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Peer-assisted learning in a Year 7 classroom: Do structured group-work strategies impact upon the learning and engagement of pupils studying Earth Science?

Samantha Jane Armsby

(PGCE Secondary Science/Biology, 2009-2010)

email: samanthaaarmsby@cantab.net

Abstract

The general shift in education towards pupil-centred learning provides a platform for class teachers to integrate more structured group-work strategies during science lessons. This action research intervention considers the impact of peer-assisted learning, in the form of practical and discursive group-work activities and 'Complex instruction' (specifically role allocation), on a Year 7 class studying Earth Science. Although inconclusive in terms of proving an impact of structured group-work strategies on the learning of scientific concepts, a statistically significant relationship is found between the introduction of role-allocated group-work activities and an increased engagement in science lessons, with particular reference to the 'Resource Manager' role in practical situations. Differentiated groups with allocated roles are also shown to encourage peer-discussion and promote the co-construction of knowledge and higher-order thinking. However, the development in pupil behaviour needed to facilitate group-work took time and reminders. It is vital that pupils and teachers are trained in group-work strategies and pupil expectations and roles are clearly defined.

Peer-assisted learning in a Year 7 classroom: Do structured group-work strategies impact upon the learning and engagement of pupils studying Earth Science?

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Introduction

There is a lot more to group-work than just allowing pupils to sit and work together; the defining factor being a shift towards peer-assisted learning partly arising from a general movement towards pupil-centred learning. It is widely reported that pupils learn best when they are actively involved in the process (Tudge et al., 1996; Howe & Smith, 1998; Dillon, 2008). 'Pupils working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats' (Beckman, 1990 cited in Hackbert, 2004, p.39). For the purpose of this assignment, 'peer-assisted learning' is group-work that includes pupils collaborating as part of a team to achieve a common, defined goal.

There are many factors which can be analysed within the field of group-work, such as classroom layout, group composition and associated dynamics, pupil-led group activities including work-books which are completed throughout a topic, group behaviour management and so on. This investigation will focus on three key aspects drawn from the literature, which consider the role of group-work within the science classroom: The use of group practical activities to develop understanding of scientific concepts; the production of group concept maps to consolidate knowledge and develop links between entities; and the associated role allocation whilst completing such structured group-work tasks to ensure active pupil participation from all group members. This study shall seek to establish whether there are any relationships to be found between these ideas and the learning and engagement of the pupils involved. The study will consider the intellectual impact of peer-assisted learning in the context of a class of Year 7 pupils studying Earth Science, but will also consider the wider pedagogical implications of group-work in the classroom.

Earth Science is fraught with abstract concepts that are inaccessible to pupils, such as the movement of tectonic plates and the formation of metamorphic rocks deep underground. The intention of a science teacher is to make such concepts tangible and practical group-work is one way teachers can achieve this aim. The following literature review will investigate existing trends between investment in group-work in the science classroom and the apparent impact on pupil learning and engagement.

Literature Review

The following section shall discuss the importance of structured group-work with respect to improving pupil learning of science concepts and will evaluate existing studies of group-work in the classroom. Published literature will be critically reviewed in order to shape the research questions and the key-terms featured in the project title will be defined. The main areas that will be evaluated are the general benefits of group-work in the science classroom, specific strategies for delivering structured group-work (specifically practical activities and the production of concept maps) and the allocation of roles within groups.

Benefits of group-work

Vygotsky's 'Social Development Theory' argues that social interaction precedes development and that higher-cognition and learning is the end product of social behaviour (Vygotsky, 1962 cited in Daniels, 2001). The theory promotes learning contexts in which pupils play an active role in their own learning. Experimental research on the effectiveness of within-class groupings has demonstrated small, positive effects on pupil achievement and attitudes (Kulik & Kulik, 1992 cited in Blatchford *et al.*, 2005b).

From personal experience as a teaching assistant it was noted that Year 7 classes that feature a wide-range of abilities can often be needy and demand constant feedback from the teacher, be it instructional, praise or prompting. It is almost impossible for a teacher to provide such attention to a class of 30 pupils whilst maintaining whole-class order and lesson pace. In a study of 180 six to nine year-olds predicting the movement of a mathematical balance beam, in the absence of teacher feedback, having a more capable partner proved more beneficial than working alone (Tudge *et al.*, 1996). Pupils with partners who exhibit higher-level reasoning were more likely to benefit from collaboration than those whose partner did not, providing the pair achieved shared understanding (Tudge *et al.*, 1996).

