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Research project in Biomedical Sciences

The Use of Interactive Teaching to Support Learning in Primary Science Education

Sarah Waite

200378293

B.Sc. (Hons) Medical Sciences

Faculty of Biological Sciences
University of Leeds

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Supervisor: Sue Deuchars

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Signed

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Summary

This research aims to explore the benefit of interactive teaching within science lessons, while also investigating the effect of plenaries and mixed ability seating arrangements on pupil performance. The obstacles preventing effective science education are also considered. This research was conducted by delivering an interactive lesson to six classes of pupils from Years 3, 4 and 5 (7-10 year olds). Prior pupil knowledge and knowledge gained after the lesson was assessed by the use of a pre- and post-lesson test. The interactive teaching session was successful in enhancing the knowledge of all pupils in each class regardless of differences in preferred learning styles, as shown by the significant increase in knowledge from the pre- to the post-lesson test for all classes ($P < 0.0001$, by a paired T-test). The greatest improvement was seen with class 5C, which had a mean pre-lesson test score of 2.3±0.2;n=28 (38% correct answers) which rose to 5.9±0.1;n=28 (98% correct) at the post-lesson test. Class 3J incorporated a plenary and adopted mixed ability seating arrangements and achieved a post-lesson test mean score of 5.9±0.1;n=20 (98%) which is significantly higher than class 3B which did not include the aforementioned variables and achieved a post-lesson test mean score of 5.3±0.1;n=22 (88%). This suggests that the use of plenaries and ecological variables such as seating arrangements may influence how effective learning is. The obstacles most likely responsible for preventing effective science education are poor teacher subject knowledge and a lack of available resources. Interactive teaching demonstrated a positive effect on all pupils' attainment, confirming that interactive teaching does enhance learning.

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Introduction

Learning requires a combination of both vicarious and enactive experiences. The idea of learning and the concept that all individuals have the ability to learn has been around for many years, yet there is still not a widely accepted view on how individuals learn and the processes that are involved (Hayes, 1978). There have been many different interpretations and perspectives on learning, which led to the development of numerous learning theories which are effectively hypotheses that aim to describe how learning occurs. These theories offer an insight into different outlooks on the process of learning and how knowledge is developed (Rao, 2003). The principles and concepts behind the different theories have been used by schools within their methods of teaching and when they are designing the curricula (Rao, 2003). Learning theories are important as they allow teachers to understand their pupils better and provide guidance on teaching methods (Bigge and Shermis, 2003). Most learning theories are identified as one of the following categories; behaviourism, cognitivism and constructivism, these will be discussed in turn (James, 2007).

Behaviourism

Behavioural theories focus on observable behaviour rather than internal thought processes such as thoughts, beliefs and feelings (Smith 1999). Behaviourists consider learning to be manifested by a change in behaviour or responses, where the environment has an important role to play by providing stimuli to which responses can be developed (Schunk, 2007). Behaviourism conveys that the formation of associations between stimuli and responses is what underpins learning (Schunk, 2007). The behaviour or response changes according to the immediate consequence, this can either be by reinforcement or punishment. The former produces a consequence which makes the response more likely to occur, such as praise or reward, which strengthens the behaviour, while the latter produces a consequence which makes the response less likely to occur (Schunk, 2007). Reinforcing and punishing consequences have an important part to play in the concepts of behaviourism.

John B. Watson, who is generally considered to be the founder of behaviourism predominated psychology from the 1920s until the early 1960s (Schunk, 2007). His ideas are first traced back to his article entitled “Psychology as the Behaviourist Views It” in 1913 and this strongly stated that psychology is a science of behaviour rather than of mind (Kendler, 1987). He also stated that introspection was unreliable and formed no part of the learning process (Watson, 1913). Watson interpreted Pavlov’s conditioning model and believed it

could be extended to explain diverse forms of learning, however his research lacked relevance for educational learning. One of the main ideas that other behaviourists took from Watson was his emphasis on the importance of the environment (Schunk, 2007). B. F. Skinner developed a behavioural theory known as operant conditioning, it assumes that features of the environment such as stimuli, events and situations act as cues for a response, where reinforcement will strengthen the response making it more likely to occur (Schunk, 2007).

These conditioning theories describe learning in terms of environmental events and believe mental processes are not required to explain the cause of learning, it is this ignorance regarding mental processes that underlies why these theories are challenged and not widely accepted, especially by cognitive theorists. However operant principles are firmly established in psychology and can be demonstrated in some educational settings, such as those teachers that use behavioural objectives to outline what pupils should be able to do by the end of the lesson.

Cognitivism

Cognitive theories differ from behaviourism as they place great emphasis on the learners mental processing as a central cause of learning (Schunk, 2007). For many years it has been well considered that during education and in the process of learning there is something happening in the human mind, indicating that this process is of cognitive nature (Hughes and Hall, 1989). In 1879, Wilhelm Wundt was studying the mental mechanisms involved in the learning process by the use of subjective methods, he objected to the views later known to be behaviourism and instead believed that introspection was the key (Hayes, 1978). This idea was referred to as “introspectionism” and was popular from 1875 to 1910, just before the advent of behaviourism (Hughes and Hall, 1989). By the 1960s attention had turned back to the study of mental processes and events, where this cognitive psychology now employed objective methods whereby mental events would be inferred from observed behaviour (Martindale, 1981). Cognitive theories agree that the environment influences learning, but their main stance is about what students do with the information and how they process it, highlighting the importance of learners’ thoughts, attitudes, beliefs and values (Schunk, 2007). Cognitivists advise that teachers should consider the thought processes of students when devising lessons (Schunk, 2007).

After cognitivism was established, there was the merge of cognitive and behavioural ideas by so called cognitive-behaviourists; they consider the mind to be essential for

understanding behaviour unlike radical behaviourists. Cognitive-behavioural approaches in education appreciate and recognise pupils' learning styles as well as believing each individual is accountable and in control of their own learning (Hughes and Hall, 1989).

Constructivism

Constructive theories arrived later than behavioural and cognitive theories and differ by focusing on how knowledge is constructed rather than acquired, with the idea that individuals form or construct much of what they learn and understand (Bruning, 2004). An assumption of constructive theories is that individuals are active learners and must construct knowledge for themselves through their experiences and beliefs (Simpson, 2002). This means that one person's constructions may not be the same to someone else's, implying that all knowledge is subjective, personal and is a product of our cognitions (Simpson, 2002). This approach is often associated with enactive learning and social interaction. Vygotsky who was a social constructivist, stressed the importance of social group learning and peer collaboration in his theory, emphasising the value of the social environment for learning (Ratner et al., 2002). Vygotsky also stressed the importance of the teacher and learner interactions where a 'scaffolding' metaphor was created to describe this interaction where the teacher should provide the 'scaffolding' for the building, but the building itself can only be constructed by the learner (James, 2007). Perspectives on constructive theories differ as to how much influence social factors and environment have on learners' constructions (Schunk, 2007). Constructive perspectives can be implemented into the classroom by actively involving students in their learning, such as through interactive teaching by allowing practical involvement.

Typically most teaching strategies are drawn from the constructivist ideas of learning, where it is believed children need to think about the scientific activity in order to be able to make sense of it and understand the scientific concepts behind it (Appleton, 1999). In primary science education an emphasis is placed on conceptual learning through a number of different learning processes, such as group learning and practical experiments (Appleton, 1999).

Interactive teaching

The purpose of interactive teaching is to move away from the traditional methods of teaching where pupils would sit passively listening to the teacher. Interactive teaching is simply about engaging all pupils, often best achieved by activities that contain practical involvement. The importance of this interactive experience became popular through the ideas of social

constructivists, such as Vygotsky and Bruner, where they stressed the importance of the social contexts of learning (Moyles, 2003). Practical involvement allowing 'hands on' learning and activities requiring movement are found to be an enjoyable and fun experience for all pupils, while importantly maintaining pupil interest in the curriculum (Moyles, 2003). Therefore, teachers should be encouraged to include as much practical involvement as possible in order to provide a successful interactive teaching session.

