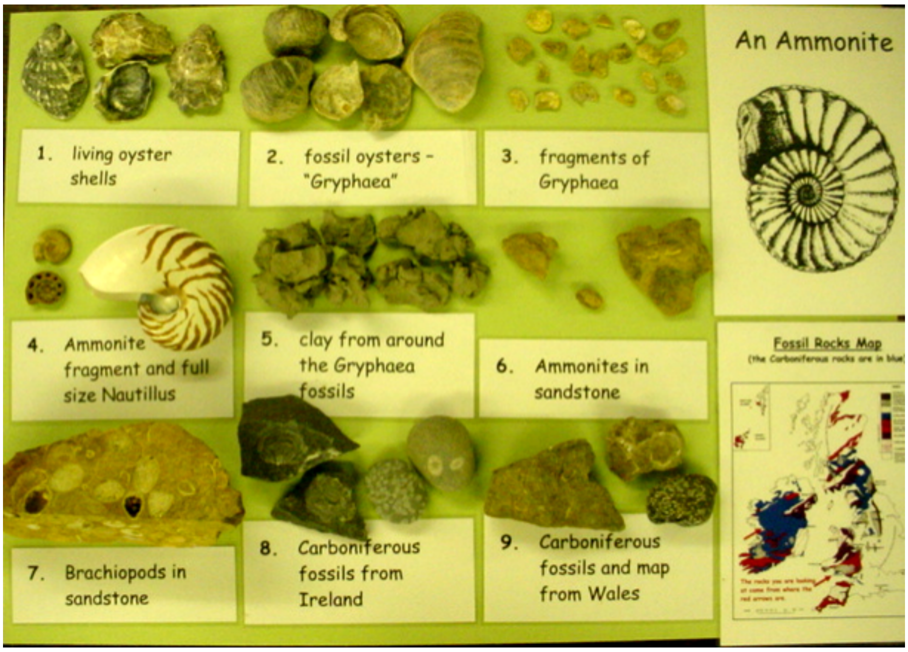
**Picture 12:** A fish tank kindly provided by a retired member of staff.

**Picture 13:** "Gummy" the fish with a large benign tumour growing on his head. This had been present for three years prior to the school being given him and was used when discussing mutations.

**Picture 14:** A stick insect posing as a twig on a bramble leaf, its staple diet.

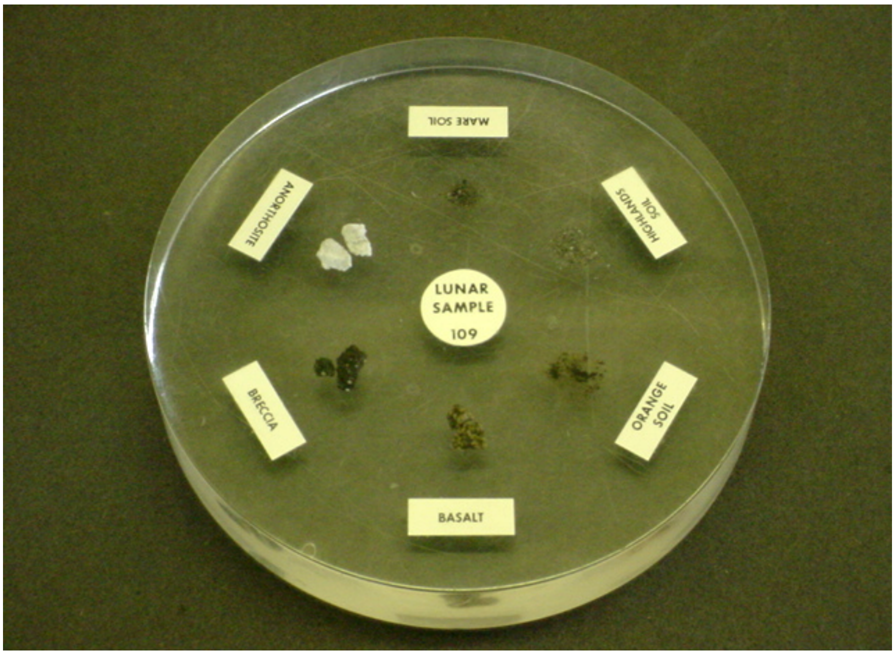
**Picture 15:** The stuffed birds loaned from Oxfordshire County Museum (in cases) to look at beak sizes. From left to right: male bullfinch; juvenile greenfinch; juvenile great tit; female bullfinch; blue tit (top); robin; male greenfinch; male bullfinch.


**Picture 16:** Two small display cabinets. The one in the foreground contains carboniferous fossils collected from Wales by students and Ireland by the writer. The other one contains more recent fossils collected by students from the nearby reservoir at Farmoor.

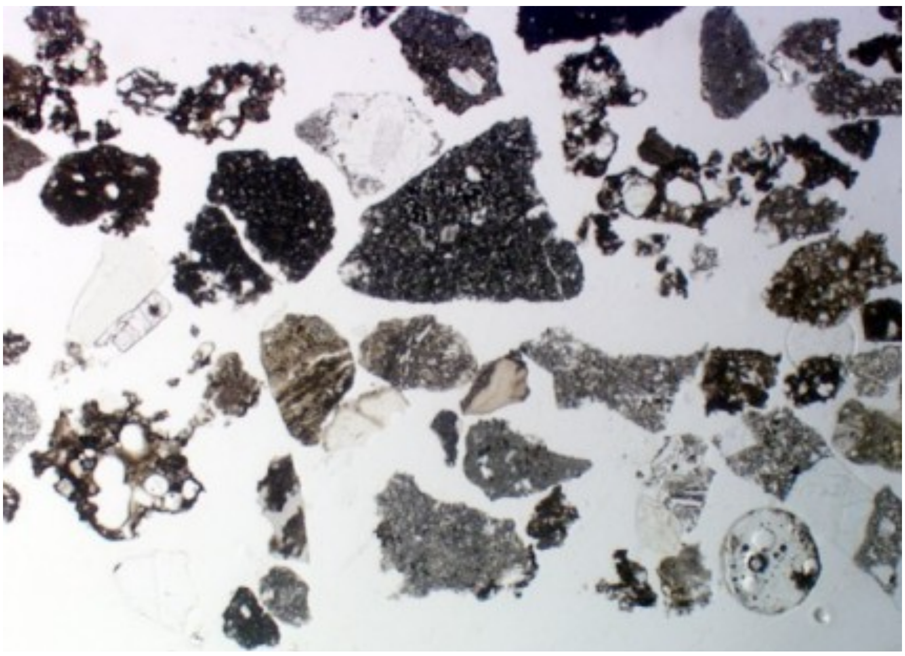



**Picture 17:** A representative sample of materials used in the year 11 fossils practical. The nine groups of objects were spread around the lab to ease student access.

**Picture 18:** The University Museum's rocks mat in use. The class has been shown a rock and are deciding if its card is in the right place on the rock cycle. (NB staff consent given for photo).




**Picture 19:** The lunar samples in their sealed plastic case (about 15cm across). Students also got to see and hold meteorites.



**Picture 20:** Microscope view of some lunar dust. Image © Particle Physics and Astronomy Research Council (PPARC).

**Picture 21:** Students and staff taking out the lunar samples to look at during a lesson. (NB staff consent given for photo).

**Picture 22:** “Roz” the Chilean Rose Tarantula in her tank.

**Picture 23:** Roz's moulted skin. Apart from the shrivelled abdomen (and lack of movement!) this is indistinguishable from the live animal.

**Picture 24:** "Josephine" the African Emperor Scorpion.

**Picture 25:** Scorpions fluoresce under ultraviolet light due to the molecular structure of their cuticle. A small UV lam is used to demonstrate this to students learning about the electromagnetic spectrum. Picture taken from Marshall (2001).

**Picture 26:** Students in the Wildlife Elective being shown around the University Museum. They were also taken behind the scenes to hold live invertebrates and find out how to care for them. (NB staff consent given for photo).

**Picture 27:** Death's Head Cockroaches donated by the University Museum. They are easily maintained and so make ideal school pets.


**Picture 28:** The locust cage which the school already possessed but which had been out of use for some years. Inset: locust on a student's arm.

**Picture 29:** The preserved specimens. Some of the invertebrates have been dried but most specimens are pickled in alcohol.

**Picture 30:** A common hawker dragonfly which hatched out of the tank shown in picture 5. Its exuva (empty nymph shell) was left in the tank.

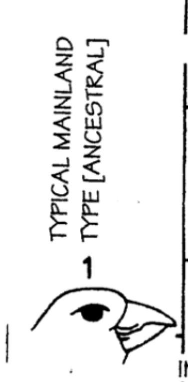

**Picture 31:** The stuffed birds in close up with their labels below and some small posters behind to act as stimulus material.

# APPENDIX II – Resources Discussed in this Report

# DARWINS FINCHES AS EVIDENCE THAT EVOLUTION TOOK PLACE.

**Study the birds below which need to be labelled Galapagos Finches**
**The Typical Mainland Type (1) was their ancestor.**

Fill in the columns BEAK CHANGE and REASON

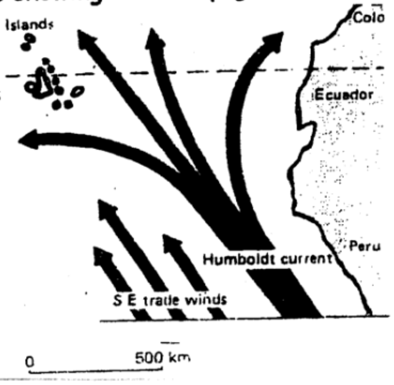



| GALAPAGOS FINCHES | FOOD SOURCES | BEAK CHANGE | REASON |
|---|---|---|---|
| LARGE GROUND FINCH | LARGE SEED | | |
| CACTUS GROUND FINCH | CACTUS SEEDS AND NECTAR | | |
| WARBLER FINCH | FLYING INSECTS | | |
| INSECTIVOROUS TREE FINCH | LARGE INSECTS | | |
| VEGETARIAN TREE FINCH | BUDS AND FRUIT | | |
| WOODPECKER TOOL - USING FINCH | INSECT LARVAE | | |

**Below is a map showing the Galapogas Islands and the mainland of South America.**

Darwin's finches are small grey or brown birds about the size of sparrows. They are only found on the Galápagos Islands which lie on the Equator about 1000 km west of South America.

There was no life on these islands when they were first formed from volcanoes.




**How would the finch have reached the islands originally?**

.................................................................

.................................................................

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.................................................................

# METALS REACTIVITY SERIES

*The reactivity series only applies to chemical reactions (the chemical corrosion of coins), not physical wear. The table further explains this difference. Look at chemical corrosion on the coins you see and use your observations to answer the questions on each metal below.*

| Chemical Wear | Physical Wear |
|---|---|
| • ***Reaction*** with finger acid (pH5.5).<br>• ***Reaction*** with gases in the air (mainly oxygen, water and sulphur). | • Being worn smooth by rubbing.<br>• Being scratched and dented by other coins. |

**1. Gold (Au)**
Compare the 1893 and 2002 sovereigns. How much of the wear is due to chemical reactions? ..........................................................................................................................
What properties of gold make it prone to physical wear?......................................................
..........................................................................................................................................

**2. Silver (Ag)**
Describe how the coins corrode over time. .............................................................................
..........................................................................................................................................
Three of the silver coins seem to defy the general trend. The *1887 Sixpence* is darker than expected and the *Henry III Long-Cross Penny* and *Seleucid Tetradrachm* are shiny. Why?
*1887 6d. (Hint: it came from the Birmingham area)* ...............................................................
..........................................................................................................................................
*Henry III Penny*.........................................................................................................................
..........................................................................................................................................
*Tetradrachm (Hint: is all of the coin shiny?)* ..........................................................................
..........................................................................................................................................
Why is the French word for money "argent"? ..........................................................................

**3. Copper (Cu)**
Describe the corrosion on these coins - is it serious? ..............................................................
..........................................................................................................................................
The 1773 farthing was left outside for many years. What chemical reaction took place? What is the name of the green substance on its surface. (I.S.2, page 72 may help you)
..........................................................................................................................................
..........................................................................................................................................
..........................................................................................................................................
If pure copper is so resistant to corrosion, why are pennies now made of copper-plated steel? ..........................................................................................................................
..........................................................................................................................................
..........................................................................................................................................

**4. Lead (Pb)**

Lead is pretty unreactive, was discovered about 4000 years ago, and yet has never been used for coins. What properties of lead might make it unsuitable for coinage? ....................

.......................................................................................................................................

.......................................................................................................................................

**5. Iron (Fe)**

Describe the corrosion of the pennies that have had their copper-plating removed. .............

.......................................................................................................................................

.......................................................................................................................................

Why do you think iron wasn't used for coinage until the 1940's? .......................................

.......................................................................................................................................

What is the common name for iron oxide? ............................................................................

The Italian coins haven't corroded at all. What metals have been alloyed with the iron to make this possible? What is this alloy called? (C.S.Chem. Pg 155 may help you) ..............

.......................................................................................................................................

.......................................................................................................................................

**6. Zinc (Zn)**

Describe the corroded zinc coins ..............................................................

.............................................................................................................

.............................................................................................................

If zinc is so reactive, why was it used for coins? (Hint: look at the dates and countries) ...........................................................................................

.............................................................................................................


**7. Aluminium (Al)**


Why wasn't aluminium used for coins before the 20th century? (C.S.Chem. Pg 148 may help) .................................................................

Aluminium is the most reactive metal ever to have been used for coinage. Does the amount of corrosion on the coins you see reflect this? Why/why not? ..........................................................................................

..............................................................................................................

..............................................................................................................

..............................................................................................................

**8. Corrosion Prevention**

Why haven't the coins in the cases corroded?

.................................................................................................

.................................................................................................

.................................................................................................

.................................................................................................