Structured group-work strategies

The next section of this review shall focus on the impact on learning and engagement of two streams of structured group-work strategies. For the purpose of this investigation 'structured group-work strategies' should be taken to mean any group-work activity which has been clearly defined by the teacher, which requires pupils to work together as part of an organised team, and for which pupils are clear about the task that they need to complete and the outcome that will be achieved. The term 'learning' encompasses the understanding of science concepts and progression from an earlier state of knowledge to a more advanced appreciation of the subjects taught. The term 'engagement' includes attitudes towards science, motivation to learn, interest in science activities and enjoyment of science lessons.

The two strategies this investigation is predominantly concerned with are the use of investigative practical work and discursive group-tasks, such as concept maps and posters. The final section of the review considers the thread running through the management of all discussed group-work strategies – 'Complex instruction' (Boaler, 2007) and the allocation of roles within groups.

Practical group-work

'Practical work in science has enormous potential for exciting pupils, giving first hand knowledge and supporting theory' (Wellington, 1998, p.135). However, descriptions of practical work in science are frequently used with little clarification. The National Curriculum (NC) regularly refers to both 'practical and investigative activities' and 'experimental work' (Qualifications and Curriculum Agency (QCA) 2007a/b) with no further definition, apart from detailing that pupils should be able to 'use a range of scientific methods and techniques to develop and test ideas and explanations' (QCA, 2007b). After consulting various sources, for the purpose of this assignment I will define practical work as any investigative activity in which pupils are using practical science equipment to model a concept or explore an outcome. In a recent National Endowment for Science Technology and the Arts (NESTA) survey of 510 UK science teachers, 83 percent believed that 'enquiry learning' (an investigative technique which involves pupils raising and testing hypothesis before drawing conclusions), had a positive impact on student performance and attainment

(NESTA, 2005, p.13). As the large survey has been conducted by a leading independent expert, it can be classed as a reliable source.

Practical group-work activities can be used to re-enact scientific models and encourage pupils to bridge the gap between the observable and their 'realm of ideas', which 'allows for a natural extension of knowledge' (Millar, 1998, p.18). Such 'enquiry learning' (Millar, 1998, p.18) is especially relevant when considering the learning demand of the Earth Science topic. It is not possible for the class to see an erupting volcano in person or witness metamorphic processes deep inside the Earth.

The positive impact of collaborative practical work on pupil conceptualisation has been documented by Howe & Smith (1998). In a study of 100 eight to 12 year-olds from two primary schools, pre-tests were used to determine conceptions about object flotation and heat transfer. Pupils were then assigned to groups of four and asked to complete tasks presented in work-books, involving formulating individual predictions, then sharing predictions and finally coming up with a common group prediction. Post-test measures were then used to score conceptual knowledge focusing on factors such as 'explanation of prediction' and 'interpretation of outcome' (Howe & Smith, 1998, pp.229-230). The greatest pre- to post-test score was observed by pupils whose conceptions differed from their fellow group members. Such a finding implies that in practical situations, the discussion of scientific concepts with peers prior to investigation is beneficial to learning. However, it should be noted that this research was conducted in a Scottish primary school setting, and only a small number of the pupils involved in the tests were of Year 7 age (11 to 12 years old). Therefore parallel with assumed behaviour of secondary school pupils needs to be made with caution.