Different learning styles

Learning styles are the different ways pupils begin to concentrate, process, internalise and remember new and difficult information (Dunn and Dunn, 1999). All individuals have preferences about how they learn, this is referred to as their preferred learning style (Sims and Sims, 2006). When individuals use their preferred learning style they learn more quickly. Learning styles have been interpreted in many different ways, this consequently led to a number of different learning style models being produced (Sims and Sims, 2006). Some of the common models are outlined below:

1. Visual, auditory, kinaesthetic (VAK)
2. Reflectors, activists, theorists and pragmatists
3. Innovative, analytic, common sense and dynamic
4. Field-dependent and field-independent
5. Sequential/global; visual/verbal; sensory/intuitive; active/reflective (Hayes, 2008).

It is thought that identifying pupils' learning styles is an essential requisite for a successful educational program, such that teachers should plan their lessons to accommodate all learning styles (Sims and Sims, 2006). Furthermore, as learning becomes more complex throughout life, an understanding of your preferred learning style will undoubtedly help individuals achieve the most, as efficiently as possible (Sims and Sims 2006).

This research will use the VAK model to interpret the learning styles of pupils. VAK is based on the learner's preferred method of receiving and internalising new information, in particularly by which sensory modality is used:

Visual – learn best by seeing.
Auditory – learn best by hearing.
Kinaesthetic – learn best by doing (Tanner and Allen, 2004).

Visual learners enjoy writing, drawing and seeing pictures, while auditory learners prefer to listen and enjoy discussing information, and kinaesthetic learners like to make things, learn by practical hands on activities and through their experiences (Hayes, 2008). The VAK learning style was developed by Neil Flemming and is one of the most widely used learning style models (Dobson, 2010). It is known that pupils are able to use all sensory modes for learning, however it is believed that there will be a stronger preference for one or two of the modes, exhibiting unimodal or multimodal preferences respectively (Ramirez, 2011).

The awareness of each pupil's preferred learning style is important for the teacher as it will highlight the variety of preferences within a single class, it will also help to determine the best way to provide instructions, and will encourage the teacher to implement all modalities into the lesson, ensuring that they do not only use their own preferred mode (Lujan and DiCarlo, 2006).

Sociological preferences in learning

Individuals may learn best when working alone, with peers, or with an adult/teacher. It is essential that the teacher uses a variety of tasks within lessons, in order to cater for students with different sociological preferences. Group activities are important as they provide an opportunity for interaction and discussion as well as allowing peers to work together and promote teamwork (Sims and Sims, 2006). Many studies have shown social interaction to be an invaluable tool for learning (Kumpulainen and Wray, 2002). Collaborative group work has been reported to assist students to construct new ideas and provide an opportunity for different perspectives and views to be shared which can challenge pupils' thoughts, consequently allowing new interpretations to be constructed which otherwise would not have been discovered (Arvaja et al., 2000).

The National Curriculum

Before implementation of the National Curriculum teachers had substantial autonomy to cover their particular areas of interest and expertise in the classroom, where the only requirement was to teach religious education which was established by the 1944 Education Act (Osborn et al., 2000). This consequently meant that children were often being exposed to the same content and activities on multiple occasions, whilst some subject areas were being completely neglected (Osborn et al., 2000). This was one of the main reasons for the introduction of the National Curriculum, as it would provide a broad, balanced and coherent curriculum for all school pupils across the country (Osborn et al., 2000). The introduction of

the state-controlled National Curriculum occurred in England and Wales as part of the 1988 Education Reform Act (Wragg et al., 1989). Where the main aims of the National Curriculum were:

- To raise standards and expectations about pupil achievement
- To provide a broad, balanced and relevant curriculum
- To provide continuity and progression for all pupils (Fitzgerald, 1991)

For primary schools the National Curriculum consists of the three core subjects, six foundation subjects and religious education, making a total of ten subjects. The national curriculum outlines what knowledge pupils should know for each subject area, providing a national understanding of what is being taught in schools, so that there is a clear entitlement of curricular content for all children (Riley and Connell, 1992). The curriculum is comprised of four key stages, which occur across the age ranges of 5-16, where primary school covers key stage one (Years 1 and 2) and key stage two (Years 3-6). In order to assess the impact of the National Curriculum teachers are instructed to assess the level of attainment for each subject for each pupil. Furthermore, to complement this a comprehensive assessment system was implemented for the core subjects, which is through the use of externally prepared 'Standard Assessment Tasks', commonly referred to as SATS which are completed by all children at the end of each key stage; this provides a level of attainment for each pupil, reflecting both the pupils' progress and the teachers' success (Ball and Bowe, 1992). All class results are available to the local educational authority (LEA), governors and parents, ensuring schools are more accountable for the education they provide, which sparks competition between schools through the publication of national 'league tables' and allows school performance to be evaluated. (Riley and Connell, 1992).

Science was and still is to an extent a subject that is viewed with anxiety by many primary teachers; there is a national concern as many teachers lack understanding of many content areas. Since the implementation of the National Curriculum it was identified that schools would require additional training and support in planning and resourcing equipment for science lessons, including specialist science equipment such as thermometers and weighing apparatus (Riley and Connell, 1992).

The Primary Assessment, Curriculum and Experience (PACE) project began in 1989 to assess the impact of the implementation of the National Curriculum and assessment system on the teachers, pupils and head teachers (Osborn et al., 2000). One of the greatest findings of the PACE study was the rise of the measured standards in English, Mathematics and

Science during the 1990s. This was particularly rewarding as raising the standards was one of the primary aims of the National Curriculum (Osborn et al., 2000).

The role of the teacher

The role of the teacher is essential for the process of pupil learning (Hayes, 2008). The teacher can act in a variety of different roles to cover a number of preferred learning techniques, these roles include; an informer, a demonstrator, a facilitator and an interpreter, where often all four roles will be used at some point during each lesson and each have their place in providing pupil knowledge and understanding (Hayes, 2008). A number of factors can influence the effectiveness of teaching, these includes pupil dispositions, teacher knowledge and available resources (Hayes, 2008). Most importantly, teaching and consequently learning takes place best when all pupils are motivated, when they understand why the learning and subject matter is necessary and have clear views of what is expected of them by the teacher (Hayes, 2008). The latter can be achieved by sharing learning objectives with the pupils, which will allow pupils to understand the purpose of the activity. Children will always learn best when the lessons are fun, so teachers have to make every effort to provide an exciting learning experience, free of boredom (Hayes, 2008). All effective teaching sessions should include a plenary at the end of the lesson where learning is reinforced and a sense of fulfilment can be achieved for all pupils (Hayes, 2008).

Classroom layout in primary schools

Until the 1960s classrooms were ordinary set out in rows, this is because it reduced the amount of disruptions and on-task behaviour was found to be greatest when pupils were seated in rows (Croll and Hastings, 1996). This classroom arrangement meant that pupils spent the majority of their time completing individual work. After the Plowden Report was released there was a rapid shift towards group seating, which is the current practice in most primary schools (Wheldall and Glynn, 1989). This change came about because it was thought that interaction was essential for effective learning with socialisation being an important process (Wheldall and Glynn, 1989).

Ability grouping in primary schools

The practice of grouping pupils based on ability has been familiar in the UK since the 1940s; after the implementation of the National Curriculum, ability grouping was regarded as a method to raise attainment and standards, consequently all schools were encouraged to introduce it (Hallam, 2002). Since the twentieth century there has been a substantial amount

of research conducted on the use of ability grouping and whether it enhances pupils' academic attainment (Sukhnandan and Lee, 1998). The most rigid form of ability grouping is termed as streaming, whereby pupils are assigned to a class based on their overall ability and intelligence measured by tests (Hallam, 2002). When comparisons were made between schools that adopted streaming and those that didn't, it was found that the schools that did not adopt streaming achieved a higher average level of attainment (Daniels 1961). This finding was explained by an increase in attainment by the lower attaining pupils in the non-streamed schools, without holding back the higher attaining pupils (Hallam, 2002). Currently the most popular grouping within primary schools in the UK is by within-class grouping, where pupils are grouped within the class on the basis of ability. Research into within-class grouping identified that pupils of low ability learn more in mixed-ability groups, average ability pupils learn more when grouped with pupils of similar ability, while high ability pupils are unaffected and learn best in any group setting (Kulikand and Kulik, 1987).