2. Silver (Ag)
2003
Elizabeth II
£2 Britannia
1945
George VI
Shilling
1928
George V
Shilling
1895
Victoria
Florin
1823
George IV
Half Crown
1818
George III
Crown
1712
Anne
Shilling
1696
William III
Shilling
1604
James I
Sixpence
1664
Elizabeth I
Sixpence
1547-51
Henry VIII
Groat
1427
Henry VI
Groat
1301-10
Edward I
Penny
1222-36
Henry III
Penny
1887
Victoria
Sixpence
1251-72
Henry III
Penny
AD 193-211
Roman –
Septimius
Severus
Denarius
94-89 BC
Seleucid –
Philip
Philadelphus
Tetradrachm

# <u>Year 11 Fossils Practical</u>

*You will find a number of exhibits around the lab. Look at each of them and answer the questions below (each exhibit has the same number as its question). Feel free to touch the fossils!*

## <u>Part A – Comparing Fossils and Living Organisms</u>

**1.** There are two types of living oyster here, thee Common and Portuguese Oysters. Have a look at them and try to find:
Two differences ..........................................................................................
..........................................................................................................
Two similarities ..........................................................................................
..........................................................................................................

**2.** These are a type of fossil oyster called Gryphaea. They were found at Farmoor reservoir (Oxfordshire was once under the sea!) and are about 155 million years old. What do these fossils have in common with the living oysters? ..........................................
..........................................................................................................
..........................................................................................................

## <u>Part B – The Habitat Fossils Lived In</u>

**3.** These are some fragments of Gryphaea shells from near Middle Barton. They were like this when they were found. What could have caused this:
Where they lived? ..........................................................................................
..........................................................................................................
During the fossilisation process? ......................................................
..........................................................................................................

**4.** Hundreds of Gryphaea were found at Farmoor but just one bit of an Ammonite (a similar modern shell, a Nautillus, is beside it to show you what it looked like). What does this tell you about feeding relationships 155 million years ago? (Hint: pyramids of numbers) ..........................................................................................
..........................................................................................................
..........................................................................................................

## Part C – The Fossilisation Process

**5.** This is the clay the fossil Gryphaea were found in. After 155 million years it still hasn't turned to stone! What does this tell you about fossilisation? ..........................................................................
..........................................................................................................

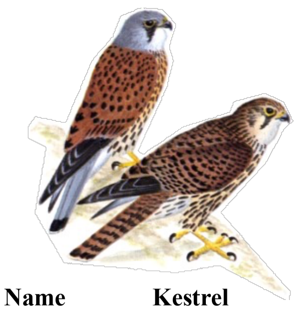
**6.** This is some sandstone from near Banbury. It contains Ammonites. How many can you see? ..................................................
Why might this rock have such a reddish colour? ............................
..........................................................................................................

**7.** Here are some Brachiopods (another type of shell). This rock has been cut so you can see inside some of them. What has formed inside the Brachiopods and how? ..........................................
..........................................................................................................
..........................................................................................................

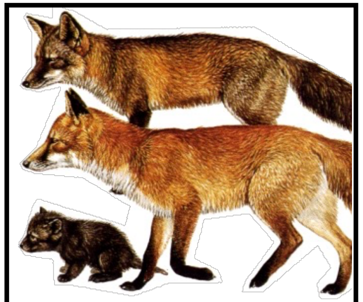
**8.** These are 340 million year old fossils from western Ireland.
What effect has time had on:
The fossils? ..........................................................................................
The substrate around them? ..................................................................
What sort of fossil creatures can you see? .......................................
..........................................................................................................

**9.** Here are some 340 million year old fossils from Wales (Kilvrough actually!). Fossils of this age are called Carboniferous fossils.
What does the map tell you about where they are formed?
..........................................................................................................
..........................................................................................................
..........................................................................................................
..........................................................................................................

| | |
|---|---|
| **Name** | **Sparrowhawk** |
| **Habitat** | Woodlands |
| **Diet** | Small birds |
| **Time / Year** | All year |
| **Numbers** | 2 |
| **Biomass** | 15 |
| **Pollutants** | 10.6 |



| | |
|---|---|
| **Name** | **Kestrel** |
| **Habitat** | Open places |
| **Diet** | Small rodents |
| **Time / Year** | All year |
| **Numbers** | 2 |
| **Biomass** | 12 |
| **Pollutants** | 0 |



| | |
|---|---|
| **Name** | **Red Fox** |
| **Habitat** | Widespread |
| **Diet** | Birds/rodents |
| **Time / Year** | All year |
| **Numbers** | 2 |
| **Biomass** | 30 |
| **Pollutants** | 0 |

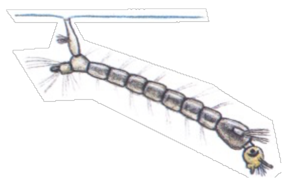
| | |
|---|---|
| **Name** | **Blue Tit** |
| **Habitat** | Tree/bush branches |
| **Diet** | Insects |
| **Time / Year** | All year |
| **Numbers** | 16 |
| **Biomass** | 50 |
| **Pollutants** | 5.3 |

| | |
|---|---|
| **Name** | **Robin** |
| **Habitat** | Ground under trees/bushes |
| **Diet** | Insects |
| **Time / Year** | All year |
| **Numbers** | 19 |
| **Biomass** | 60 |
| **Pollutants** | 5.5 |

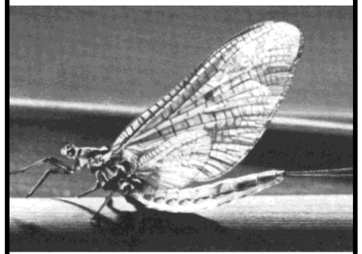
| | |
|---|---|
| **Name** | **Song Thrush** |
| **Habitat** | Trees/bushes |
| **Diet** | Insects/fruit |
| **Time / Year** | All year |
| **Numbers** | 7 |
| **Biomass** | 70 |
| **Pollutants** | 7.8 |

| | |
|---|---|
| **Name** | **Redwing** |
| **Habitat** | Trees/bushes |
| **Diet** | Insects/fruit |
| **Time / Year** | Autumn/Winter |
| **Numbers** | 8 |
| **Biomass** | 70 |
| **Pollutants** | 0.1 |

| | |
|---|---|
| **Name** | **Field Vole** |
| **Habitat** | Fields |
| **Diet** | Grasses |
| **Time / Year** | All year |
| **Numbers** | 30 |
| **Biomass** | 80 |
| **Pollutants** | 0 |

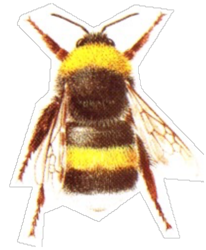


| | |
|---|---|
| **Name** | **Mosquito larvae** |
| **Habitat** | Free swimming |
| **Diet** | Algae |
| **Time / Year** | Spring/Summer |
| **Numbers** | 12,500 |
| **Biomass** | 80 |
| **Pollutants** | 0 |



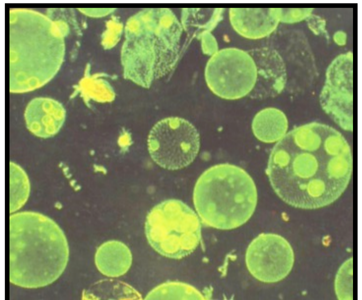
| | |
|---|---|
| **Name** | **Mayfly** |
| **Habitat** | Free flying |
| **Diet** | Doesn't eat |
| **Time / Year** | Summer/Autumn |
| **Numbers** | 500 |
| **Biomass** | 25 |
| **Pollutants** | 0 |

| | |
|---|---|
| **Name** | **Mosquitos** |
| **Habitat** | Free flying |
| **Diet** | Bites animals! |
| **Time / Year** | Summer/Autumn |
| **Numbers** | 2,000 |
| **Biomass** | 30 |
| **Pollutants** | 0 |

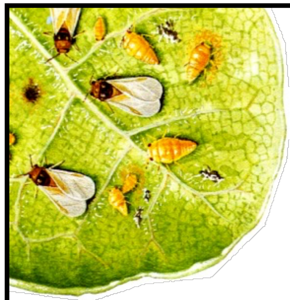


| | |
|---|---|
| **Name** | **Bumble Bee** |
| **Habitat** | Beside pond |
| **Diet** | Flower nectar |
| **Time / Year** | Spring/Summer |
| **Numbers** | 200 |
| **Biomass** | 5 |
| **Pollutants** | 0 |

| | |
|---|---|
| **Name** | **Water fleas** |
| **Habitat** | Free swimming |
| **Diet** | Algae |
| **Time / Year** | Spring/Summer |
| **Numbers** | 50,000 |
| **Biomass** | 120 |
| **Pollutants** | 0 |



| | |
|---|---|
| **Name** | **Algae** |
| **Plant type** | Floats /on weeds |
| **Features** | Microscopic |
| **-When?** | Spring-Autumn |
| **Numbers** | 1,000,000 |
| **Biomass** | 2,000 |
| **Pollutants** | 0 |



| | |
|---|---|
| **Name** | **Greenfly (aphid)** |
| **Habitat** | Trees/shrubs |
| **Diet** | Leaf/stem sap |
| **Time / Year** | Spring/summer |
| **Numbers** | 10,000 |
| **Biomass** | 100 |
| **Pollutants** | 1.0 |

| | |
|---|---|
| **Name** | **Water hoglouse** |
| **Habitat** | On weeds/mud |
| **Diet** | Dead leaves |
| **Time / Year** | All year |
| **Numbers** | 10,000 |
| **Biomass** | 130 |
| **Pollutants** | 0 |

# Pollution in Food Chains

*Work in pairs using the food web cards. This activity will help refresh your memory out food chains, food webs and pyramids of numbers/biomass. It will also help you to work out for yourself how pollutants accumulate in food webs and get you thinking about the alternatives to pesticides which farmers might use.*

**1.** Use your pack of cards to write down three food chains. These must have three or more organisms in them.

**2.** For each of the above food chains
- **a.** draw a pyramid of numbers (use the "Numbers" on the cards)
- **b.** draw a pyramid of biomass (use the "Biomass" on the cards)
- **c.** explain why the pairs of pyramids are a different shape.

The diagrams on pages 146-147 of Heinemann Biology (black book) may help you.

**3.** The sparrowhawk has more pollutants in it than any other animal on the cards (pollutants = 10.6). Look at the other animals/plants containing pollutants and work out a food web in the back of your books showing how the pollutants got into the sparrowhawk (just write down the organism name and its pollution number).

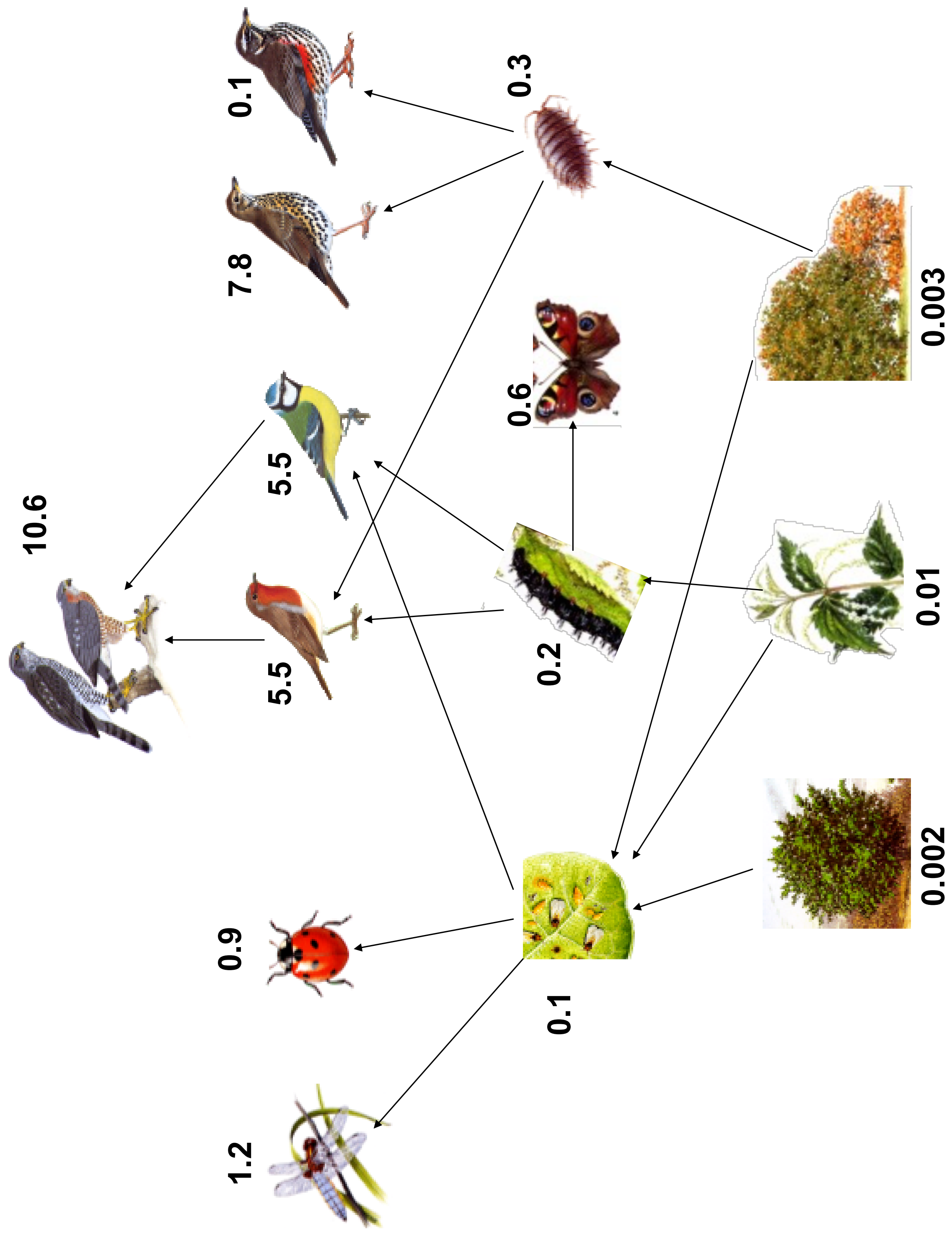
**4.** When you have had a go at the last question pick up one of the food web diagrams to see if you were right. Stick it into the front of your book and answer the following questions, using the cards to help where necessary.
- **a.** Explain why there is more pollution in animals at the top of the food web.