In 2008, Science Community Representing Education (SCORE) was tasked by the Government's STEM High Level Strategy Group to develop a focused strategy to promote practical work in school science. This request and the calibre of the institutes which are operating in partnership to run SCORE (such as the Institute of Biology, Royal Society of Chemistry, the Association for Science Education), indicates the perceived importance of practical work in secondary science teaching. The recent SCORE publication details how practical work promotes 'pupil ownership' of science which can be motivating and enjoyable (SCORE, 2009, p.9). 'Pupil ownership' refers to independence when completing tasks and the development of 'self-directed enquiry' (SCORE, 2009, p.9). Group practicals not only support experimental learning and skills development, but also extend Personal, Learning and Thinking Skills (PLTS). For example, investigative, group practicals can aid the progression of 'effective participants', 'team workers' and 'self managers' (Qualifications and Curriculum Development Agency, 2009). However, whether pupils are as engaged with the notion of practical work benefitting their learning could be debated. In a recent online survey of 1450 pupils, individuals were asked to choose the three methods that were most useful in helping them to understand science. Only 38 percent of respondents to the online survey chose 'doing a science experiment in class'. The two approaches that were regarded as being most useful and effective were 'having a discussion/debate in class' (48 percent of respondents) and 'taking notes from the teacher' (45 percent) (Cerini *et al.*, 2003, p.10 cited in Dillon, 2008). Perhaps group-work in the UK has become stagnant and pupils spend too much time following recipes and not enough time participating in investigative activities where pupils are given autonomy in deciding how a task is performed, analysed and evaluated?

Kerr's (1963) study supports the view that good practical work can communicate the wonder of science by reporting that of the 701 science teachers interviewed with regards to their view of the aims of practical work at Key Stage 3 (KS3), the highest ranking aim was to arouse interest in the subject (Kerr, 1963 cited in Wellington, 1998). Such an aim appears befitting when considering the huge pupil expectation of practical work in secondary school science as illustrated by Year 6 Open Evenings and the elaborate science experiments often on display at such events. From my own experience as a teaching assistant at an 11-18, coeducational, comprehensive school with 1100 pupils on-role in rural Cambridgeshire, practical science work engaged even the most reluctant of learners. In one such class I supported, with numerous pupils on the special educational needs register, the class teacher strived to involve practical group-work at least once every two lessons. Pupils with literacy problems were able to access the science curriculum through practical activities, allowing them to synthesise complex theories in an interactive way.

Student engagement is crucial to developing focused classroom environments where all pupils are willing to participate in learning opportunities. Disaffected pupils may disrupt classes with off-task behaviour, therefore impacting on the learning of themselves and others.

Discursive group activities

'Social learning theory makes clear the importance of promoting group-work so that conceptually focused dialogue takes place' (Wellington, 1994, p.406). This section will consider how group-strategies that promote discussion between pupils can be beneficial to learning and engagement.

Whilst on my first professional placement (an 11-18, coeducational, comprehensive school with 1350 pupils on-role in rural Cambridgeshire) I witnessed a discursive group-work activity in a Year 7 mixed-ability classroom. The class was split in two and briefed that they had to define the word "fossil" or the word "fuel". The teacher guided the pupils' productivity by explaining the structure and the aim of the task. It was clarified that the group should work together to discuss any existing ideas that they had and consolidate such ideas into a one sentence definition which would be presented back to the other group. Small-group discussion involves peer-to-peer interactions that are on a more 'symmetrical' level (Mercer *et al.*, 2004) than those of teacher-pupil interactions. The following interaction has been transcribed from the group definition task, focusing on the "fossil" group:

Pupil 1: "**I think** it's been dead for years and years."

Pupil 2: "Yeah, it's a prehistoric animal that's been turned into stone."

Pupil 1: "How does it get fossilised?"

Pupil 2: "**If** it died in soil it **would** be preserved."

Pupil 3: "**If** it gets pressed over millions of years."

Pupil 1: "**I think** a fossil is something that is old and is made of dead creatures."

The terms highlighted in bold type have been defined by Mercer *et al.* (2004) during previous research as 'indicator words' and are associated with reasoning and the justification of views. The example transcribed illustrates how the pupils are teaching their peers by making statements based on their prior knowledge, questioning things they don't quite understand and then extending the answers of their peers to conclude what a fossil is, all of which are indicators of a progression in learning.

Another structured group-task that provides the platform for pupil collaboration and discussion of ideas is the concept map. A concept map graphically illustrates the relationship between key-terms (Vanides *et al.,* 2005). Concept maps can be presented in different forms, the most telling being open-ended, where pupils are not given guidance on what propositions to display. Such concept maps elicit higher-order thinking processes (Vanides *et al.,* 2005). Concept maps allow groups of pupils to discuss connections between science terms being used, organise the relationships between said terms and reflect on their understanding (Vanides *et al.,* 2005). Teacher analysis of prepositions can reveal the pupils' level of understanding and can be a useful diagnostic tool or pre- and post-intervention measure.