Aside from the effects ability grouping has on attainment, the grouping is considered to be more manageable for the teachers as it reduces the range of differentiation in each class and allows differentiated tasks to be given out easier, but whether this grouping should be used as a means of simply managing the classroom is questionable (Hallam, 2002).

Primary schools teachers with a lack of science knowledge

The introduction of the National Curriculum heightened concerns about the lack of scientific knowledge of most primary school teachers; Her Majesties Inspectorate (HMI) in England reported that many existing teachers lack a working knowledge of science appropriate to children at primary school which has been identified as the most severe obstacle to the improvement of science in primary schools (Department of Education and Science (DES), 1978). Varley (1975) and Symington (1974) first identified that primary school teachers lacked the relevant knowledge and confidence for teaching science, this then became a common finding in primary science education literature. Appleton (2003) states that the teaching profession seems to attract people into primary teaching who fear science rather than those who love it, in which case these teachers require support and help to ensure they teach science effectively. Ultimately, in order to improve the quality of teaching and learning in science it has been identified that a key constituent will be increasing the scientific knowledge of teachers (Harlen, 1997).

Resources available for science teachers

In order for a teacher to provide an effective science lesson for their pupils, other factors may impinge on their efforts to do this besides from their own subject knowledge and confidence (Appleton, 1992). For many teachers a huge restraint on teaching science is simply the lack of availability of resources, this includes equipment for practical activities and experiments, student references and teacher resource materials containing activity suggestions (Appleton, 1999). In the United Kingdom, there is infrequent use of a textbook to teach science in primary schools, with a favoured tendency for activities that engage the pupils (Appleton and Asoko, 1996). The most common activity being printed activity sheets for the pupils to complete, however most teachers agree that the most important activities are hands-on. (Appleton, 2002). Ideas for hands-on activities are available from teacher-resource materials such as handbooks. Many studies found that if the equipment necessary for a hands-on activity was not easily accessible in schools then they would simply not use the activity, with many teachers portraying it as a “hassle” to organise equipment (Appleton, 2002).

Hypothesis

This research will aim to explore the benefit of interactive teaching within science lessons. The hypothesis is that interactive teaching will enhance science education in primary schools. Other aims of this research include investigating the effect a plenary has on pupil performance and whether seating arrangements can influence the amount of knowledge learnt. Furthermore, this research aims to consider any obstacles that may be preventing effective science education in primary schools.

Method

Educational setting

The research was conducted with 6 different classes at two different primary schools in Leeds, see Table 1. Primary schools can be compared by their value added measure. The value added measure is formulated by using pupils’ results from key stage 1 (KS1) assessments in Year 2 and key stage 2 (KS2) assessments in Year 6, whereby the KS2 result is compared to the median KS2 result for those pupils that had a similar result at KS1 (Department for education, 2011a). All pupils’ data is averaged to produce a score representative of the school as a whole. The value added score is a number that is based on

100, if the score is greater than 100, the pupils have made more progress compared to other pupils nationally that achieved similar KS1 attainment, while scores that are less than 100 indicate that pupils have made less progress (Department for education, 2011a). Therefore this value added measure provides a way to assess the value the school has added on average for their pupils and has been regarded as the fairest way to compare school performance. Both Talbot and Highfield have a value added measure of above 100 and are situated within the top 25% of schools nationally portraying a high achieving school status. Out of the 117 primary schools in Leeds that completed SATS assessments in 2010, Talbot was ranked 15th and Highfield was ranked 29th based on the value added measure (Guardian, 2010).

Primary School	Value added measure of school	Year Group	Class size	Length of lesson (mins)	Seating arrangements	Plenary Used
Talbot	101.4	5M	29	75	Ability	No
Talbot	101.4	5C	28	75	Mixed ability	Yes
Highfield	101	3B	22	60	Ability	No
Highfield	101	3J	20	60	Mixed ability	Yes
Highfield	101	4H	22	60	Ability	No
Highfield	101	4E	21	60	Ability	No

Table 1. Information about the classes used in the research. Seating arrangements indicate whether the pupils were grouped in tables by ability or mixed ability groups.

Developing the lesson

The topic allocated to this research project was “Keeping your heart healthy”. First of all the National Curriculum was consulted to discover what knowledge pupils should have on this subject area by the end of KS2. The National Curriculum states that pupils should know:

- that the heart acts as a pump to circulate the blood through vessels around the body, including through the lungs
- about the effect of exercise and rest on pulse rate (Department for education, 2011b).

Consequently, these then became the main learning objectives for the lesson. It had been identified that individuals learn in different ways and that the ability to teach to the needs of different learners has become increasingly important, stressing the need for all teaching

sessions to incorporate different learning styles. The lesson was developed in association with the VAK learning style, ensuring all three components were apparent within the lesson.

With the range of class years, it was appreciated that the lesson would need to be tailored to the lesson time available and the specific age groups, especially since the Year 5 classes had already covered the heart within their science lessons, while the Year 3 and 4 classes had not covered it at all. Therefore two lessons were developed based on the same subject content but with a greater depth of detail and extended concepts in the Year 5 lesson. To assess the impact of using a plenary and the use of mixed ability seating arrangements within the classroom, one Year 5 class and one Year 3 class will be subjected to the aforementioned variables. The seating arrangements normally adopted by the classes involved in this research are within-class grouping into ability groups; this arrangement is chosen by the teachers because it allows different ability groups to be assigned different levels of work and support, where pupils of the same group are able to work at the same pace.

Pre- and post-lesson test assessment

In order to assess whether the lesson had improved the content knowledge of the pupils, a written MCQ test was devised based on some of the main concepts of the lesson. This was given to the pupils at the start of the lesson to record their baseline knowledge (referred to as pre-lesson test) and then was completed again at the end of the lesson (referred to as post-lesson test) to measure the improvement in their knowledge. The test was comprised of 6 questions, with 3 possible choices for each question; the correct answer, an incorrect answer and a “don’t know” option. Again this was tailored to the age group, with separate questions for the Year 5s compared to the Year 3s and 4s. However the test was modified after the first Year 5 class, in order to make it more challenging for the other Year 5 class, in the hope that there would be an increase in the range of knowledge from before to after, further emphasising the effects of using a plenary and adopting mixed ability seating arrangements. Attached to the post-lesson test was an additional feedback form which asked questions to identify the pupils’ preferred learning style and favourite activity among other questions. The preferred learning style was interpreted from their answer to the following statement: I remember the most and learn best when:

- I write things down and draw pictures (Visual)
- I listen to the teacher and talk about the subject with my friends (Auditory)
- I touch the object I am learning about and do practical activities (Kinaesthetic)

The answer marked as their first choice was referred to as their preferred learning style, coded by either visual (V), auditory (A) or kinaesthetic (K). A feedback form was also given to the teachers which evaluated the success of the lesson and asked questions about the current teaching practice in primary science education.