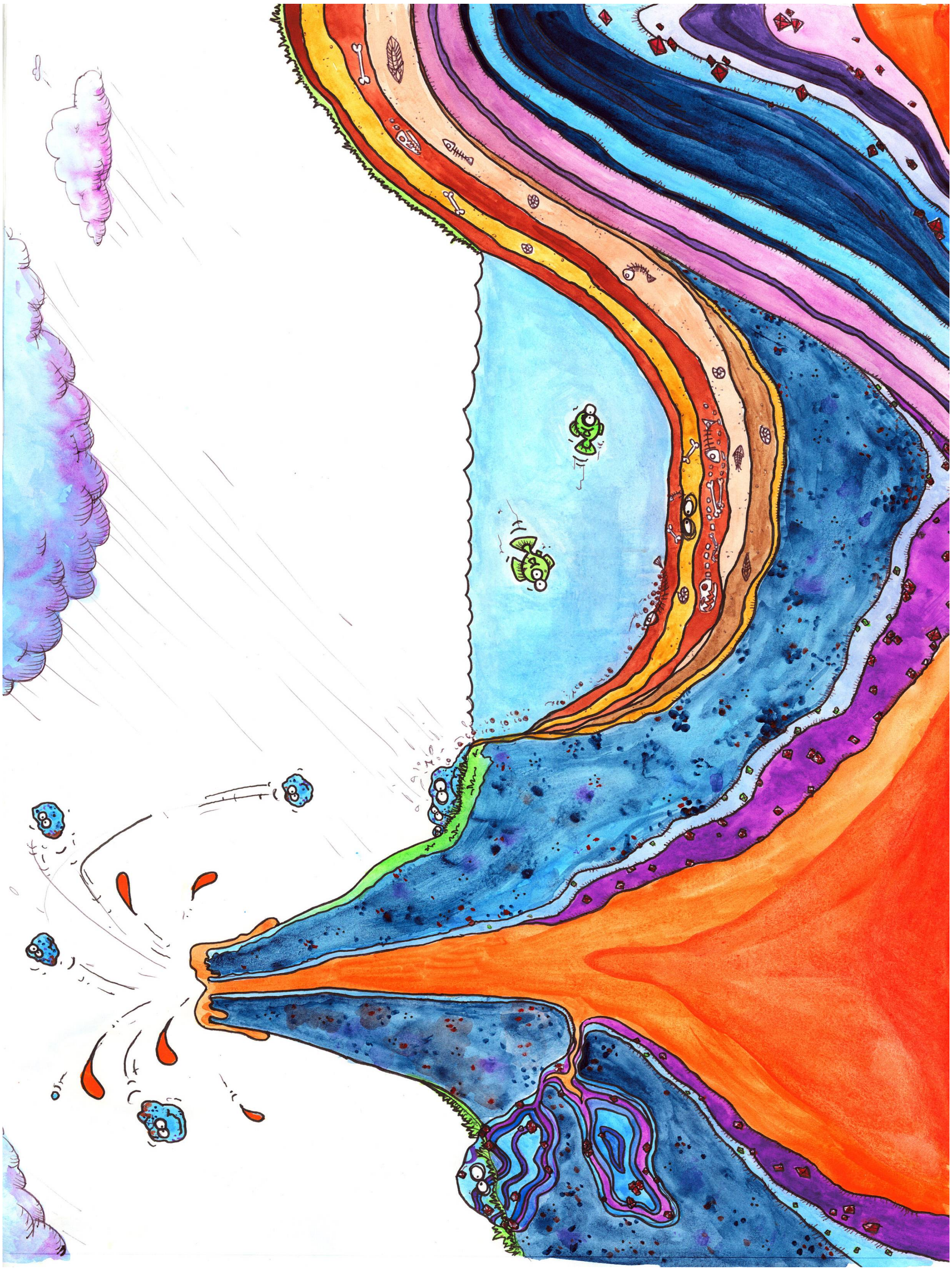
- **b.** The polluting chemical was an herbicide. Which hedgerow plant was the farmer who used this herbicide trying to kill? What was the problem with the farmer doing this?
- **c.** Each individual greenfly has far less pollutants in it than the woodlouse. Use the numbers on the cards to explain why the pollutants in greenfly are so damaging.
- **d.** The adult butterfly doesn't actually eat its own caterpillars. Why does it have more pollution in it than the caterpillars do?
- **e.** The redwing has a similar diet to the thrush but it has far less pollution in it. Look carefully at the cards for these two birds and explain why this is so.

**5.** Write a short essay about how pollution builds up in food chains. Use the following words to do this: ***herbicides, insecticides, fungicides, DDT, dieldrin, bioaccumulation, persistent chemical, biomagnification***. Heinemann Biology (black book) p166 & CS Biology p179 (green book) will help you.

**6.** Use the information on p167 of Heinemann Biology to explain what biological control is.

**7.** Draw a table with the headings "advantages" and "disadvantages" and use it to compare the chemical and biological approaches to controlling pests.


0.1
7.8
0.3
5.5
0.6
0.003
10.6
5.5
0.2
0.01
0.9
0.002
0.1
1.2



## Shale

Shale is a sedimentary rock that forms from wet clay. Layers of clay accumulate on the bottom of lakes. The layers are compressed and water is forced out making shale. Shale has fine grains, less than 0.1mm across, and has a smooth, layered appearance. Shale often has many fossils within it. The fossils usually show an incredible amount of detail because of the fineness of the grains.

## Slate

Slate is a metamorphic rock. It forms when mudstone and shale are crushed beneath other layers of rock. The enormous pressures that develop cause the flaky mineral, mica, to form crystals at right angles to the pressure. The resulting slate splits easily into thin sheets. Slate is a hardwearing stone with many uses. It can be used for roof and floor tiles, fire places and provides the smooth surface under the green baize of snooker tables. Metamorphic rocks formed by high pressures are called regional metamorphic rocks.

## Marble

Marble is a metamorphic rock formed when limestone is exposed to very high temperatures. High temperatures are caused by molten rock pushing through the earths crust. When limestone is exposed to very high temperatures, new crystals of the white glassy mineral calcite grow. This gives marble its distinctive appearance. Metamorphic rocks formed by high temperatures are called contact metamorphic rocks. Extremely pure marble is used for statues. Large blocks of coloured marble are used for columns, floors, and other parts of buildings. Smaller pieces of such marble are crushed or finely ground and used as abrasives in soaps and other products.

**Lava**

**Extrusive igneous rock**

**Weathered rock**

**Sediment**

**Sedimentary rock**

**Contact metamorphic rock**

**Regional metamorphic rock**

**Magma**

**Intrusive igneous rock**

Rock is broken down by weathering and erosion.

Grains of rock are transported to lakes and seas by rivers.

Grains of rock form sediments on the bottom of lakes and seas.

Layers of sediment are deposited on top of each other.

The weight of layers of sediment squeezes out water.

Particles in the layers of sediment become fused together over millions of years.

Sedimentary rock can be lifted up to the surface, where it is exposed to weathering and erosion again.

Sedimentary rock can be buried deep underground, where high pressures turn it into metamorphic rock.

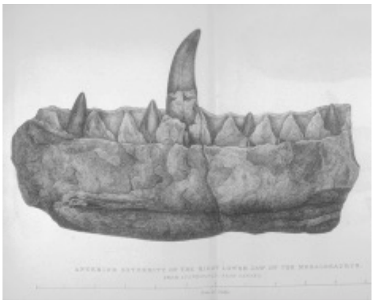
Sedimentary rock can be heated by magma under the earths crust and turned into metamorphic rock.

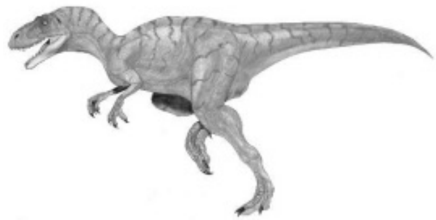
# William Buckland (1784-1856)

In 1815 Buckland found a collection of fossils near Stonefield, 9miles North West of Oxford. He carefully analised the fossilised teeth, jaws, and limb bones from a large, carnivorous reptile. He gave this creature the name *Megalosaurus,* meaning giant lizard. The word 'dinosaur' did not exist at this time and Buckland thought he had discovered some sort of large, extinct lizard. However, he was the first person to give a scientific name to a species of dinosaur, *Megalosaurus bucklandii.*

William Buckland was born in Axminster in 1784. His farther was a clergyman and when William was 17, he was sent to study theology in Oxford. He became a highly regarded man of the church and became the Dean of Westminster, appointed by the former prime minister, Sir Robert Peel.

Buckland was also a very keen scientist. His main scientific interests included collecting and studying fossils. And in 1813 he became the first Professor of Geology at Oxford University.





*Megalosaurus* was an active, carnivorous dinosaur that roamed around on two legs, 168 million years ago. It is thought to be the most common dinosaur species that existed, although no complete skeletons have ever been discovered.

Buckland was an eccentric, often dressing in strange clothes and behaving oddly. Some would describe Buckland as a brilliant science communicator who had an open mind and the grace not to take himself too seriously.

One of his students told how Buckland once rushed, hyena skull in hand, at the first student in the front row of a lecture and shouted, "What rules the world?" The youth, terrified, sat back in his seat, and said nothing. He rushed to the person next to him, pointing the hyena skull at him "What rules the world?" he repeated "Haven't an idea," the student answered. "The stomach, sir!" he cried.

In another lecture, Buckland strutted about the room imitating the walk of giant birds he believed left their footprints in ancient mud. (The "birds" could well have been dinosaurs.)

Buckland enthusiastically pioneered coprology (the study of fossil poo).

Some found Buckland's antics funny. Some found him intensely annoying and found it difficult to take his ideas seriously. Many were inspired by one of the most enigmatic free thinkers of the scientific community of the time.

# SCIENCE DEPARTMENT RISK ASSESSMENT

**Activity: Madagascan Hissing Cockroaches**

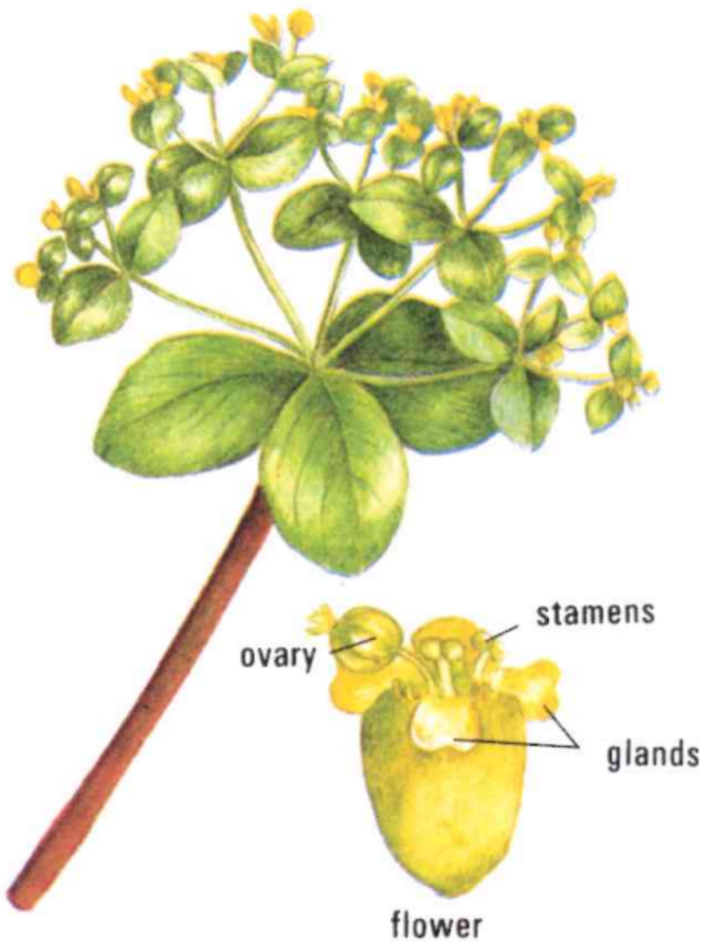
**Date:** ____________________

**Assessor:** ____________________

| Hazard Observed | Types of Risks | Current Control Measures Including who is responsible for implementing them | Risk Rating with Controls Implemented | Additional Controls Needed Including who will be responsible for them and when by |
|---|---|---|---|---|
| Infection | Illness | No species to be kept that carry known human pathogens. Obtain from reputable sources (Yarnton Nurseries and Oxford University Museum).<br>Madagascan Hissing Cockroaches have mites but these are species-specific and do not affect humans.<br>Empty and wash out food dishes regularly.<br>Clear away any droppings carefully and wash hands.<br>Wash hands after handling as an extra precaution. **. | Low | |
| Tetanus | Infection | Anyone handling animals or soil should be immunised. **. | Low | Check school policy – **/$$ |
| Allergies | Allergic reactions | Symptoms could include dermatitis, asthma or irritation of the membranes of the eye or nose.<br>Ask students if they are prone to allergies/anaphylactic shock prior to handling.<br>Handling only to be carried out in the presence of a member of staff.<br>Advise students to wash hands before leaving the room.<br>Empty and wash out food dishes regularly. | Low | |

| | | | | |
|---|---|---|---|---|
| | | Clear away any droppings carefully and wash hands.<br>Any students complaining of eye irritation to be sent to the prep room to have eyes washed out. **. | | |
| Handling animals | Animal stress<br>Close contact | To avoid animal stress explain to students how to handle them appropriately (let animal walk onto a clean hand; point out they can tickle; insects can be difficult to remove from clothes).<br>Avoid passing more than two or three animals out at once to allow careful monitoring.<br>Animal handling is only appropriate in classes exhibiting high standards of behaviour – a noisy environment can stress animals and makes teacher monitoring of the situation impossible.<br>These arthropods do not bite so are safe even in stressed. **. | Low | |
| Human phobias | Panic | Do not force any unwilling student into holding an animal.<br>It may be advisable to use the systematic desensitisation approach with pupils who are afraid (i.e. allow them to sit away from tanks, familiarise them with animals behind glass of tanks, allow them to stand back during any teacher demonstrations).<br>Discourage "hype" from noisy/unruly students.<br>Understand that most pupils will be mildly apprehensive about seeing/handling unusually large arthropods but it is quite rare for this fear to be more extreme than, for example, riding a bike or swimming for the first time. **. | Low | |
| Animals escaping | Fear / Panic (see above also) | Animals to be kept in tanks at front of room.<br>Tanks too large to be readily moved by | Low | |

| | | | | |
|---|---|---|---|---|
| | | students and on shelves of such a height that the lid can be lifted neither by students nor the animals themselves.<br>In the event of an animal escaping, all staff in area to be informed to reduce risk of accidents due to shock of finding an animal.<br>Procedure for capturing animal to be explained.<br>Students to be informed of escape in a low key manner and asked to report any sightings of animal to members of staff.<br>Students to be asked to allow a member of staff to retrieve the animal.<br>The risk of animals breeding when escaped is low as escapes are rare and the British Climate is unsuitable for most species (even in buildings during winter). **. | | |
| Moving tanks | Damage | Tanks only to be moved (e.g. to allow access for feeding/handling) by a member of staff or trained students during elective time as part of a small group. This is not a suitable activity for year 7 students. **. | Low | |
| Heating apparatus | Electrical mishaps | All equipment to be tested in line with County regulations. **. | Low | |