The pitfalls of group-work

The introduction of group-work strategies in the classroom is not without issues. From classroom layouts which are not conducive to physically inclusive group-work, to group activities providing opportunities for social interaction that is not on-task. The following section shall consider how pupil participation in group-work, or lack thereof, and the unfair division of tasks can impair engagement and how strategies for allocating roles to group-members can increase participation.

Whilst operating in groups without clearly defined roles, it is common that strong individuals will dominate, whilst other pupils play little part in planning, predicting or carrying out the practical (Wellington, 1998; Hackbert, 2004). This has been described by Hackbert (2004) as the 'free-rider' or 'social loafer' effect, however such observations were made in the context of study groups on entrepreneurship courses in an American higher education where whole-groups are given one grade for projects. As this is not common practice at the school in which this investigation is being carried out, the 'free-rider' effect is less likely to be witnessed pupils know they will be awarded individual attitude and attainment grades. Wellington (1998) also reports that pupils may adopt various roles themselves without engaging in the whole picture, for example, one pupil may decide they shall record and tabulate all the results, but with no clue as to where they came from. For this reason, the allocation of roles when introducing group-work is an important consideration.

'Complex Instruction' and the allocation of roles

Light & Glachan (1985 cited in Tudge *et al.,* 1996, p.2893) reported that are less likely to benefit than those actively engaged in the task, however as discussed, group-work can provide some pupils with the opportunity to become a 'free-rider' (Hackbert, 2004). A 2004 Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) paper reports that small-group discussion is enhanced and focused by giving pupils some form of guidance on how to operate effectively (Bennett *et al.,* 2004). An idea that is central to the concept of 'Complex Instruction' (Cohen & Lotan, 1997 cited in Boaler, 2007).

Complex instruction is a technique being pioneered by Californian academics Liz Cohen and Rachel Lotan, which was developed to make group-work more 'effective and equitable' by grouping children of all abilities together and assigning roles so they can help to teach each other (Boaler, 2007, p.171). Complex instruction involves numerous strategies to create a 'multidimensional' classroom, including the practice of raising the status of those in the group who may be of a lower status by asking them specifically to present an idea to the class (Boaler, 2007, p.172). Pupils are also rewarded for working in different ways within the classroom and appreciating that different individuals may be better at different 'abilities', such as discussion, investigation and prediction (when transposed into a scientific context) (Boaler, 2007). The aspect of complex instruction which is particularly applicable to group-work situations is the allocation of roles, such as 'Team Captain', 'Reporter', 'Resource Manager' (Cohen & Lotan, 1997 cited in Boaler, 2007). If pupils are given a specific role to play within a group situation, the group cannot function without every member performing their role to the best of their ability, thus increasing pupil engagement and indirectly impacting positively upon pupil learning.

Boaler (2006) has conducted studies of complex instruction in England and USA, one such study being that of an inner-city high school (14 to 18 years old) in California. During the four year study, over 600 hours of classroom observations were collected alongside interviews and questionnaires. One of the most prominent findings from the research was the impact of complex instruction on the self-belief of pupils that they could achieve anything if they put in the effort (Boaler, 2006). In the year 3 questionnaires, 84 percent of pupils involved in the intervention agreed with the statement, 'anyone can be really good at math if they try', compared with only 52 percent of pupils who were not involved (Boaler, 2006, p.7). Although the available research on complex instruction has so far been conducted in a mathematics environment, I believe the results can be transposed into a science context due to the parallels between thinking and learning styles in science and mathematics.

Research questions

As highlighted by the literature review, there are many factors which play a role in the successful implementation of group-work strategies in the classroom. The aim of this study is to investigate the following three research questions:

- Does the use of practical group-work activities improve pupil learning of Earth Science concepts and engagement in science lessons?
- Does the use of a discursive group-work strategy, such as concept map, allow for higher instances of peer-assisted learning by facilitating communication between group members?
- Does the specific allocation of roles within a group increase pupil engagement?