Resources used within the lesson:

- Powerpoint slide show
- Heart models x 4
- Full body model to show location of the heart in the body
- 5 litres of fake blood
- Tubing that emphasises the difference in wall thickness of arteries and veins
- Stethoscopes x 15
- Blood pressure monitors x 15
- Video about the heart and its function

The lesson content

Pupils complete the pre-lesson test

⇩

Location of the heart in full body model

⇩

The function of the heart

⇩

Video

⇩

What makes up the circulatory system and discussion of oxygenated and deoxygenated blood

⇩

Demonstration of 5 Litres of blood

⇩

Discussion of the 3 types of blood vessels and the relevance of blood pressure

⇩

Exploration of the heart models and tubing (resembling arteries and veins) by pupils in groups

⇩

Discussion of the pulse rate and pupils measuring own pulse rate

⇩

2 minutes of exercise and pupils measure own pulse rate again

⇩

Discussion of why exercise increases the pulse rate

⇩

Pupils work in pairs to take each other's blood pressure and use a stethoscope to listen to the heart

⇩

A sheep's heart shown to the pupils in groups

⇩

How the pulse rate relates to fitness (Year 5 only)

⇩

Pupils complete the post-lesson test and feedback form

Methods of evaluation

Statistical analyses were performed using Excel. The pre- and post-lesson test mean scores were compared using a paired Student's t-test for all classes, where values of $P < 0.05$ were considered statistically significant. Descriptive data is reported as means ± SEM.

Focus Group

A practice session was conducted with a focus group of similar year groups to the test population. The focus group consisted of:

- One female in Year 3 (had not covered the heart in school)
- One male in Year 4 (had not covered the heart in school)
- One female in Year 6 (had recently covered the heart in school)

The focus group provided an opportunity to run through the lesson as it would be in practice and evaluate what worked and what required improvements as well as investigating whether the lesson was aimed at the correct level and if it engaged all individuals.

Results

Focus group

As expected it was found that there were significant differences in the level of knowledge between the different year groups, in particularly between the Year 6 individual compared to the Year 3 and 4, however it had not been envisaged that the level of knowledge would be as great as it was.

Year 3 – very basic knowledge known prior to the lesson, however progressed well throughout the lesson learning the key objectives.

Year 4 – Some of the content was familiar, however little knowledge of the types of blood vessels. Progressed well throughout the lesson.
Year 6 – Knew all of the content extremely well and demonstrated a greater level of knowledge than the lesson covered.

From conducting the focus group, it recognised it was necessary to tailor each lesson to the class depending on their previous exposure to the topic or not. Therefore, it was clear the Year 5 classes required a more challenging lesson, since they had already covered the heart this academic year. Furthermore, a more challenging pre- and post-lesson test had to be created compared to the original to allow a greater improvement in knowledge. The practical elements worked well but it was noted that when explaining how to use the blood measure monitor the full attention of all pupils was paramount.

Improvement in knowledge from the pre-lesson test to the post-lesson test

The performance of each class was significantly improved from the pre-lesson test to the post-lesson test by an increase in mean scores ($P<0.0001$ by a paired t-test), as shown in Figure 1.

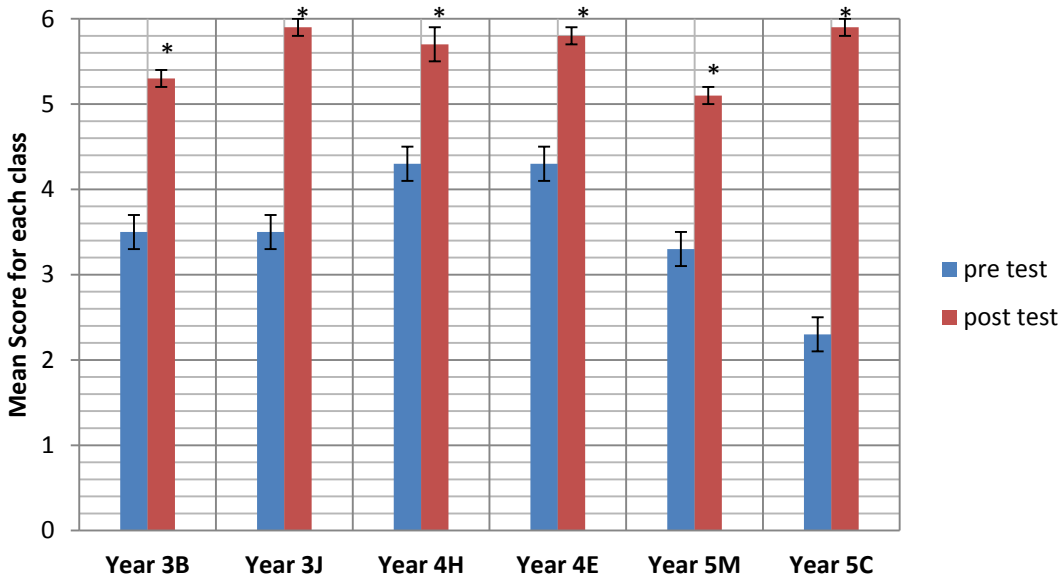

Figure 1. The mean score +SEM for each class are shown for both the pre- and post-lesson tests. Year 3B, 3J, 4H and 4E all completed the same tests, however Year 5M and 5C both completed class specific tests. The Year 5C test was more challenging than the Year 5M. A plenary was used and mixed ability seating arrangements were adopted for class 3J and 5C, while the other classes exhibited ability groupings and absence of a plenary.

* = post-lesson test was significantly different to pre-lesson test for each class, $P<0.0001$ by a paired t-test.

The Year 3 and 4 classes can be compared since they completed the same test. Both Year 4 classes had slightly higher pre-lesson test mean scores compared to the Year 3 classes.

The Year 5M class achieved the lowest mean score on the post-lesson test, while the Year 3B and Year 5C achieved the highest mean score on the post-lesson test. The largest improvement in knowledge was seen by class 5C.