Sun Spurge, *Euphorbia helioscopa.* Picture taken from Chinery (1987).

# APPENDIX III – Methodological Instruments

## Teaching Activity Questionnaire:

*(The version shown here is of actual size but was originally printed on A5 paper. The KS4 version was identical except for its heading.)*

---

# KS3 Teaching Activities

*Please tick the **nine** activities below which pupils most commonly experience in your KS3 lessons. Thanks, MN.*

| | ✓ |
|---|---|
| Class discussion led by teacher | |
| Exercises (working examples) | |
| Giving help to another pupil | |
| Group discussions | |
| Listening to other pupil's presentations | |
| Making your own notes from lessons | |
| Practical work | |
| Writing essays | |
| Presentation of a topic by the teacher | |
| Presenting your work to the class | |
| Producing original work (experiments, poetry, designing, composing and criticism) | |
| Reading | |
| Receiving help from another pupil | |
| Receiving individual help from the teacher | |
| Researching a topic | |
| Taking down dictated notes | |
| Teacher directed question-and-answer sessions | |
| Using audio or visual material | |
| Using handouts | |
| Using ICT | |
| Working in pairs | |
| Doing tests | |
| Doing questions from exam papers with help | |

| |
|---|
| If there are any teaching activities you regularly use which are not mentioned above, please name them here: |

## Year 11 Questionnaire:

# Questionnaire on Classroom Displays

*Last year students suggested we should use displays for learning rather than just leaving them in cabinets / on the wall where students often don't have time to look at or handle them. For this reason, new activities were added to the Y11 Inheritance & Selection module to replace some written work. They were (a) Stick Insects (asexual reproduction – all clones), (b) Stuffed Finches (to look at beaks – evolution) and (c) Fossils (real ones to handle and examine). This is your chance to say how it went so we can make things even better!*

| **Name:** | **Form: 11** | **Science Group:** |
|---|---|---|

**Section 1:** Below is a list of learning activities used in Science lessons. In each of the three columns below number the activities in order of importance (1, 2, 3, 4, 5, 6, 7, 8, 9, 10).

| | **Classroom Activities:** | **A:** How often was this activity used in lessons? 1=most often 10=least often | **B:** How well did you learn from this activity? 1=best 10=worst | **C:** How much did you enjoy this activity? 1=most 10=least |
|---|---|---|---|---|
| 1 | Classroom displays | | | |
| 2 | Teacher-led discussion | | | |
| 3 | Practical work | | | |
| 4 | Presentation of topic by a teacher | | | |
| 5 | Receiving individual help | | | |
| 6 | Using handouts | | | |
| 7 | Using audio &/or visual equipment | | | |
| 8 | Teacher questioning | | | |
| 9 | Working in pairs / groups | | | |
| 10 | Exercises (working examples) | | | |

**Section 2:** Please answer in detail (at least two sentences / bullet points per question):

**1.** In ***Column B*** above, why did you give display activities the rank you did? *(Hint: what made them better for learning than some activities but worse for learning than others?).*

**2.** How do you think displays can aid your learning?

**3.** In ***Column C*** above, why did you give display activities the rank you did? *(Hint: what made them more enjoyable than some activities but less enjoyable than others?).*

**4.** What makes a display enjoyable / motivating?

**5.** How would you make the displays you have used better?

# Year 10 Questionnaire:

*(a reduced version is shown here, the original being scaled to A4 paper)*

## Questionnaire on Real Objects and Classroom Displays

*Last year students suggested we should use objects and displays for learning rather than just leaving them in cabinets / on the wall where students often don't have time to look at or handle them. For this reason, new activities were added to some year 10 modules to replace some written work. They were (a) Food Web Cards (b) Plants with desert adaptations (c) Displays on the landing linked to Year 10 modules (especially Metals and Maintenance of Life). This is your chance to say how it went so we can make things even better!*

| **Name:** | **Form: 10** | **Science Group** |
|---|---|---|

**Section 1:** Below is a list of learning activities used in Science lessons. In each of the three columns below number the activities in order of importance (1, 2, 3, 4, 5, 6, 7, 8, 9, 10).

| | **Classroom Activities:** | **A:** How often was this activity used in lessons? 1=most often 10=least often | **B:** How well did you learn from it? 1=best 10=worst | **C:** How much did you enjoy this activity? 1=most 10=least |
|---|---|---|---|---|
| 1 | Teacher-led discussion | | | |
| 2 | Practical work | | | |
| 3 | Presentation of topic by a teacher | | | |
| 4 | Receiving individual help | | | |
| 5 | Using handouts | | | |
| 6 | Classroom displays | | | |
| 7 | Using audio &/or visual equipment | | | |
| 8 | Teacher questioning | | | |
| 9 | Working in pairs / groups | | | |
| 10 | Exercises (working examples) | | | |

**Section 2:** Please try to write two sentences / bullet points per question:

**1.** In ***Column B*** above, why did you give display activities the rank you did? *(Hint: what made them better for learning than some activities but worse for learning than others?).*

**2.** How do you think displays can aid your learning?

**3.** In ***Column C*** above, why did you give display activities the rank you did? *(Hint: what made them more enjoyable than some activities but less enjoyable than others?).*

**4.** What makes a display enjoyable / motivating?

**5.** How would you make the displays you have used better?

# Year 8 Questionnaire:

*(a reduced version is shown here, the original being scaled to A4 paper)*

## Questionnaire on Real Objects and Classroom Displays

*Last year students suggested we should use classroom objects and displays for learning rather than just leaving them in cabinets / on the wall where students often don't have time to look at or handle them. For this reason, new activities were added for year 8. These included (a) rocks mat and rock samples from the University Museum (b) lunar samples from the moon (c) food web cards and (d) food web cards. This is your chance to say how it went so we can make things even better!*

| **Name:** | **Form: 8** |
|---|---|

**Section 1:** Below is a list of learning activities used in Science lessons. In each of the three columns below number the activities in order of importance (1, 2, 3, 4, 5, 6, 7, 8, 9, 10).

| | **Classroom Activities:** | **A:** How often was this activity used in lessons? 1=most often 10=least often | **B:** How well did you learn from it? 1=best 10=worst | **C:** How much did you enjoy this activity? 1=most 10=least |
|---|---|---|---|---|
| 1 | Class discussion (teacher led) | | | |
| 2 | Practical work | | | |
| 3 | Teacher presentation | | | |
| 4 | Individual help from teacher | | | |
| 5 | Researching a topic | | | |
| 6 | Classroom displays | | | |
| 7 | Teacher-led question and answers | | | |
| 8 | Using audio visual materials | | | |
| 9 | Using handouts | | | |
| 10 | Doing tests | | | |

**Section 2:** Please try to write two sentences / bullet points per question:

**1.** In ***Column B*** above, why did you give display activities the rank you did? *(Hint: what made them better for learning than some activities but worse for learning than others?).*

**2.** How do you think displays can aid your learning?

**3.** In ***Column C*** above, why did you give display activities the rank you did? *(Hint: what made them more enjoyable than some activities but less enjoyable than others?).*

**4.** What makes a display enjoyable / motivating?

**5.** How would you make the displays you have used better?

## Year 7 Questionnaire:

*(a reduced version is shown here, the original being scaled to A4 paper)*

# Questionnaire on Real Objects and Classroom Displays

*Last year students suggested we should use classroom objects and displays for learning rather than just leaving them in cabinets / on the wall where students often don't have time to look at or handle them. For this reason, new activities were added for year 7. These included (a) living animals to learn about classification (b) dead animals in jars to classify (c) limpets to measure for variation (d) food web cards (e) lunar samples from the moon and (f) some wall displays. This is your chance to say how it went so we can make things even better!*

| **Name:** | **Form: 7** |
|---|---|

**Section 1:** Below is a list of learning activities used in Science lessons. In each of the three columns below number the activities in order of importance (1, 2, 3, 4, 5, 6, 7, 8, 9, 10).

| | **Classroom Activities:** | **A:** How often was this activity used in lessons? 1=most often 10=least often | **B:** How well did you learn from it? 1=best 10=worst | **C:** How much did you enjoy this activity? 1=most 10=least |
|---|---|---|---|---|
| 1 | Class discussion (teacher led) | | | |
| 2 | Practical work | | | |
| 3 | Teacher presentation | | | |
| 4 | Individual help from teacher | | | |
| 5 | Researching a topic | | | |
| 6 | Classroom displays | | | |
| 7 | Teacher-led question and answers | | | |
| 8 | Using audio visual materials | | | |
| 9 | Using handouts | | | |
| 10 | Doing tests | | | |

**Section 2:** Please try to write two sentences / bullet points per question:

**1.** In ***Column B*** above, why did you give display activities the rank you did? *(Hint: what made them better for learning than some activities but worse for learning than others?).*

**2.** How do you think displays can aid your learning?

**3.** In ***Column C*** above, why did you give display activities the rank you did? *(Hint: what made them more enjoyable than some activities but less enjoyable than others?).*

**4.** What makes a display enjoyable / motivating?

**5.** How would you make the displays you have used better?

## Instructions for Teachers Helping Students with Questionnaires

*(Instructions shown are for teachers of year 7)*

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- DO NOT let students start until you have gone through the instructions with them. It might be a good idea to do this in stages (e.g. ranked responses first, then questions 1-5). By all means give students the examples below to illustrate what you want them to do.

- Read through the following statement with the students, explaining what is meant by each of the activities. It is perfectly OK to jog their memories as to what the activities involved – the clearer they remember them the better:

*Last year students suggested we should use classroom objects and displays for learning rather than just leaving them in cabinets / on the wall where students often don't have time to look at or handle them. For this reason, new activities were added for year 7. These included (a) living animals to learn about classification (b) dead animals in jars to classify (c) limpets to measure for variation (d) food web cards (e) lunar samples from the moon and (f) some wall displays. This is your chance to say how it went so we can make things even better!*

- Now do the first part of the questionnaire. Explain to students that ranked responses are required: e.g. 9, 6, 3, 5, 1, 2, 10, 4, 8, 7 **NOT** 3, 3, 5, 6, 2, 1, 7, 1, 1, 6.

- Next do the questions:
    - Emphasise that questions 1 and 2 refer to Column B – pupils are explaining if and *how displays can aid their learning*. A suitable answer might be *"I thought displays were better than using handouts because you get the chance to see and hold things so it makes it real. But displays are worse than TV because seeing things on TV is even clearer and everyone gets to do it at once"*
    - Emphasise that questions 3 and 4 refer to column C – pupils are explaining if and *how displays make learning fun*.
    - Avoid answers that are confused with Column A – in the year 11 pilot one student said *"Handouts are better for learning than displays because we do them more often"*. In this case the student was commenting on the frequency of these activities, not on their relative merits in terms of learning / enjoyability.

Please make sure students put their name, group (year 10 only) and form on each questionnaire – I don't want any from Tony Blair, Freddy Mercury, etc. .......

Thank you for your time!

## Sample Interview Transcript:

*(Taken from Year 7. Pupil names have been changed and interview questions highlighted in bold for ease of reference.)*

---

**Luke (L), Georgina (G) and Teacher (T)**

**1. What do you think of when we use the word display in school?**

L: Putting things on the wall, like when we did about the cells and satellites .. interesting things really.
T: OK, so putting things on the wall. Anything else Georgia?
G: Like making posters and information.
T: OK, posters and information. Are there any other things that we class as displays in schools?
L: The lunar thing.
T: Lunar samples, OK. So what makes them displays then?
L: Because you get to look at them and touch them and things like that.
T: [definition of terms] then qu. 2.

**2. Here are some displays – which have you used before and what did you do with them?**

L: I've already said the cells, satellites and the lunar, the .....
G: ... planets ...
T: Planets, OK, yeah.
L: ... bugs – when we looked at them –ummm ..... would you say pond dipping?
T: In a way it's a display isn't it. Well when you take things upstairs and look at them it's kind of like display work isn't it? Anything else Georgia?
G: Mmmm ......
T: No? OK, so that's most of it.