Methodology

The following section will discuss the methodology followed whilst conducting this investigation in order to answer the research questions posed. Initially the context of the investigation is explained. The theory behind the intervention lesson plans (and corresponding group-work strategies employed) is detailed and the apparatus used to collect data are described and evaluated.

Context

The enquiry has been conducted in a comprehensive, 11-18, mixed-sex, secondary school in a Cambridgeshire town, which serves a diverse catchment area. There are approximately 1200 pupils on-roll and a significant proportion of these pupils are from families whose household income is below the national average (Ford, 2010). The class in question are a Year 7, set-two group who have been streamed based upon their Key Stage 2 mathematics grade. At the latest monitor point, the NC levels present amongst the 30 pupils (14 girls and 16 boys) in the class ranged from level 3 to level 6. There are three pupils for whom English is an additional language and nine pupils on the Special Educational Needs register (eight at School Action level and one at School Action Plus level, predominantly for either specific or moderate learning difficulties or for behaviour, emotional and social difficulties).

Overall design

This investigation takes the form of an action research project and this section will explain the procedure followed and the reasoning behind any methods used. A Year 7 class were asked to complete a questionnaire to establish their opinions of group-work and their current attitudes towards science. The class were placed into six groups (based upon attitudes and attainment data) and were asked to complete a concept map and quick quiz to establish misconceptions and current level of knowledge. An intervention was planned for involving a whole topic of ten lessons, in which various aspects of group-work were investigated. Ongoing reflection resulted in two cycles of intervention occurring after group re-structuring and the introduction of complex instruction. Pupils recorded their engagement during the lesson on a tracker document and the focus group's discussion was audio-recorded. The same questionnaires were then re-administered and an end of unit test and concept map was completed.

Action research procedure

'When a teacher intervenes to make changes to their practice and at the same time systematically collects evidence of the effects of these changes, then they are engaging in action research' (Wilson, 2009, p.189). Action research is both a cyclical and continuous process, suited to many contexts, whereby initial findings generate possibilities for change, which are then implemented and evaluated as a 'prelude to further investigation' (Denscombe, 1998, p.58 cited in Bell, 2005). Action plans, which are typically carried out within the context of the situation, rather than from an outside perspective, can be formulated through reflection after each stage of the intervention and improvements considered. The *in-situ* research ensures that the data is more 'natural' and may avoid bias; however it also means that generalisations to alternative contexts should be made with care as the action research is specific to the context of the intervention (Bell, 1996 cited in Bell, 2005). It may also be possible that due to the close nature of the study, participants may change their behaviour as a result of knowing what is being studied (Bell, 1996 cited in Bell 2005).

Ethics

It was ensured that the research conducted followed all necessary school and research ethical guidelines. The Head of Department and Professional Tutor were consulted with regards to any permission which needed to be obtained. The class chosen for the research project were briefed in terms of what the intervention would entail (a high level of group-work activities) and were assured no activities used would knowingly be disadvantageous to the group's learning. Pupils were asked if it was acceptable to be audio-recorded and were told that any audio data would be heard by the researcher only and then destroyed. Pupils were informed that, for the benefit of the research project, the questionnaire responses would need to be non-anonymous. Again, all participants were assured that any data collected would be anonymously coded for (using number coding where applicable) and then destroyed after use. All of these considerations were in line with the school guidelines on data protection and also the British Educational Research Association (BERA) code of conduct (2004).