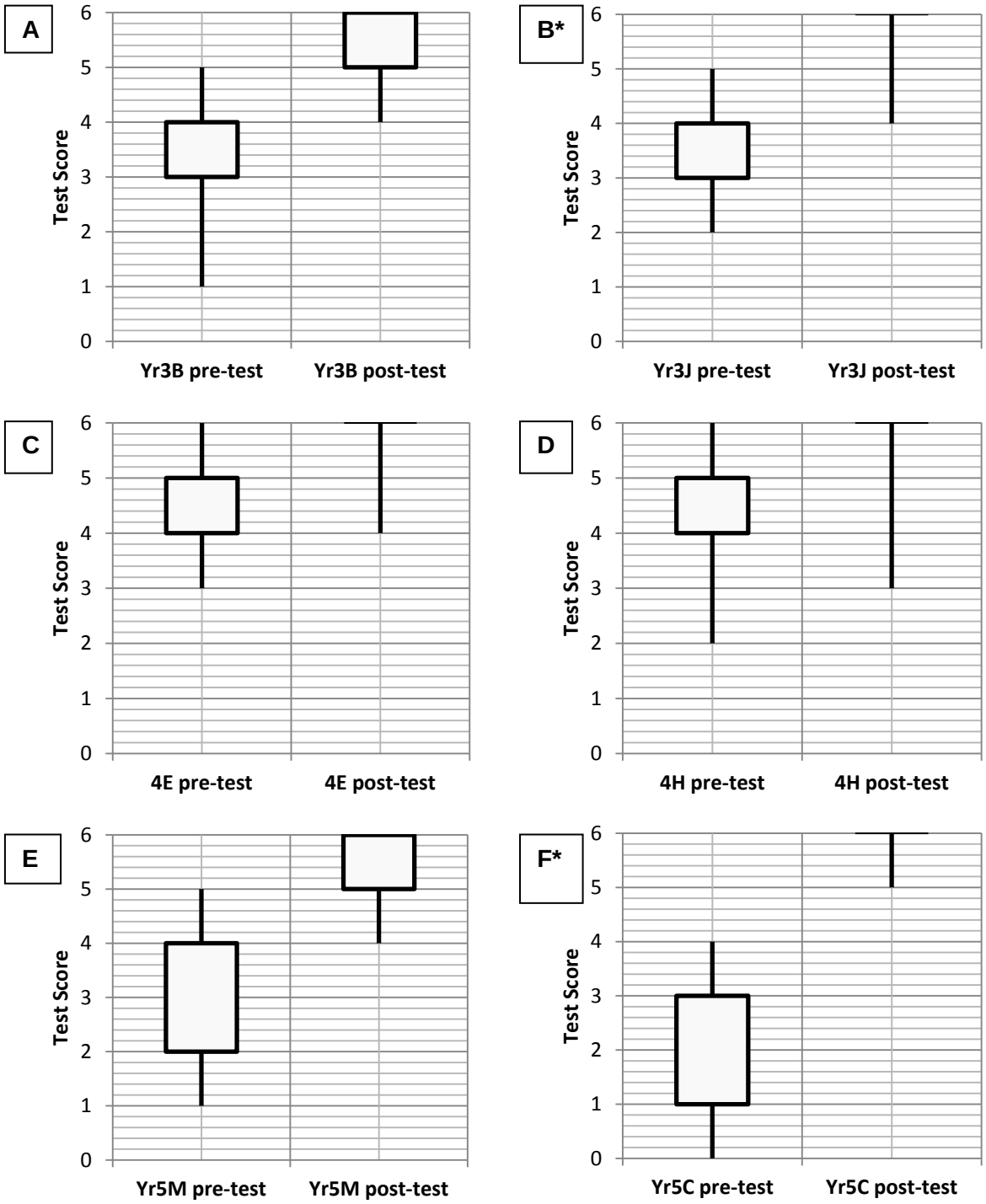

Figure 2. Box plots show spread of data for pre- and post-lesson tests for each class. Year 3B, 3J, 4H and 4E all completed the same tests, however Year 5M and 5C both completed class specific tests. The Year 5C test was more challenging than the Year 5M. A plenary was used and mixed ability seating arrangements were adopted for class 3J and 5C (indicated by a *), while the other classes exhibited ability groupings and absence of a plenary.

Overall the total number of correct responses for the pre-lesson test ranged from one to five for Year 3, two to six for Year 4, one to five for Year 5M and zero to four for Year 5C, while the total number of correct responses for the post-lesson test ranged from four to six for Year 3, three to six for Year 4, four to six for Year 5M and five to six for Year 5C, as shown in figure 2.

The effect of mixed ability seating arrangements and the use of a plenary on mean post-lesson test scores

As shown in figure 1, classes 3J and 5M that adopted mixed ability seating arrangements and used a plenary achieved the highest post-lesson test mean scores of 5.9. Since the Year 3 classes can be directly compared as they completed the same tests, class 3J achieved a significantly higher post-lesson test mean than class 3B ($P<0.05$ by a paired t-test).

Correlations between preferred learning style and performance for Year 5

The pupils were grouped into their preferred learning style and their pre-lesson test and post-lesson test performance was analysed. For class 5M, the pre-lesson test and post-lesson test means were similar for the different groups, as shown in figure 3A. For class 5C, the kinaesthetic and auditory groups had similar pre-lesson test means, with the visual group having a slightly lower mean, however all groups achieved an extremely high post-lesson test mean, indicating that all groups have benefited similarly from the design of the lesson. For both classes the visual group achieved a marginally lower post-lesson mean, however this is not statistically significantly.

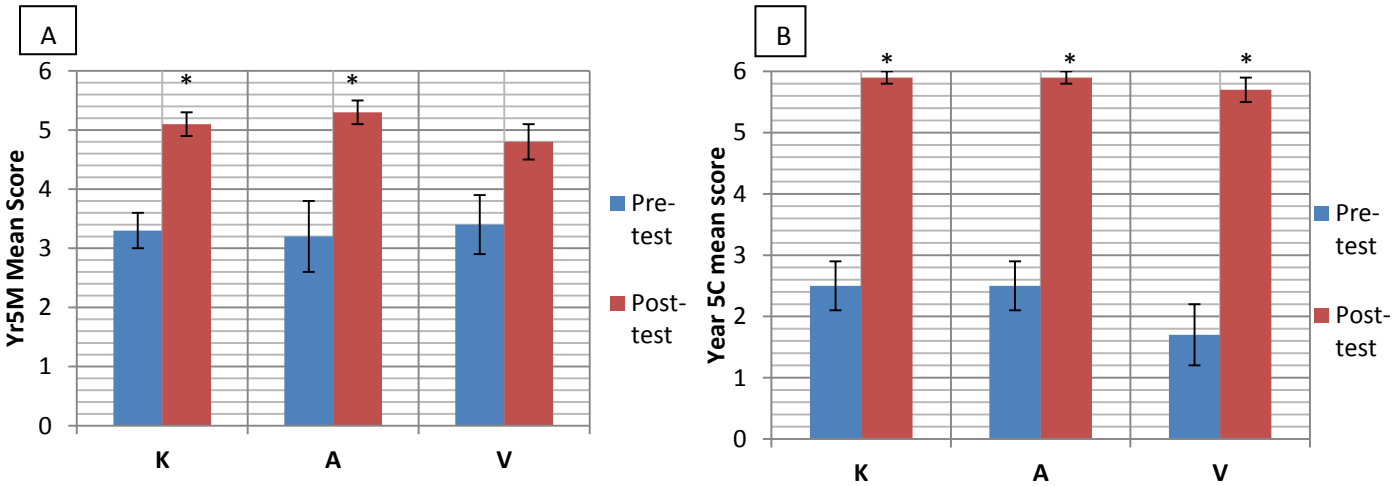

Figure 3. The mean score +SEM for Yr5M and Yr5C are shown for both the pre- and post-lesson tests, with pupils grouped according to their preferred learning style (kinaesthetic (K), auditory (A), or visual (V).
* = post-lesson test was significantly different to pre-lesson test for each class, $P<0.05$ by a paired t-test.
3A. Year 5M, number of pupils in each group K=15, A=6, V=5 (3 pupils did not complete the form)
3B. Year 5C, number of pupils in each group K=13, A=8, V=7

Breakdown of responses to one specific question

This question was included in the pre- and post-lesson test of all classes: Your pulse rate measures how many times your heart beats per? With three possible choices; seconds, minutes and don't know. The responses to this question were particularly interesting as many pupils believed the answer was seconds at the beginning of the lesson, see figure 4.