**3. The questionnaire suggested people don't get the chance to use displays very often. Do you agree?**

G: Uh Huh .....
L: Yeah .....
T: OK. Why do you think that then?

**4. Why do you think this is so?**

L: Well because, like I said, we, well because, probably because they were spread out a bit.... seems like we didn't do it so much and because we can only remember like a few.
T: OK. Why do you think you can only remember a few?
L: Because like we've probably done a few.
T: Yeah. Uh Hum. Anything else?
G: People forget most of them because they don't get to handle them so it doesn't really stick in their head.
T: Good point, yeah, good point. So can you remember then some that you did handle and some that you didn't handle?

G: I ... umm...... that rock you broke up, that one, we got to handle it and then like the other stuff.
L: We didn't really get to handle the lunar stuff but then ......{indistinct] ... so that's fair enough.
T: Yeah, there were only a few bit of it weren't there, because they were so valuable but you got to hand it around, didn't you?
L: Yeah.
T: So you don't think people get the chance to use displays very often but you have used them at times and when you do use ones that you can handle it's more memorable?
L&G: Yeah.
T: And the other ones tend to get forgotten a bit. OK, OK, that's fine.

**5. Many students thought they got to do practicals more often than using displays – what's the difference between a practical and a display (or is there one)?**

G: Yes.
L: Because a practical is when you're like doing like things to Bunsen burners and you have to build it to make it work. And then displays are, well because practical you can't exactly put up on display where, a display, you can put up a display.
T: Yes, OK, that's true. Think about the displays where you've, say for example, looked at things in jars and identified what sort of animal it was, would you class that as a practical or not?
G: Not really.
L: No.
G: Because you didn't get to, like you didn't have to build it.
L: Yeah.
T: So you didn't actually make it so you're looking at the finished product sort of thing? OK, that's fine, that's interesting.

**6. What sort of things have you personally learned from displays?**

L: Displays? Um ... well, like the lunar rocks, they're odd shapes and different colours – I thought they were all going to be like grey/black – but we got them all different colours like orange ... weird colours.
T: Yeah, OK....
L: That's about it.
T: OK – anything else Georgia?
G: How different cells work. I didn't know what the nucleus is 'cause we didn't do cells in our old school.
T: OK, I see.
L: We did do it but we didn't learn anything like ...cytoplasm ....
T: OK, and actually doing it helped you remember it then?
G&L: [nodding – no, not nodding off, *nodding*]

**7. What is it about a display that helps you learn?**

T: Well we've kind of done this. So you've said some things you've remembered. What is it about them, think of those particular things, what is it about them that actually helped you learn?

L: Well, 'cause the display, you kind of have like to know about it to do about it ... and plus when you put it up on the wall, say ... that's the type of display [pointing] .... you get to look back at it and you jus' keep remembering it.
T: OK. Anything else Georgia?
G: Ummm.... probably the best thing is that you get to look back at it.
T: OK, so it helps you remember then. What about the types of display, say, where it's jars of animals we had at the back of the room just for one lesson, how do you think you learn from that, or do you?
L: Kind of like memory .... knowing what they look like, 'cause stag beetles they have a HUGE little horn thing at the front of them. Iguana skin's all like bumpy ..
T: OK.
G: I didn't really know ..... learn much more really because there's not really much to learn if you're in a jar. You can't really hold it and feel ..... like ... the octopus ....
T: OK, so what you're saying is you'd really like to pick up the dead octopus ....
Everyone: [laughs]
T: Did they help you to remember to things you'd learnt in lessons before do you think, seeing them?
L: A bit probably, you learn a bit more because pictures, seeing them, and then seeing the real thing you can feel, if you could feel like the spine and then ones that don't feel.
G: And it's better too to see them in real life because pictures just make things look more dramatic.... it might make you think a worm's ten foot when they're really ...
T: Tiny!
G: Yeah.

**8. Do you ever find out things from displays that are around you but you haven't used in lessons (even if they're from another class)?**

L: You look at them because you just notice them. They're like in big writing so you do notice them and you want to go over and read them.
T: OK, and do you get a chance to go over and read tham?
L: Only if you're leaving the room.
T: OK, only if you're leaving the room so it's not much time. OK. Anything else? Georgia?
G: Hmmm. .... no ..

**9. What makes displays fun (or are they)?**

L: They are fun.
T: They are fun? So why? Or do you agree with that Georgia?
G: Some of them are because like, explosive you have a picture of all these bright colours they might be fun to look at but if it was black and white it would be a bit boring.
T: Anything else Luke?
L: Ummmm .. they are fun because when you go to make them .... Oh, and what I also like is if you take longer at it you get to do it better ... so the cells 'cause we got a bit of time to do that we got it to a fine t. And I think that was quite good.
T: OK, so you like having time to really, really get it right. Think about the display again where you get to look at certain things so not wall displays but the other types of displays using real objects, do you enjoy those? And if so why?
G: I do because you can touch them and fell them – it's better.

L: Depends what it is really. The lunar rocks were good. Um, but some other things – can't remember – well if we did they might be boring because we just do them and look at them .... and if you don't know much about it it's not much fun.
T: OK, so it's better to do displays maybe after you've done the topics so you understand what you're looking at?
L: Yeah.
T: OK, OK, that's very interesting.

**10. What is the worst thing about displays? (because we want to make them better)**

L: Well if you've got a form room ...... in history there were kind of like displays we did, weapons, and people just destroyed them, removed them, broke them. And that sort of thing's a worry.
G: I'd say pretty much the same because say if you've spent ages on something and people just break them and don't take any respect for the stuff.
T: OK, OK, so that's the wall displays. What about things like, say in the cabinets and so on and the insects – because they're in tanks so people can't damage them – is there a worst thing about those.
G: Yeah you can't ... you have to sort of stand there and look at them but not ....
L: If you're quite small you can't exactly see a lot but if you put them on tables and things ....
G: Because like you can only see one side of them.
T: Yes, OK, but at the end of the day we've got to keep them in cabinets so they don't get broken so how would you solve that problem?
G: Say if people said what's this, lets have a look you could put them in glass jars but have little holes in so then you can feel them.
T: OK, OK so have the jars kind of open but semi-protected so people can have a look.
L: You can feel it.
T: OK so have things to touch and feel. What about the displays where you did actually get to handle things? So like the lunar samples, like the, you know, the things along the back there that day the jars we did, how would you make that better?
G: Have bigger jars so it's clearer. Like the skin was a bit difficult to see.
T: You mean the iguana do you? The big one? OK, fair point, yes.
L: Umm ... I know it sounds quite stupid but maybe if you still have them in the little jars but have them alive.
T: So what you're saying in a way is put the tanks around the room for a day so people can go round and have a look and have a poke and that ....
L: Yeah, because you see how they adapt to where they live.
G: Because like over there you can't really see them because they're like out of the way. You should put them more in different spaces so more people can see them.
T: Yeah, fair point.
L: Because like the crickets and locusts, you can see them.
T: So that's a good place to have them then so maybe put more things at the back of the room in future? OK, OK, good point.

**11. How could you make them better and what other science topics could you use them in?**

G: Pond dipping.
L: Yeah:
T: OK, so how would you use them in pond dipping.

G: You could draw a picture of a frog and draw a picture of the pond and say where could you find it. Different types of stuff.
L: Yeah, like habitats like ....... newts live more here than the pond snails which live more there, so .....
T: So just out of interest where did you find the most snails then?
L: Well I found the most snails , you know the green house .... well the bridge is over there and you know that bit where the wall of the classroom is there I found like more there .....
T: So the bit where there was more bits of grass along the edge?
L: Yeah, and the  where the tree was, closer to the bridge, because we dunked our net in and we found like loads of newts in there.
G: In, this is like near the classroom there was this like weedy bit and we put our net underneath and all these news were in there so like there was loads of stuff there.
L: The newts like it hidden, quite deep and then, I can't, well, pond scaters and, well the waterboatman was lucky it was where we found the pond snails ....

# APPENDIX IV – Figures 10 to 32

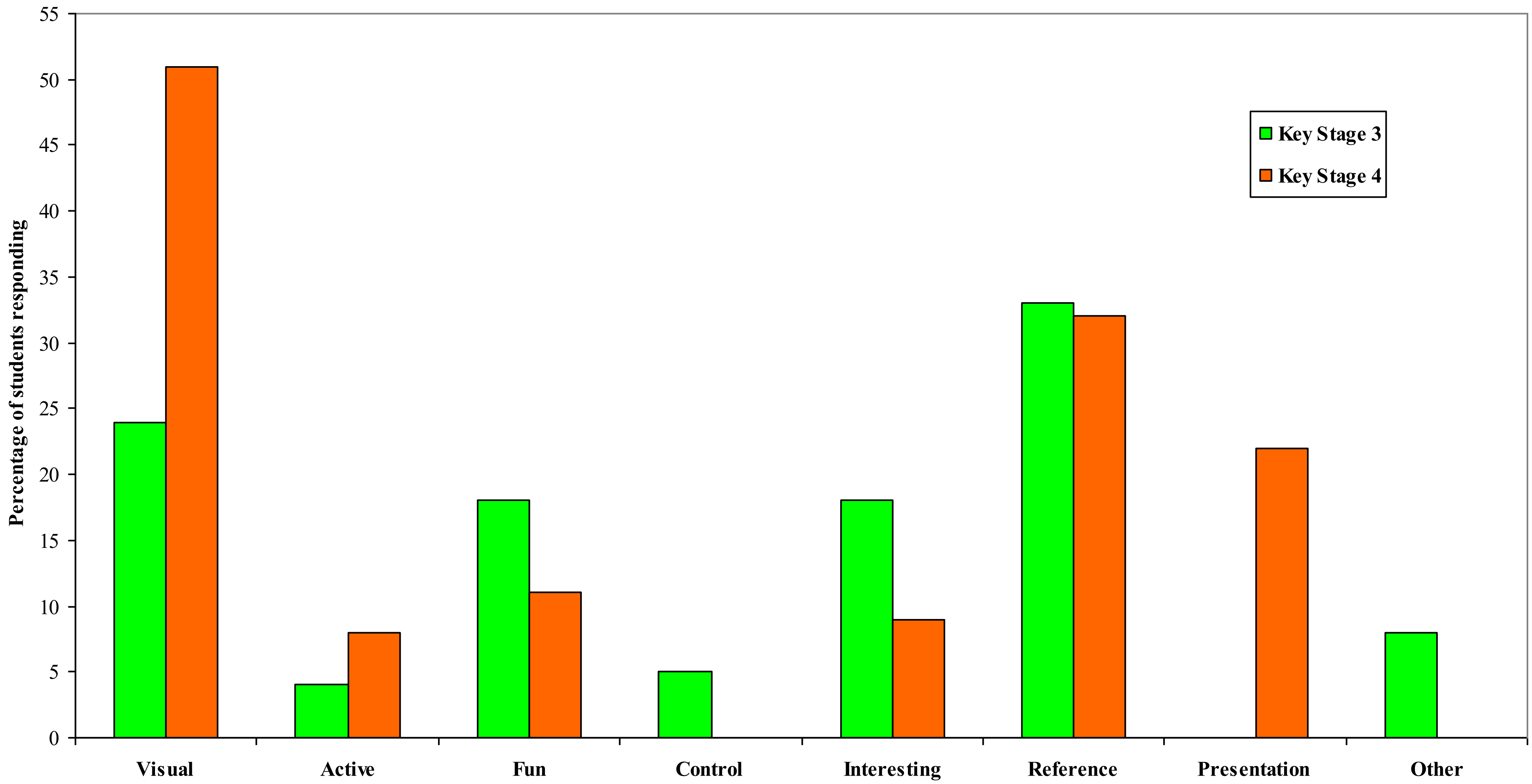


*Figure 10: Reasons given by students in key stages 3 and 4 for learning well from the use of wall displays.*

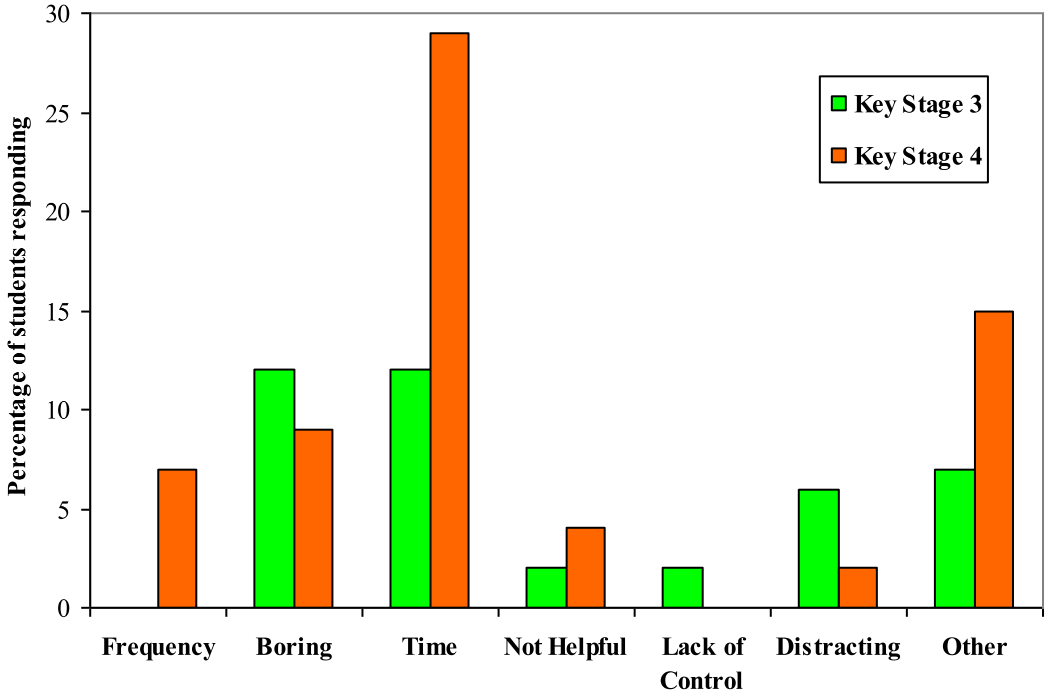


*Figure 11: Reasons given by students in key stages 3 and 4 for poor learning from the use of wall displays.*