Assigning the groups pre-intervention

Initially a 'Myself-as-learner Scale' (MALS) (Burden, 1998) was completed by the class to obtain a measure of the pupils' academic self-concept. The simple, 20-item scale has been designed as a reliable diagnostic tool when considering pupils' self-beliefs (Burden, 1998). In this instance MALS results were used to assign differentiated pupil groups, as this was highlighted in the literature review as having a positive impact on pupils' cognitive processes (Howe & Smith, 1998; Wellington, 1994). To assign such groupings, MALS results were combined with recent attainment data (average of October and December monitor points) and ranked by attainment and then attitude. Due to the wide-range of NC levels within the group (levels 3 to 6), and the fact the class were set based upon KS2 mathematics grades, it was important that groups should not solely be assigned on pupils' opinion of themselves as learners. Such self-concepts may reflect how willing pupils are to engage with science lessons, but need to be considered alongside current ability. Initially, five groups of six pupils were then constructed by taking the top three pupils and placing them in a group with the bottom three pupils, and then taking the second highest ranking trio of pupils and combining them with the second to lowest ranking trio of pupils. One amendment was made to group one (which was to be the focus group as it was the most differentiated group); two pupils were swapped, to suit the learning needs of one pupil whose English is still very weak. Group size was considered with relation to the context of the class in question. As a Year 7 class, they are more 'needy' than other groups so I did not want to form many smaller groups and be faced with constant conflicting demands for teacher attention. Groups were also constructed for classroom management purposes, with an equal number of males and females where possible and the separation of those who are known to be disruptive when working together. The group structure was changed three times; after the first lesson (swap to avoid personality clashes), after the second lesson (again to avoid conflicting personalities) and after the sixth lesson when one person from each group was removed to form a sixth group.

Lesson	Main Group-work Activity
1 – Introduction	Initial **concept map** with provided key-terms. **Rock sample sort** (without teacher guidance). **'Experts'** move groups after 10 minutes. Extension – production of a key to identify unknown rock samples.
2 – Weathering & Erosion	**Chemical weathering practical** (adding hydrochloric acid to various rock samples and observing what happens). Relate to acid rain.
3 – Weathering APP Poster	**'How long will my gravestone last?' APP task** (strands AF3 and AF5). Using knowledge from previous lessons and practicals, form hypotheses about what factors affect the rate of weathering. Consider material, location, preservation etc. Design a poster to represent this information. '**Complex Instruction' role allocation**. **Peer-assessment** of posters using given APP criteria.
4 – Sedimentary Rocks	**JESEI making sedimentary rocks practical.** Using syringes and different cementing agents (nothing, clay and Plaster of Paris), make three sedimentary rock samples to test during the next lesson. **'Complex Instruction' role allocation**
5 – Sedimentary Rocks II	**Continuation of JESEI practical, testing strength of rocks. 'Complex Instruction' role allocation.** Place masses on 'rocks' and record weight at which they crumble. Also note observations of grains. Write a conclusion linking the formation of the sedimentary rock to the materials it is made from.
6 – Igneous Rocks	*JESEI salol crystal size practical planned, but had to change plan due to practical issues with gas taps (needed for earlier teacher demo of wax volcano). Therefore, no group-work activity during this lesson.*
7 – Igneous Rocks II	**Define own success criteria. JESEI salol crystal size practical,** modelling crystallisation of magma with salol on heated and cooled slides. How do crystal sizes differ? Write conclusion. **'Complex Instruction' role allocation. Pupils now in 6 groups.**
8 – Re-cap (cover lesson)	Various worksheets completed
9 – Metamorphic Rocks	**JESEI metamorphic rock formation practical.** Modelling the formation of metamorphic rock using egg white (country rock) and a beaker of hot water (igneous intrusion). **'Complex Instruction' role allocation.**
10 – The Rock Cycle	**Snowballing topic concept map.** Starting in pairs and using key-word prompts, begin to build a concept map which covers everything learnt this topic. Join with another pair and add to the concept map. Discuss with another group. Assess work using Tim & Moby video and completed example of concept map.

Table 1. Main group-work activities introduced during each lesson Intervention

Based on the school's own scheme of work the Earth Science topic contains the following key areas:

- Weathering, erosion, transportation and deposition

- Sedimentary, igneous and metamorphic rocks
- The rock cycle

A series of ten lessons were planned for and taught during the action research cycles. Unless acting as a control lesson, or due to unforeseen circumstances, each lesson included a structured group-work activity, which used practical or discursive techniques to dispel misconceptions that were uncovered and model abstract theories. Table 1 describes the main group-work activity that took place during each lesson.

Complex instruction

As uncovered in the literature review, Boaler (2007) reported that grouping pupils of different abilities and assigning roles to individuals can increase pupil engagement in a task and promote self-belief. In this project, complex instruction was introduced in the form of role allocation during the group-work activities from lesson three to lesson seven of the intervention. Pupils were shown a table with their name and corresponding role for that lesson and all roles were explained. The roles allocated differed by pupil each lesson and also increased in volume, with only a few pupils having a role in lesson three to all pupils having a role in lesson seven. Table 2 illustrates roles developed from those created by Boaler (2007), which were allocated to members of the groups.