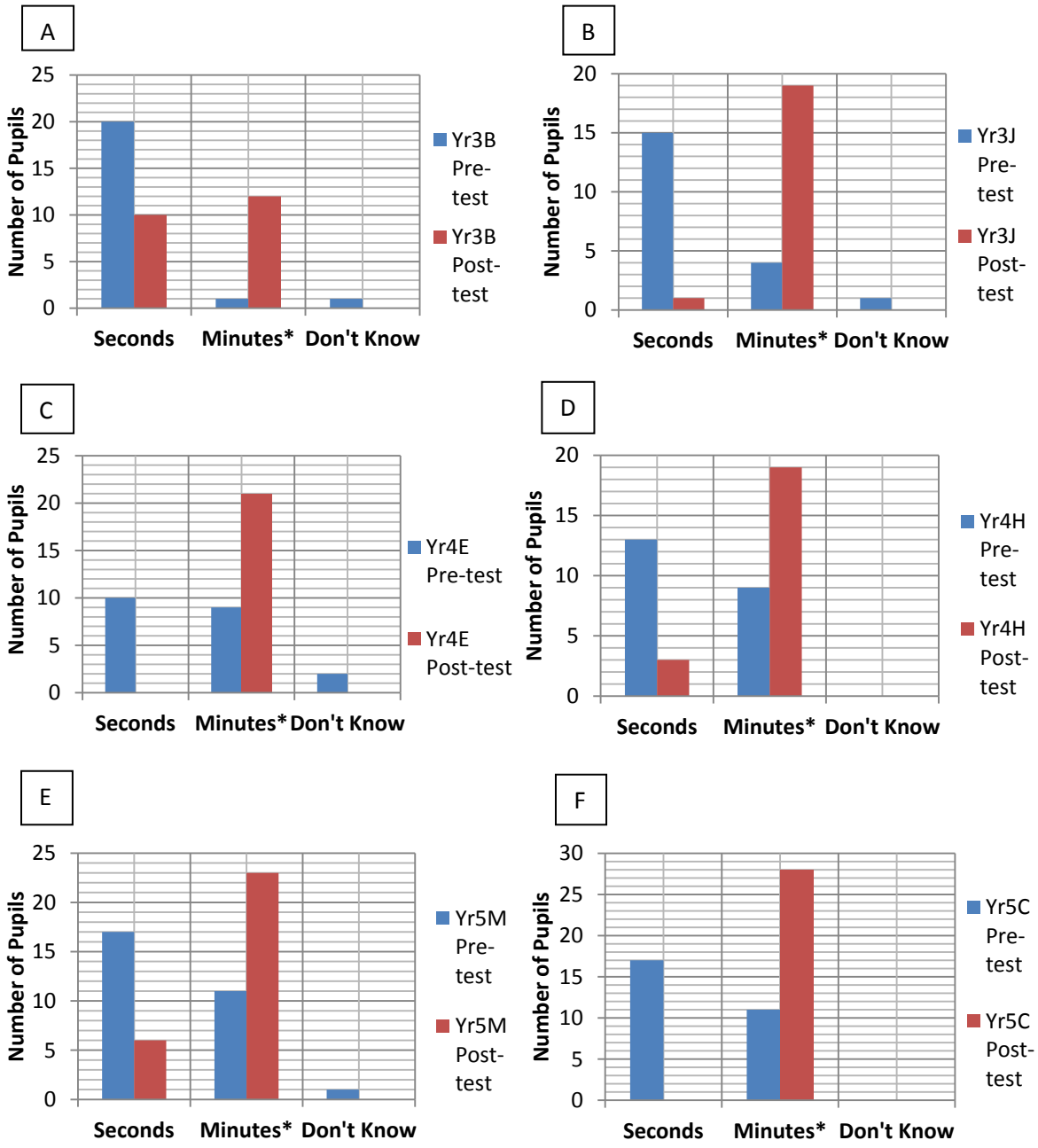

Figure 4. The breakdown of answers for one specific question on the pre- and post-lesson test for each class. Classes 3J, 4H, 4E and 5C measured their pulse for a period of one minute, whereas 3B and 5M didn't.
*= Identifies the correct answer

Pupils in classes 3J, 4H, 4E and 5C measured their pulse for a period of one minute under instruction both before and after exercise to gain a value for their pulse rate in beats per minute. However classes 3B and 5M only felt their pulse for a short period of time to feel the pace of it, both before and after exercise, not establishing a pulse rate. The classes that worked out their pulse rate had a higher proportion of the correct answer in the post-lesson test compared to the classes that didn't, see figure 4.

Favourite part of the lesson and preferred learning styles of Year 3 and 4 classes

The feedback form at the end of the lesson asked questions to identify the pupils' preferred learning style and their favourite part of the lesson. Table 2 shows the preferred learning styles, distinguishing gender. Overall, the preferred sensory modality was kinaesthetic, with auditory second and visual last, however a wide spread of preferences was still apparent.

Preferred sensory modality	Females	Males
Visual - I write things down and draw pictures	30%	27%
Auditory - I listen to the teacher and talk about the subject with my friends	34%	27%
Kinaesthetic - I touch the object I am learning about and do practical activities	36%	46%

Table 2. The preferred sensory modality of males and females in Year 3 and 4

Table 3 shows the preferred activity of the pupils, with more females preferring the measurement of blood pressure, while considerably more males preferred seeing a sheep's heart.

Preferred activity	Females	Males
Seeing a sheep's heart	39%	73%
Measuring blood pressure	59%	20%
Using a stethoscope	2%	7%

Table 3. The three preferred activities in the lesson, with the corresponding percentages for males and females in Year 3 and 4

No gender correlation between the pre- and post-lesson test results

There was no correlation between the female and male results of the pre- and post-lesson test, as shown by figure 5. The post-lesson mean scores were similar for males and females

within the same class, as well as across the different classes, highlighting that the interactive teaching lesson was successful for both genders.

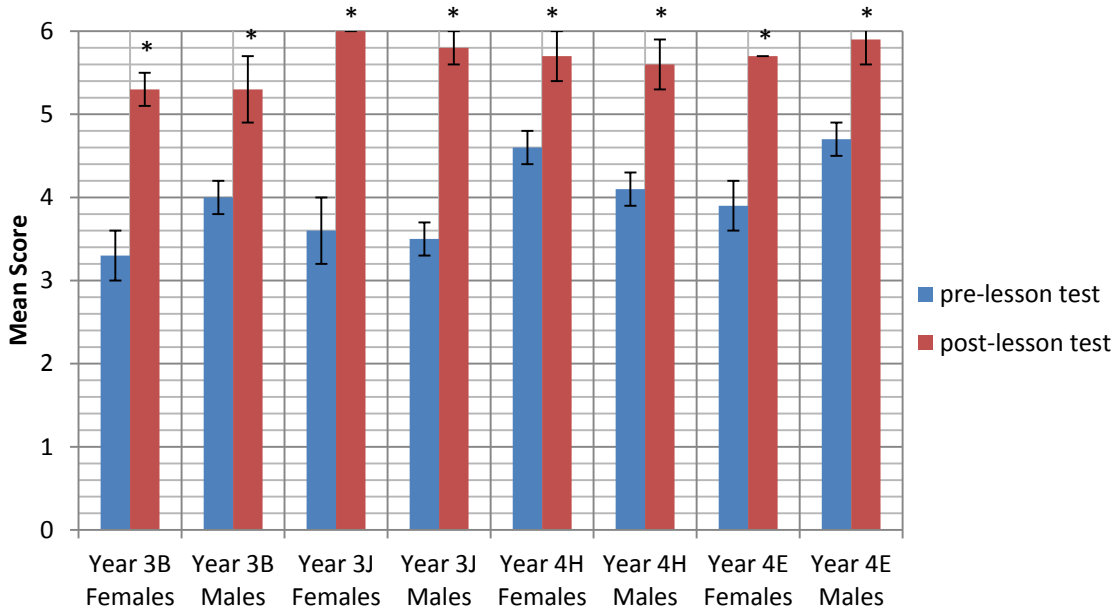

Figure 5. No gender correlation observed between the pre-and post-lesson mean results for females and males across the Year 3 and 4 classes.
* = post-lesson test was significantly different to pre-lesson test for each class, P<0.05 by a paired t-test.

Teachers' Feedback

All of the teachers thought the lesson went well and that the pupils were interested and engaged throughout, with the key objectives learnt. All of the teachers commented on the quality of resources being excellent, as they would not regularly be available in school. The most common responses for aspects of the lesson that worked the best are shown below:

"The number of resources used and the opportunity for the pupils to take their own blood pressure"
"The pupils seeing a real heart"
"The amount of practical activities and the volume of equipment"
"Actively testing the effect of exercise on the heart rate"

The following improvements were suggested by the teachers; including key vocabulary, adopting behavioural management strategies and differentiated work and tests for higher and lower ability pupils.

All of the teachers agreed that as a general rule when teaching science lessons, the more practical work the better. Most felt the practical work contained in their lessons was enough but that there was always scope for more, and that the quality of resources available at their school was good, however they would not have access to equipment such as blood pressure monitors and stethoscopes. When teachers were asked to rate their own science knowledge, either average or good was reported. The most common responses for the biggest challenges in teaching science are shown below:

"My own subject knowledge"
"Ensuring all abilities are catered for in the lesson"
"Tailoring the lesson to meet the needs of all pupils"
"Resources being in use"
"The amount of time it takes to prepare a science lesson"

Discussion

Improvement in knowledge from the pre-lesson test to the post-lesson test

The interactive teaching session with practical involvement was successful in enhancing the knowledge of all the pupils in each class. The Year 3 classes had lower pre-lesson test mean scores compared to the Year 4s, this was expected since the Year 3s are younger in age and have been in education for less time. However despite the age difference, with effective teaching the Year 3s were able to learn as much and achieve a slightly higher post-mean score than the Year 4s in the case with class 3J, illustrating that the mental capability was present with the younger pupils.