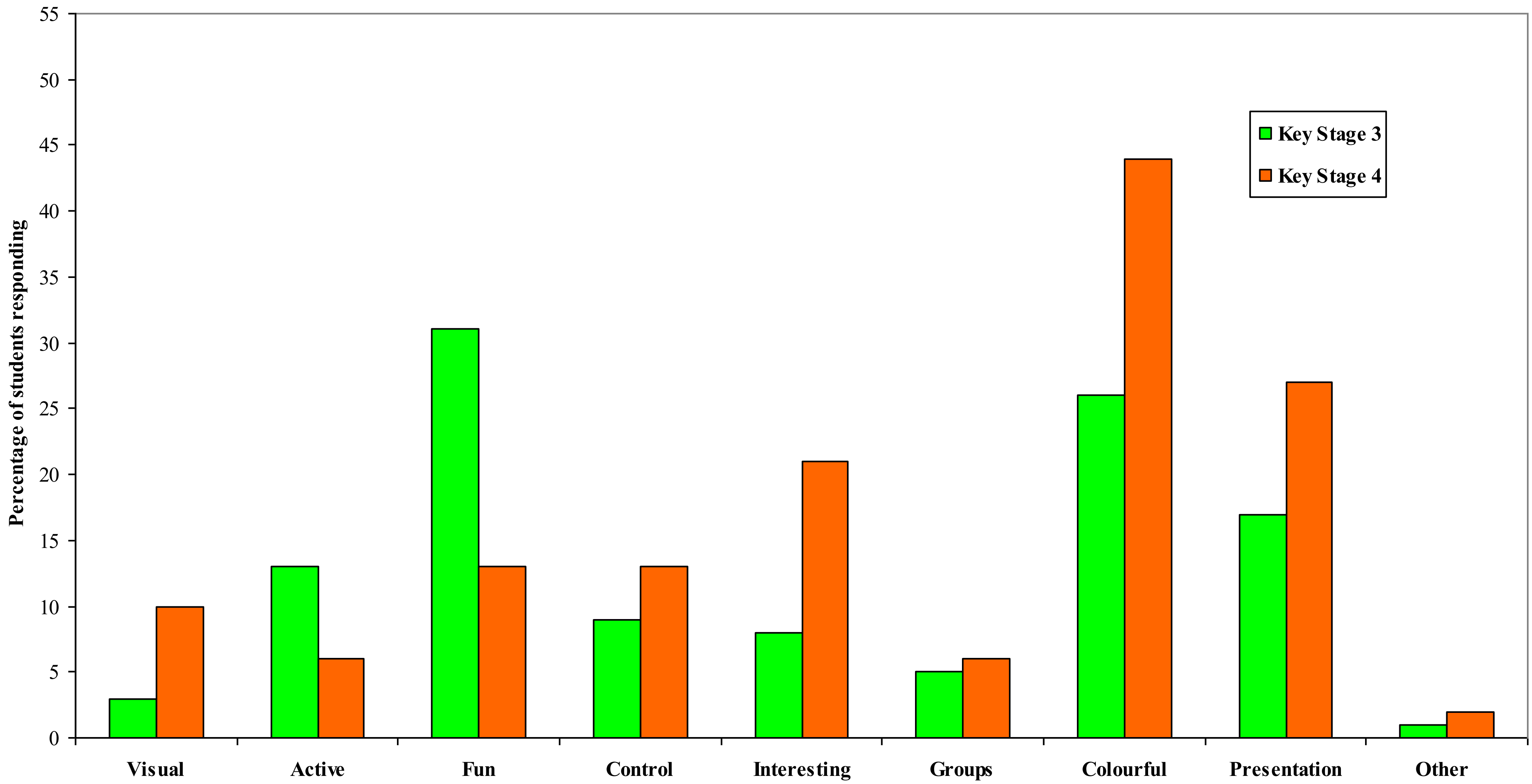


*Figure 12: Reasons given by students in key stages 3 and 4 for enjoying the use of wall displays.*

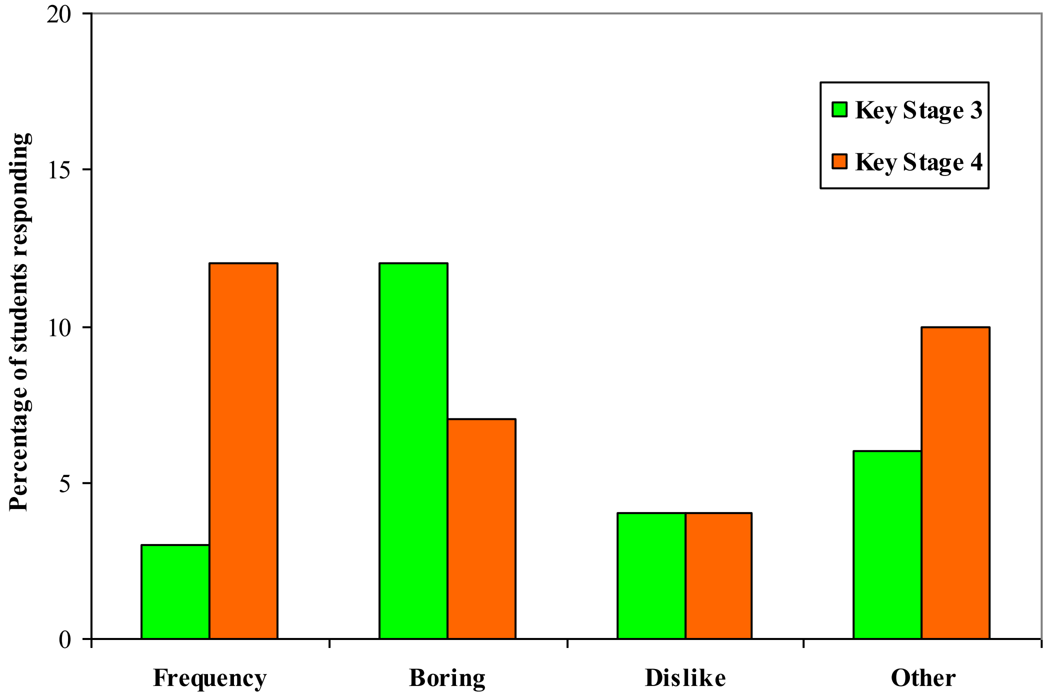


*Figure 13: Reasons given by students in key stages 3 and 4 for low enjoyment of the use of wall displays.*

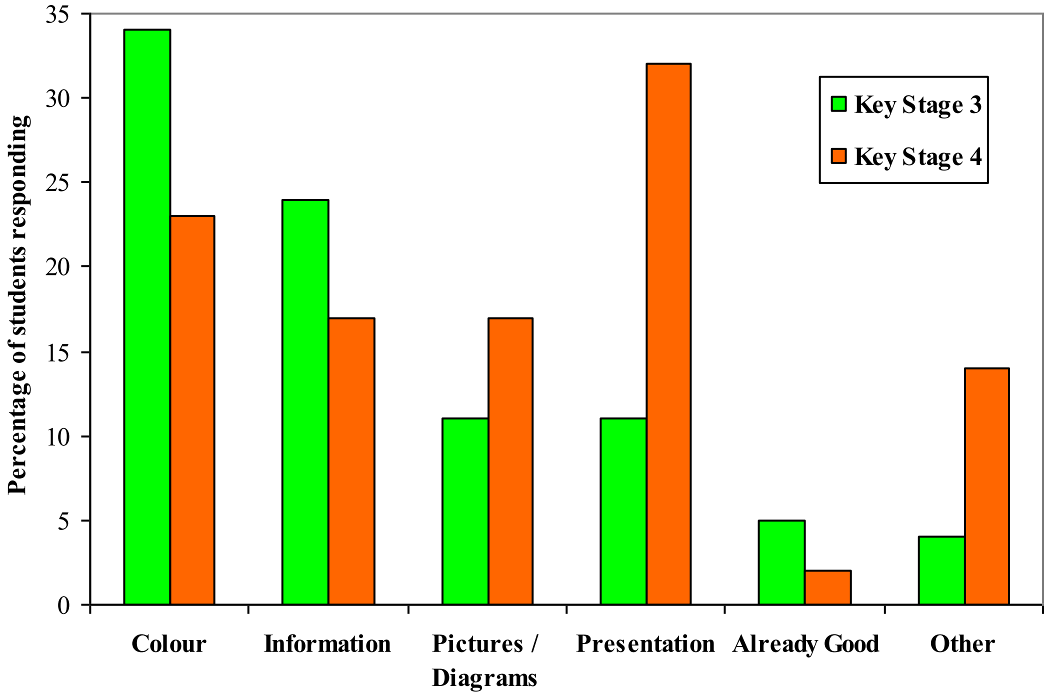


*Figure 14: Improvements which could be made to the use of wall displays in the classroom suggested by students in key stages 3 and 4.*

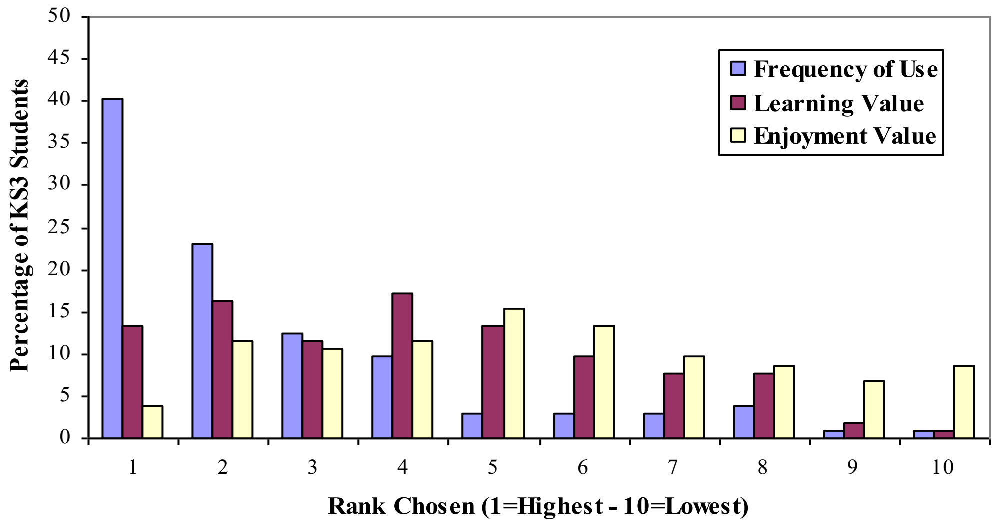


*Figure 15: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***classroom discussion (teacher led)*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

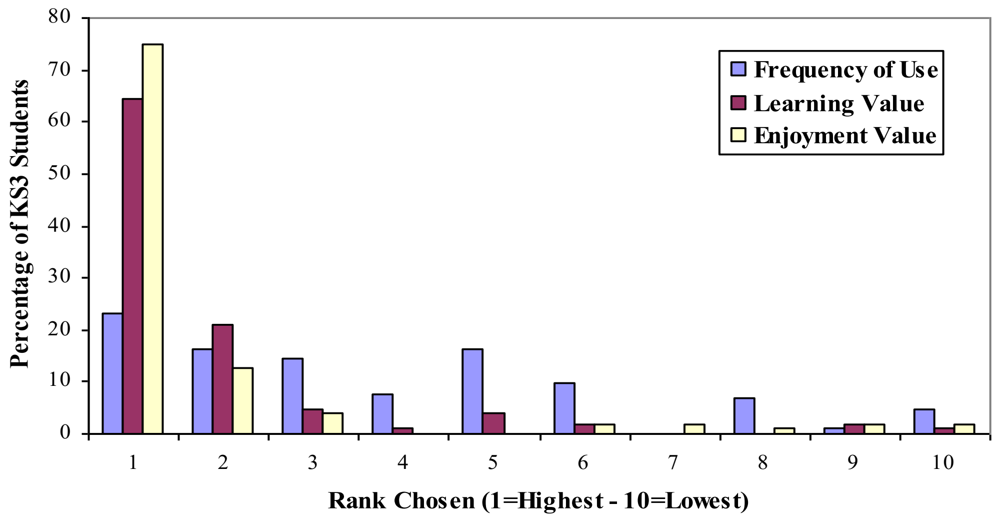


*Figure 16: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***practical work*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

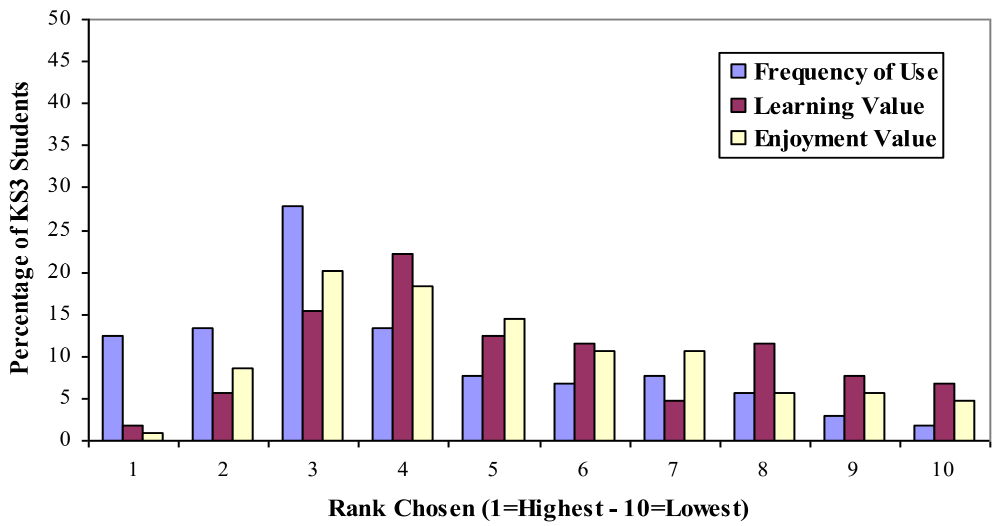


*Figure 17: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***teacher presentation*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