Role	Description of duties
Leader	Responsible for the general running of the group, time-keeping and ensuring all tasks are completed.
Question Asker	The only person allowed to ask the teacher a question, therefore ensuring all questions are discussed with the group prior to asking.
Resource Manager	Responsible for collecting and returning all necessary resources for the lesson, from practical equipment to work-sheets. There were typically two 'Resource Managers' assigned per group.
Spokesperson	It was the duty of this person to report back any findings to the class if asked to do so by the teacher. This role was typically assigned to pupils who would not normally discuss their ideas with others to ensure communication of opinions and results occurred.

Table 2. Roles allocated during group-work activities

Data collected

Table 3 illustrates the array of data collected for analysis, which is detailed in two sections; primary data sources, which are typically qualitative and more reliable; and secondary data sources, which provide more anecdotal evidence. Data was collected concurrently and has been merged both at the data collection stage and at data analysis.

	Type of Data
Qualitative	1. Use of Dictaphone to record focus group discussions 2. In class teacher questioning 3. Book mark 4. Photocopying work
Quantitative	1. MALS survey, which combined with attainment and attitude to learning (and teacher/mentor knowledge) would shape groups, including identifying the focus group 2. End of unit test results
Both	1. Pre and post intervention questionnaire 2. Pre-intervention quiz and concept map to identify misconceptions in topic and establish base-line for any learning that may occur 3. Engagement tracker allowing pupils to voice their own opinions at the end of each lesson 4. Mentor observation of engagement during lessons

Table 3. Types of data collected for the purpose of this study

Primary data sources

Questionnaire

Pupils were asked to write their name on the questionnaire so a direct comparison could be made between pupil opinions before and after the intervention. It was explained that the questionnaire was not a test and there were no wrong answers.

Questionnaires collect a large amount of structured data that can be less time-consuming for a researcher to analyse (Wilson & McLean, 1994). However, due to a potential lack of detail, a second section was added where pupils were encouraged to answer three open-ended questions to elicit a wide range of responses. The questionnaire was designed to probe the pupils' views of group-work and their current attitudes towards science lessons, which would be used alongside engagement tracker scores (see section *Engagement tracker* in *Primary data sources*) to represent their engagement during lessons. The 15 closed questions ranged from those concerned with opinions of group-work to those concerning enjoyment in science lessons. Participants indicated their answer by ticking a five-point Likert scale ranging from 'never' to 'always', which means a large number of questions could be answered quickly and accurately (Oppenheim, 1992). Most of the questions were worded positively, however one question was worded negatively and the scale was therefore reversed, which meant participants would not just tick the same answer every time. Higher scores indicated a more favourable view of group-work with an inferred understanding of its learning and engagement benefits. The answers to the open-ended questions were harder to summarise due to their varied nature and for this reason were only used anecdotally to support in-class observations. Post-intervention, the same questionnaire was issued to the pupils to enable a direct comparison to be made between the pupils' view of group-work and engagement in science lessons before and after the intervention.

Learning demand probes

A common concern of science teachers is whether the 'everyday' views held by the pupils are in agreement with the recognised scientific views. Such a discrepancy can be described as the 'learning demand' of the subject (Leach & Scott, 2005). In order to highlight Earth Science learning demands and ascertain the existing level of subject knowledge, two probes were used. The first was an un-prompted concept map and the second was a quick quiz with multiple choice questions.

Concept maps allow pupils to not only exhibit their ideas about a topic in an unstructured way, but also draw explicit connections between key-words and 'evaluate aspects of their learning' (Taber, 1999). In order to provide qualitative evidence with regards to higher-order thinking and learning, prepositions can be scored using a three-level rubric: 0 = not scientifically correct; 1 = partially correct or correct but scientifically thin or irrelevant; 2 = scientifically correct (Vanides *et al.,* 2005). Comparisons can then be drawn between pre- and post-intervention concept maps.

Quick quizzes identify misconceptions in bulk. The sixteen-question multiple choice quiz featured four possible responses for each question, therefore presenting three incorrect answers or 'distracters' (Krause *et al.,* 2003). The quizzes were completed as groups and more than one group choosing the same incorrect answer may hint that a misconception surrounds the subject.