The effect of mixed ability seating arrangements and the use of a plenary on mean post-lesson test scores

The classes that were arranged in mixed ability groups and included a plenary demonstrated significantly higher ($P<0.05$) post-lesson test mean results compared to those classes that didn't, indicating that these variables could be responsible for enhancing the learning of the pupils.

A plenary is used to draw out the learning and refer back to the lessons objectives ensuring they have been met, it also provides an opportunity for pupils to reflect upon and articulate what they have learnt (Davison and Dowson, 2003). A plenary is useful because it summaries the lesson and helps pupils to focus on the most important points such as those

in the learning objectives rather than the most recent points they have learned. When a plenary is used correctly, knowledge is reinforced and consequently learning is enhanced, therefore a plenary session should be incorporated into all lessons by teachers.

Mixed ability groups may be responsible for the higher attainment in this interactive lesson due to higher ability pupils supporting the lower ability pupils. This is because the lesson involved practical work in pairs and group discussions, of which works best and is more effective when carried out in mixed ability groups (Swing and Peterson, 1982). Vygotsky, a social constructivist, stressed the importance of group learning and interaction, recommending the use of mixed ability seating (Vygotskiĭ et al., 2004). Evidence in the literature suggests that ability grouping itself has no significant effect on raising attainment (Barker Lunn, 1984). In fact research is indicating that pupils make greater progress when in mixed ability classes (Whitburn, 2001). Advantages of mixed ability grouping is related to how pupils can support fellow classmates in their learning, by inspiring, helping and motivating each other (Hallam, 2002). While an advantage of ability grouping includes how work can be better matched to the individual pupil needs, allowing the higher ability groups to be stretched and the lower ability groups to receive more support and time (Hallam, 2002). However, a common problem reported when classes decide to adopt ability grouping is that teachers expectations change, having a negative influence on the lower ability pupils as the teachers now have lower expectations of them, resulting in them not being pushed and stretched like the higher ability pupils. Ability grouping in classes can have an effect on pupils' personal and social development especially for lower ability groups, where they can feel devalued by being given easier work and possess negative views of their academic ability (Turney and Hyde, 1931). When lower ability pupils are taught within mixed ability classes they often have a more positive view of their ability and feel less stigmatised (Turney and Hyde, 1931). Ideally pupils should experience a variety of working environments including working independently and in mixed ability and ability groups. The subject and content of the lesson should ultimately determine what environment is used, as some will be suited and more effective in certain situations. This needs to be considered by the teacher when planning the lesson and flexibility needs to be encouraged at all times. However, it is important to consider that the effects of ability grouping on attainment will also depend on other independent factors such as the quality of teaching, pupil motivation and effort.

Correlations between preferred learning style and performance for Year 5

The lesson incorporated all three learning styles, however due to the amount of practical involvement it was questioned whether it would be more beneficial to kinaesthetic learners

resulting in them performing better in the post-lesson test assessment compared to pupils classified as visual and auditory learners. However, the results found that regardless of pupils' preferred learning style, all pupils performed well in response to the interactive lesson and there were not any significant differences between the different learning styles. The same findings have been found in other research investigating the use of interactive activities (Breckler and Yu, 2011). Consequently, the interactive lesson that was delivered to the pupils was appropriate for all individuals. This provides evidence that interactive teaching in schools can have a positive effect on all children's attainment in science.

Breakdown of responses to one specific question

During all of the lessons it became apparent that many of the pupils had a misconception about the units of the pulse rate, with numerous pupils confidently answering it as seconds rather than minutes. This misconception was seen with all year groups at the pre-lesson test, with a greater proportion of pupils answering seconds rather than minutes with virtually all pupils in Year 3 holding this misconception. This misconception is probably the result of incorrect understanding based on everyday life or assumptions from science lessons covering other topics, where often results are recorded in seconds, for example time. It is important that when misconceptions are identified in the classroom that they are addressed immediately while learning is occurring to ensure any incorrect ideas are not perpetuated (Carvalho and West, 2011). However this can be difficult as once misconceptions are assimilated by pupils they are often difficult to eliminate. The method used to teach the pupils can determine how well the material is learnt, such that the classes that actively counted their pulse for one minute, had a higher number of correct answers at the post-lesson test, indicating that the participation of counting for one minute made the answer more memorable compared to the classes that didn't and instead only felt the speed of their pulse for a few seconds. Therefore, this proves that active learning can promote understanding and enhance learning when the activities are designed appropriately.

Favourite part of the lesson and preferred learning styles of Year 3 and 4 classes

The preferred learning styles were widely spread demonstrating the need for a range of visual, auditory and kinaesthetic techniques in each lesson in order to cater for all the pupils in the class. Overall, there was greater preference for a kinaesthetic mode of learning, this is not surprising as most pupils will find this method the most fun and enjoyable, furthermore as it is used the least out of the three modes, it will be considered more of a novelty and a reward (Dobson, 2010). Males showed a greater preference for kinaesthetic learning than

females, which is commonly found in the literature and is explained by males usually being more “hands on” than females (LeFever, 1995; Isman and Gundogan, 2009). However there was no significant relationship between gender and preferred learning style found. Measuring and identifying students preferred learning styles accurately is a difficult task, within this research the preferred learning style was classified according to the pupils first preferred sensory modality only and did not take into account multimodal preferences. It is common for pupils to have strong preferences for more than one modality, such that 64% of individuals prefer to use at least two modalities when internalising information, while 36% of individuals only use one modality and exhibit unimodal preferences (Dobson, 2010). It’s believed that individuals that are multimodal benefit as they have the flexibility and choice of more than one mode to use, possibly making learning easier (Ramirez, 2011).

Feedback was gathered to find out pupils favourite part of the lesson, where the top two responses were, measuring their own blood pressure and seeing the sheep’s heart. The sheep’s heart would have been appealing to the pupils because it was real and something they hadn’t seen before. It also allowed the pupils to picture what their own heart looks like, providing a visual resource better than any model, picture or video. The measuring of blood pressure was popular because it was a “hands on” kinaesthetic activity which allowed the pupils to act as scientists or doctors, where they were able to engage with and find out their own blood pressure, again this was an activity that they would not usually have the opportunity to do. If this topic had been taught by the teachers, the pupils would have not been exposed to these activities, so it’s likely the novelty also influenced them being the preferred parts of the lesson. A gender correlation was evident, where the majority of males reported that seeing the sheep’s heart was the best part, while females were split with slightly more preferring the measuring of blood pressure. The greater preference of the males for the sheep’s heart is probably because males are typically more fascinated and intrigued with gory material, not being phased by blood.

Since a gender correlation was identified for the favourite part of the lesson, the results highlight the importance of a variety of activities within the lesson to ensure all pupils are engaged. Otherwise, it could be assumed that if only a sheep’s heart was used within the lesson, this would be of more interest and engage the males more than the females, possibly being more advantageous to them. Ultimately, a range and variety of activities within each lesson will further support all pupils’ preferences.

Teacher feedback

The quality of the resources were described as being excellent by the teachers, this is because the equipment used such as the blood pressure monitors, stethoscopes and heart models are not regularly available in school. Furthermore, with the ratio of one piece of equipment between two pupils, this ensured that everyone had sufficient time to get involved and use it. Additionally, although the teachers would have had access to resource a heart, all of them felt that it would not be something they would incorporate into their own lesson, mostly because they felt they lacked the necessary knowledge and background to explain the anatomy of the heart, as well as it being slightly inconvenient to supply. Therefore, the lessons were devised and delivered in a way which the teachers would not have been able to provide for their pupils, ensuring the sessions were of benefit to both the pupils and the teachers.