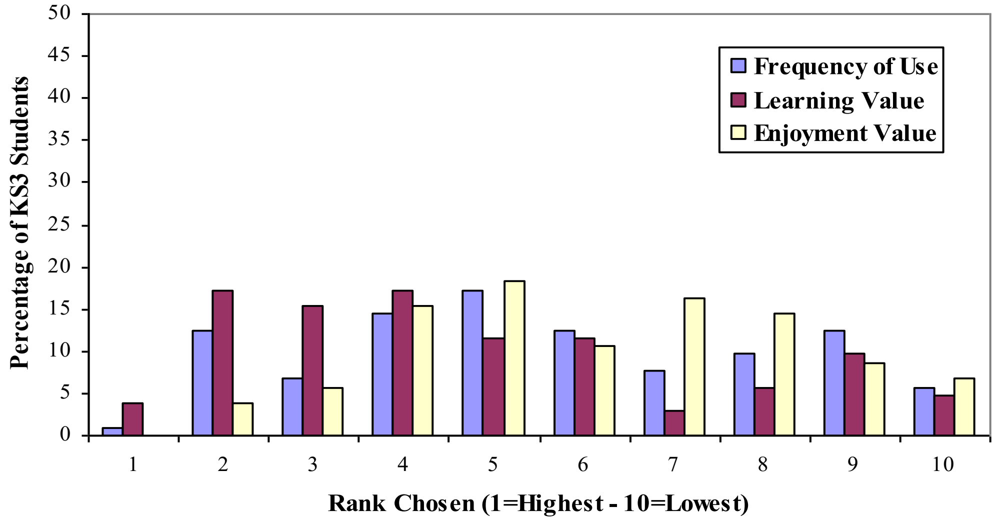


*Figure 18: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***individual help from teacher*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

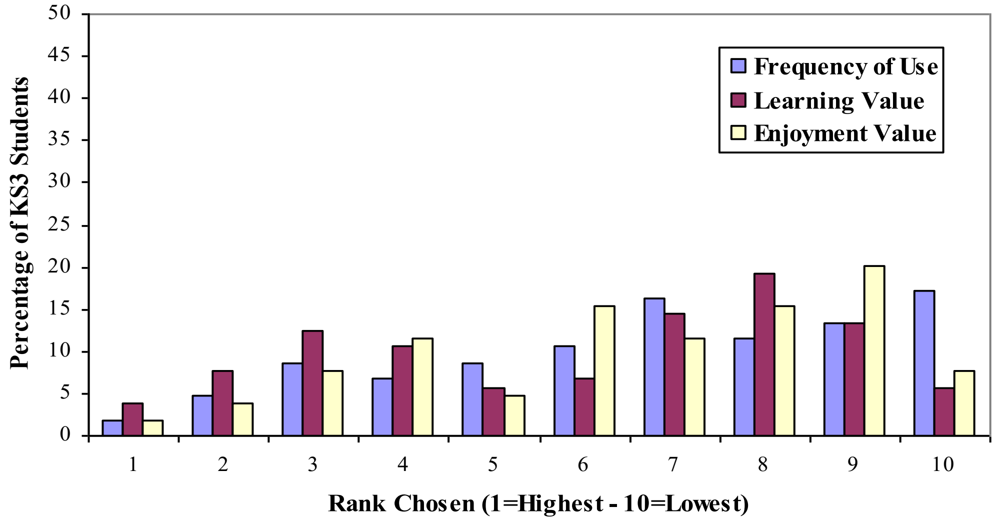


*Figure 19: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***researching a topic*** *for (a) Frequency, (b) Learning Value, and (c) Enjoyment Value.*

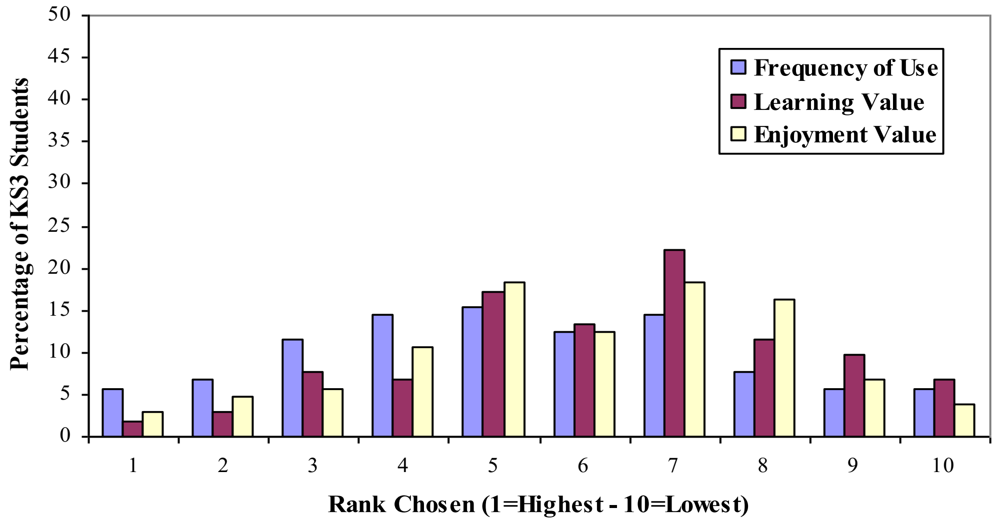


*Figure 20: Percentage of KS3 students (n=104) assigning each of ten ranks to* ***teacher-led questions and answers*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

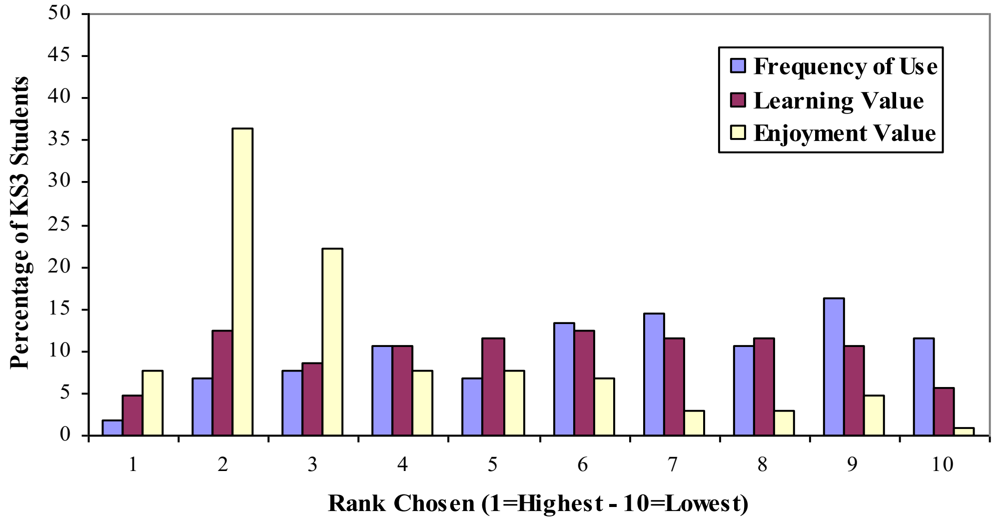


*Figure 21: Percentage of KS3 students (n=104) assigning each of ten ranks to **using audio visual materials** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

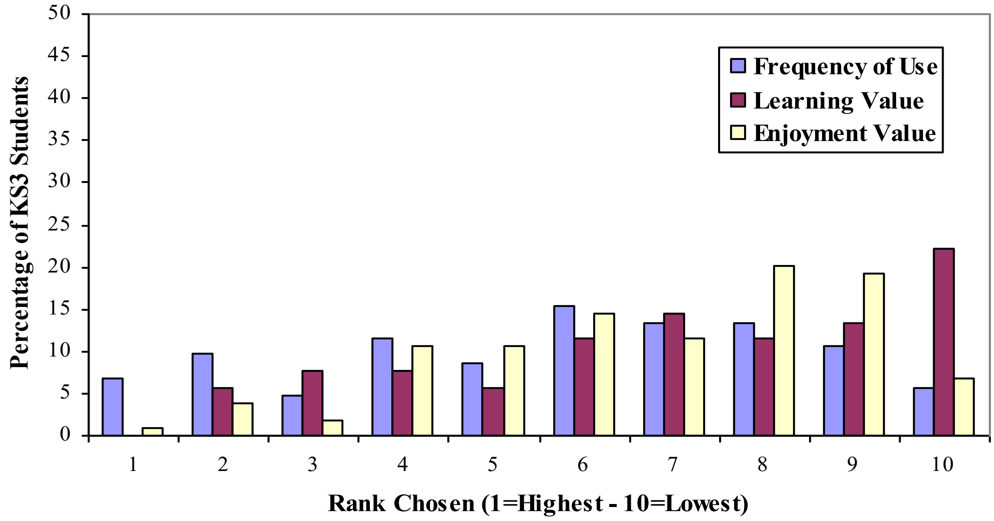


*Figure 22: Percentage of KS3 students (n=104) assigning each of ten ranks to **using handouts** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

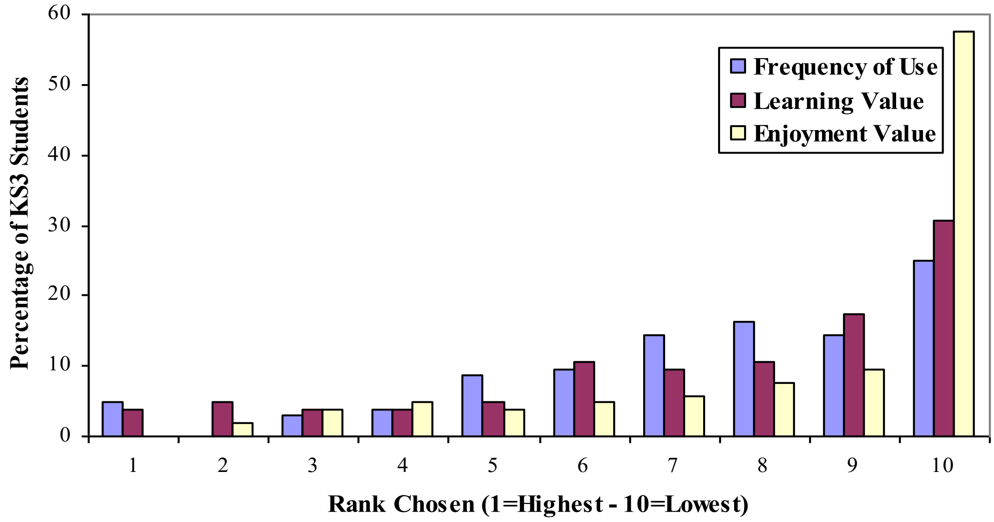


*Figure 23: Percentage of KS3 students (n=104) assigning each of ten ranks to **doing tests** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

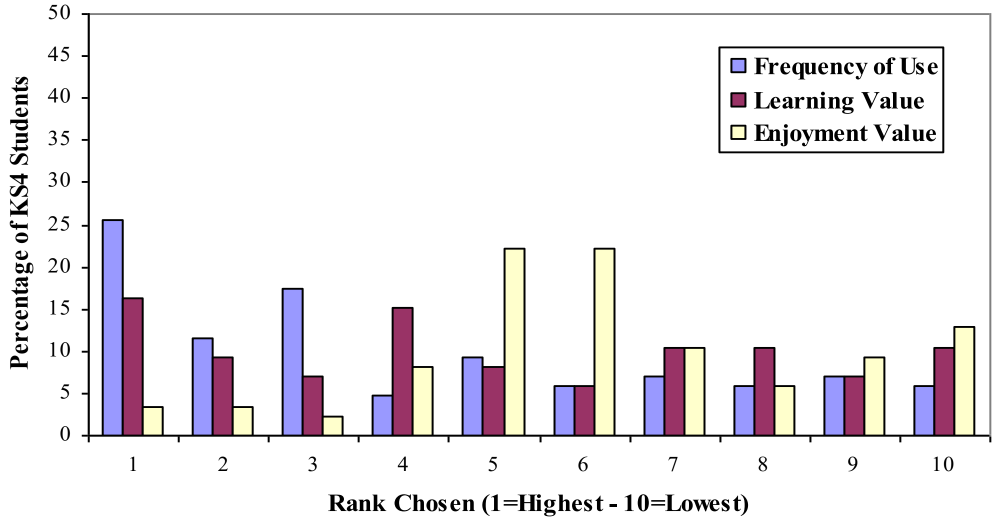


*Figure 24: Percentage of KS4 students (n=86) assigning each of ten ranks to **classroom discussion (teacher led)** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

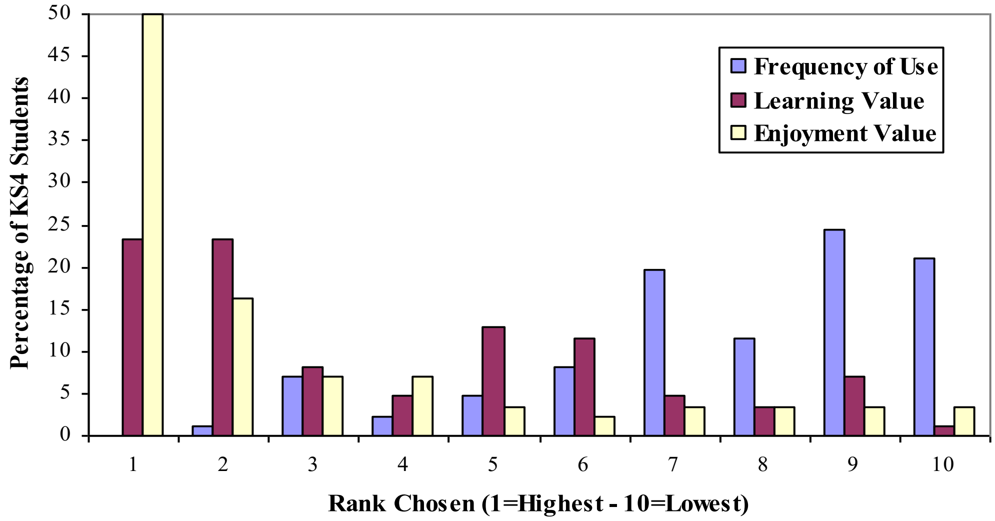


*Figure 25: Percentage of KS4 students (n=86) assigning each of ten ranks to **practical work** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

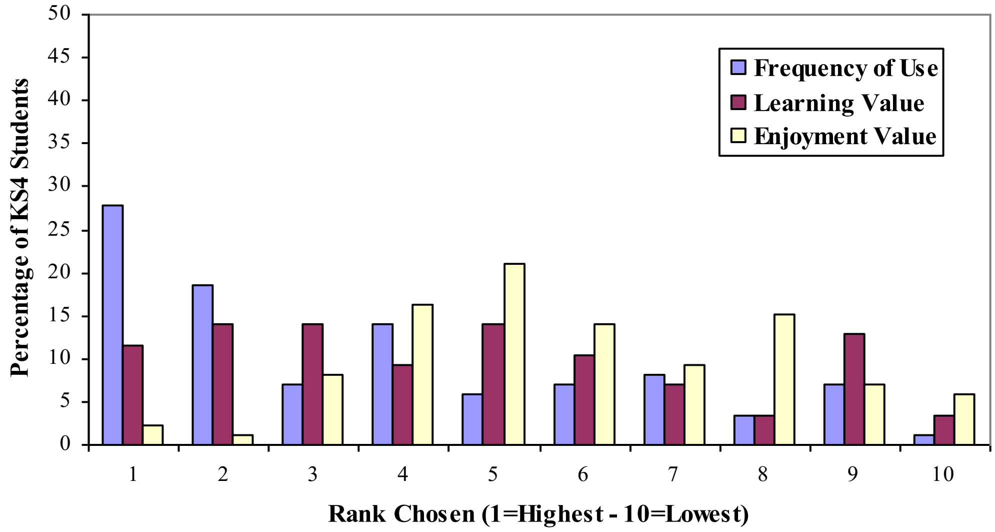


*Figure 26: Percentage of KS4 students (n=86) assigning each of ten ranks to **teacher presentation of topic** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

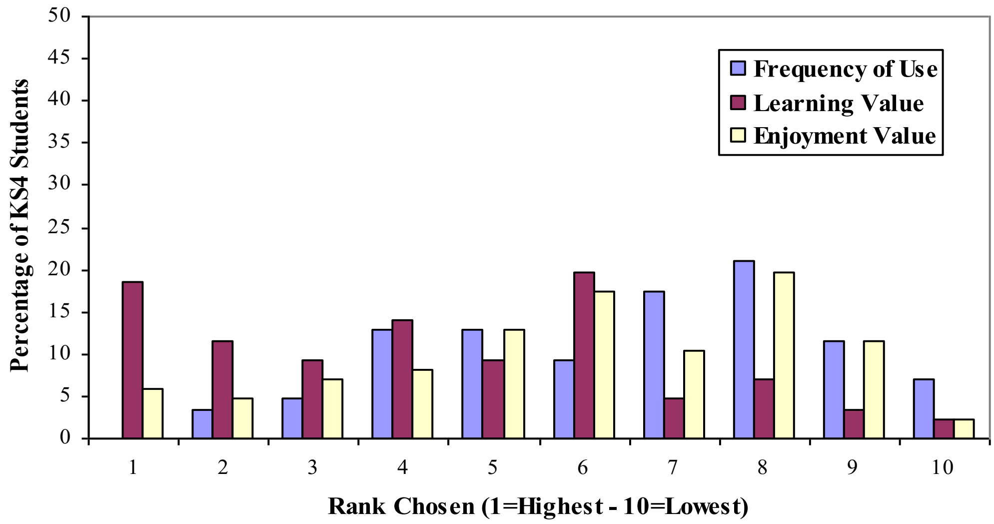


*Figure 27: Percentage of KS4 students (n=86) assigning each of ten ranks to **receiving individual help** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

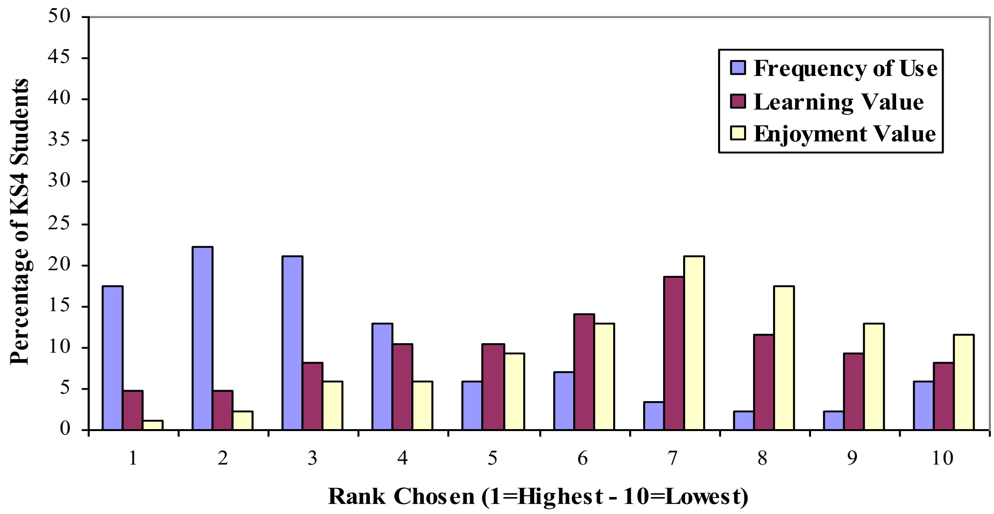


*Figure 28: Percentage of KS4 students (n=86) assigning each of ten ranks to **using handouts** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

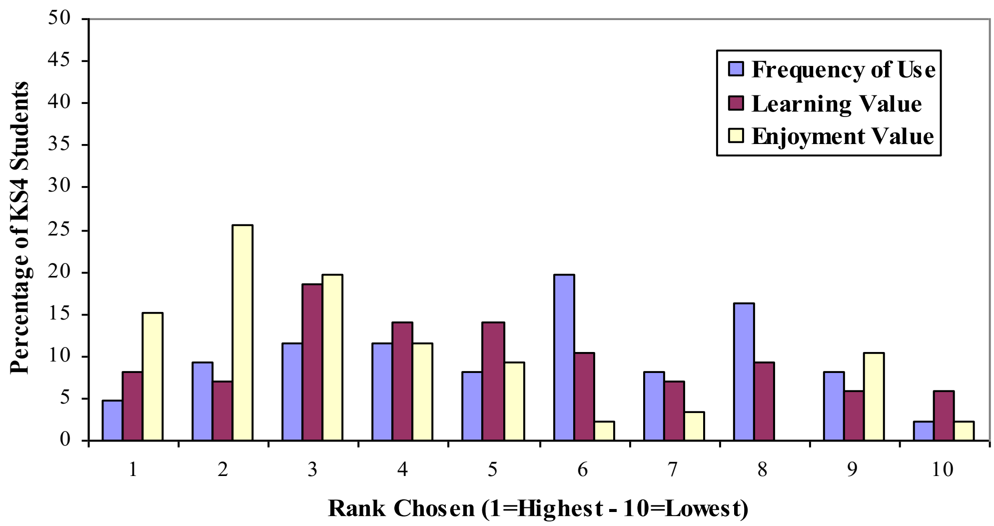


*Figure 29: Percentage of KS4 students (n=86) assigning each of ten ranks to **using audio visual material** for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

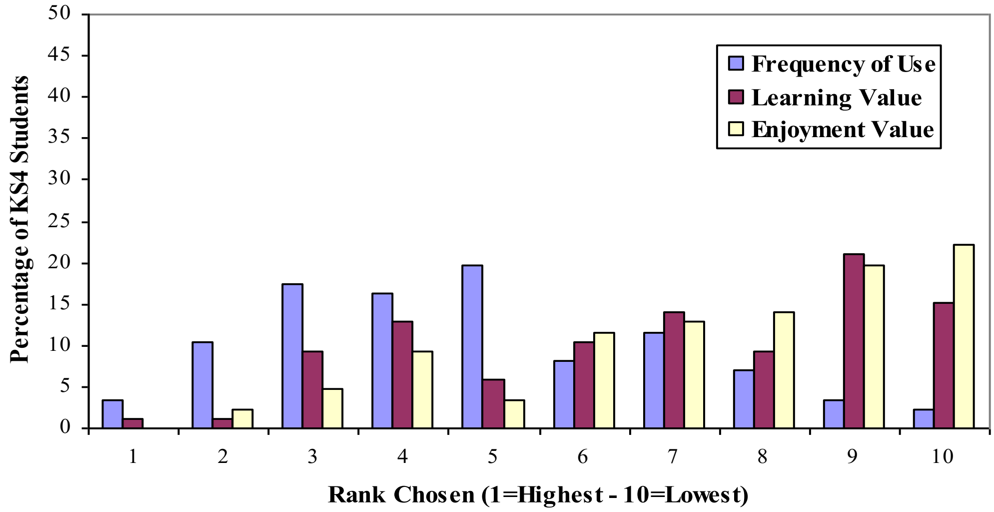


*Figure 30: Percentage of KS4 students (n=86) assigning each of ten ranks to* ***teacher questioning*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

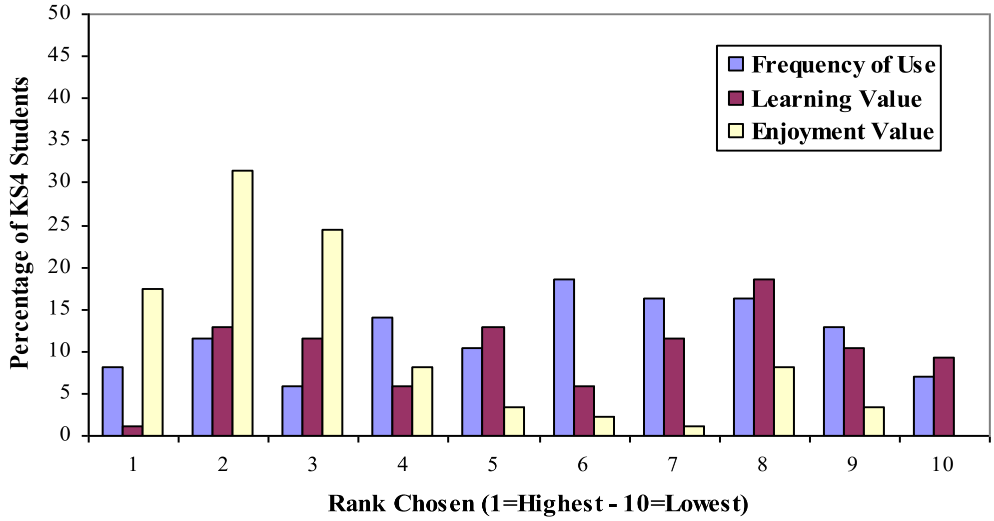


*Figure 31: Percentage of KS4 students (n=86) assigning each of ten ranks to* ***working in pairs / groups*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*

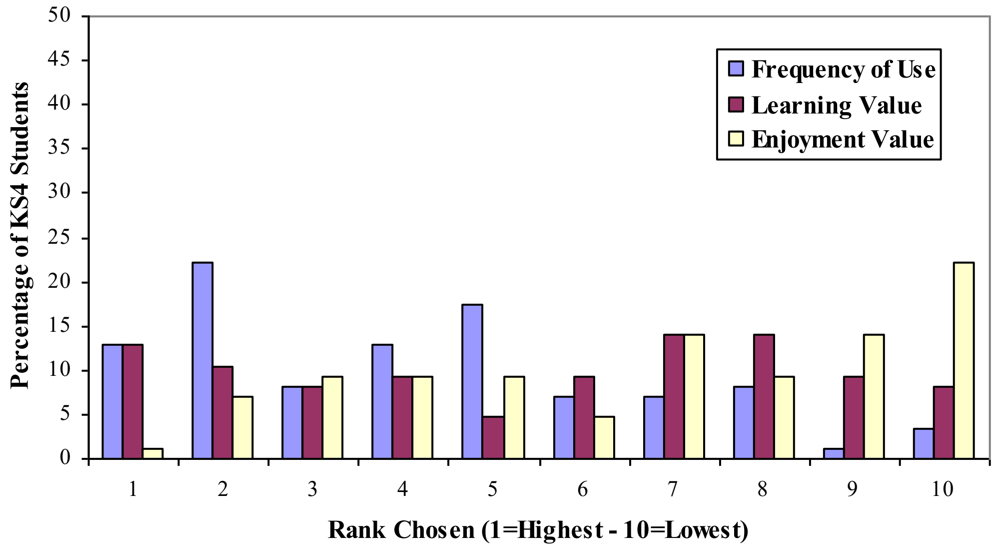


*Figure 32: Percentage of KS4 students (n=86) assigning each of ten ranks to* ***exercises (working examples)*** *for (a) Frequency of Use, (b) Learning Value, and (c) Enjoyment Value.*