A hurdle for most primary school teachers when teaching science is often their limited knowledge of the subject area, especially due to the vast number of topic areas it covers. Most teachers feel that they are more confident with their knowledge of biological areas of science compared to physical areas such as energy and forces (Harlen, 1997). Coulby & Ward's (1996) research found that when interviewing primary school teachers it became apparent that the teachers had problems with their own understanding of science concepts and felt it was a result of receiving a poor science education when they were at school. This is particularly true for older primary school teachers as they may not have a formal qualification in science if they were schooled when science was not perceived to be an important part of the curriculum, fortunately this has been resolved since the introduction of the National Curriculum, in which science is now a core subject (Coulby and Ward, 1996). Wragg, Bennett and Carre (1989) conducted research to assess how competent teachers felt at teaching the National Curriculum with their existing knowledge of each subject area, only a year after its introduction. They completed a survey with over 900 teachers in England, the results found that teachers felt most competent in English with Maths at second place, however Science was ranked eighth out of ten subjects (Carré and Carter, 1990). As a result of this extremely concerning finding for one of the core subjects, training was provided for teachers and resources for science teaching were improved (Harlen, 1997). A follow up of the survey mentioned above was completed in 1991 with over 400 teachers, ranking their competency of each subject again, the results were well received as science had risen up to third place after English and Maths (Bennett et al., 1992).

Another challenge for primary school teachers teaching science can be a result of the lack of availability of resources, which are necessary to allow experiments to be conducted and have previously been described as an important tool in aiding learning in science. If the resources are not available in school, it consequently means that the teacher has to obtain the resources for themselves, which relies on extra organisation and early preparation, of which some teachers are not prepared to invest the necessary time. Appleton (1999) reported that often the choice of what was taught in science was a result of the resources available, inevitably leading to some topics not being covered well or occasionally not even at all. Furthermore, if time is considered a resource, many teachers feel this is an important factor, as science requires significantly more time and effort to prepare a lesson in contrast to the majority of other subjects, therefore when time is short, it is not surprising that science is postponed or not delivered as effectively as it should (Appleton, 1999). Thus in order to support the teaching of science, it appears that resources need to be readily available, easily obtainable within the school and the teacher has to be prepared to spend additional time and effort in order to gather the resources, especially when they are not available (Appleton, 1999).

The use of interactive learning

The lessons given to the pupils were heavily based on interactive learning, with numerous practical elements involved. Appleton (2003) said that hands on activities or experiments are extremely important when teaching science. It has been reported that by engaging students in active learning they will develop a greater understanding of the subject area, especially in science where the use of experiments provides an opportunity for the students to predict and discuss the results, resulting in more information being retained (Carvalho, 2009). This is supported by the constructivist theory of learning, as it states that a student's conceptual understanding is improved when they are actively engaged in the learning process. Allowing and encouraging pupil discussion in the lesson was in order to promote long-term learning, this is because by verbalising their understanding of the ideas, the individual is required to make their explanation more concrete and specific (Carvalho and West, 2011). The use of practical experiments within science lessons provides visual, physical and verbal associations that students will use to recall information. The activities that work the best are said to be the ones that are enjoyable and are of interest to the pupils, as well as those that grab the children's attention, all of which are likely to make the subject more memorable and inevitably enhance learning (McCarroll et al., 2009).

Limitations and development work

One of the main limitations with this research is the accuracy of defining the preferred learning styles of each pupil, especially since it was self reported and only one question was used to determine this. If further time was available a VAK learning style questionnaire test could have been completed by the pupils to provide a more precise interpretation of each pupil's preferred learning style, as well as allowing discrimination between unimodal and multimodal pupils. Furthermore, as the use of a plenary and mixed ability seating arrangements were investigated together, it's impossible to know the effect each one had, therefore it would be beneficial to investigate them separately if this study be completed again.

In order to establish whether the lesson had effectively enhanced the pupils learning for the long term, a second post-lesson test could be completed by the pupils 10-14 days later to determine whether the lesson content, including the key objectives were retained. Analysis would include comparing the second post-lesson test to the first post-lesson test and investigating whether there's any correlation between the three different types of learning style and the amount of knowledge retained. To fully appreciate the benefits of an interactive lesson, other lessons could have been delivered which lacked the interactive teaching and the use of experiments, in order to compare the post-lesson test mean results. This would allow interactive teaching and conventional methods of teaching to be compared to firmly establish which enhances learning more.

Further development work would investigate other classroom seating arrangements and how they affected pupil attainment. This includes the use of mixed-sex seating arrangements and whether on-task behaviour and productivity is greater when pupils are seated next to the opposite gender.

Ethical implications and wider social impact of this research project

This research involved the use of school pupils between the ages of 7-11 years, these individuals are classified as vulnerable subjects so before embarking on the project I underwent a criminal records bureau (CRB) check to ensure I was suitable to work in a teaching environment with children. This was a legal requirement and is put in place to help protect vulnerable individuals in society. Before admission into schools I had received consent from the head and the specific class teachers. The research involves interactive, engaging teaching sessions about the heart that aims to ignite pupils' interest in science and health. The pupils would have benefitted from these sessions as the resources used are not

regularly available in school, which should enhance and stimulate learning. An aspect of the lesson incorporated physical activity to investigate the effect of exercise on the heart rate, this required strict adherence to health and safety regulations. A sheep's heart was shown to the pupils to demonstrate the heart anatomy, a stringent risk assessment was completed to assess potential risks and from this preventative measures were put in place to minimise any risks. I recognised there may be cultural differences within the classroom, therefore a sheep's heart was chosen, opposed to a pig's or a cow's. All pupils had the option to not participate in any activity if they did not wish to. An important issue in this project was the sensitivity of the pupils to death caused by heart disease, therefore it is paramount my language is diplomatic at all times. I recognised there may be cultural differences within classes and therefore instructed pupils to listen to the heart with a stethoscope on top of their clothes rather than exposing bare skin. It was hoped that as a result of these sessions, the pupils will be inspired and motivated by science.

Conclusion

The results from this research indicate that the use of a plenary enhances learning by providing reinforcement. The results also suggest that ecological variables such as seating arrangements have the potential to influence how effective the learning environment is. It is therefore important that seating arrangements are determined according to the nature of the task or activities to be completed in the lesson. The obstacles preventing effective science education are nowhere near as great as they have been in the past, however it seems that the teachers subject knowledge and the availability of resources still have the potential for further improvement. The interactive teaching used within the lessons successfully improved the knowledge of all pupils, evidenced by the change in scores from the pre- to the post-lesson tests. All pupils regardless of their preferred learning style performed well with the use of interactive teaching, providing confirmation that interactive teaching can have a positive effect on all pupils' attainment in science. All pupils enjoyed the interactive learning highlighted by the Year 3 and 4s responses to their favourite part of the lesson. Teacher feedback emphasised the usefulness of the quality and amount of resources used within the lesson, which were essential in allowing the interactive teaching to occur. The findings discussed above support the hypothesis that interactive teaching does enhance learning.

Personal Reflections

My initial expectations were that I wanted to deliver a stimulating, interactive lesson that all the pupils would learn from and enjoy. I believe I successfully achieved this, evidenced by the significant increase in knowledge of all pupils and the extremely positive feedback I received from the pupils and the teachers. At the start of the project I identified that in order to be successful I should continually analyse ways to improve the lesson and my research. After each lesson, I marked the pre-and post-lesson tests to evaluate how well the pupils did. After the first two lessons that I taught, I realised that many pupils were not retaining the correct unit of the pulse rate. Through this reflective teaching, I adapted the way I taught this area by instructing the pupils to count their pulse rate for one minute. By actively measuring the pulse rate for one minute themselves, this made the information more memorable and therefore more pupils choosing the correct answer in the post-lesson test. Furthermore, I also decided to edit the pre- and post-lesson test for the second Year 5 class in order to make it more challenging, in the hope of achieving a greater increase in knowledge, which it successfully achieved.

I thoroughly enjoyed this research project and gained great satisfaction from the teaching sessions. I believe as a consequence of delivering these sessions, I have improved my communications skills and the ability to adapt to different levels of intelligence. This research has ignited a passion for teaching and I would now consider teaching as a future career option.

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Appendix