The most common misconceptions in Earth Science are documented as the non-acceptance of the concept of water expanding on freezing (Driver, 1994) and the definition of 'texture' as 'feel' instead of 'the size, shape and arrangement of grains that make up a rock' (Pearson Education Limited, 2008). Pupils struggled to distinguish between weathering and erosion and believed that all types of weathering involved physical weather. At the end of the intervention, the same two probes were issued and compared to the pre-intervention results, in conjunction with monitor point data, to ascertain whether a progression in 'learning' had been made.

Focus-group recordings

Audio-recordings of Group 1 were coded to reveal indicator words, which were reported by Mercer *et al.* (2004) as being associated with higher-level reasoning, increased levels of discussion and peer-to-peer teaching. An advantage of using such an apparatus for data collection is the natural data you can collect when pupils are more likely to discuss their ideas freely without the presence of a teacher. However, as discovered, pupils may play-up to the Dictaphone!

Engagement tracker

The engagement tracker, which was stuck into the back of pupil's books, posed three questions to be scored at the end of each lesson by ranking opinions on a scale of 0 to 10 (where 0 meant definitely no and ten meant definitely ten). Upon analysis, this was not the most reliable data collection method as pupils often forgot to fill out the tracker at the end of every lesson (although always prompted to do so) and therefore sometimes wrote in random scores. Pupils may also have been likely to raise their scores to please the researcher. Results were also influenced by negative occurrences during the lesson, for example an argument between two boys resulted in scores of 0 amongst a small group of pupils when actually the pupils in question were predominantly engaged throughout the lesson and were contributing to group discussions.

Secondary data sources

Class-teacher engagement observation grid

During a few intervention lessons, the usual class-teachers were asked to complete an engagement observation grid. Every five minutes teachers were asked to code the behaviour of pupils in the focus group as follows; blank = on-task; N = not on task; D = disruptive. These results were analysed in conjunction with a record of when group-activities took place during the lesson to identify if on-task behaviour was associated with practical or discursive activities.

The large discrepancy between the pupils' behaviour as recorded by the observer, and my own opinion of whether they were engaged with the task highlights the limitations of the observation grid. This discrepancy was supported by the book-mark where many pupils who were recorded as being 'on-task' had taken no notes or completed no work to support this premise.

Alternative assessment

Alongside a book-mark, class-work was also assessed (for both evidence of learning progression and engagement). At the end of the intervention the pupils completed an end of unit test, which would prove indicative of an advancement of learning.

Results

This section shall seek to answer the research questions posed in the methodology through analysis in the following key areas:

- General impact of group-work on;
    - Learning of Earth Science concepts
    - Pupil engagement
- The impact of practical and discursive group-work strategies
- The impact of role allocation

The impact of group-work on learning

In order to highlight a progression in learning from the beginning to the end of the investigation a comparison of pre- and post-intervention attainment levels was made. Out of the thirty pupils in the focus class, only two pupils obtained a lower level in their Earth Science test than in their previous Forces test. However, it must be noted that such a comparison does not take into consideration the difficulty of the Earth Science topic in the context of all other Year 7 units. In order to glean whether the increase in attainment can be attributed to the intervention lessons or just a common higher attainment for this unit the results for the Earth Science end of topic test were compared to other module results from the same focus class. Results were then compared to another Year 7 classes' test results for the same modules. It should be noted that the other Year 7 class are set-one and therefore direct comparisons between set-two and set-one group results have not been made. Instead results have been used comparatively intra-class to determine whether the Earth Science topic test was generally viewed as harder or easier than other unit tests.

The difference in levels between the results for the previous unit and the Earth Science unit is comparable between the set-one and focus class; the Earth Science result is approximately two sub-levels higher than Forces result in both class cases. In Figure 1, the focus class results for the Earth Science unit are shown to be within the typical range of average Year 7 unit test results. Therefore, it could be reported that although an improvement in NC level was seen for 28 pupils, this was witnessed across the board for this particular test paper and therefore, the impact on the intervention on learning with regards to attainment levels is inconclusive when considering full-class results.

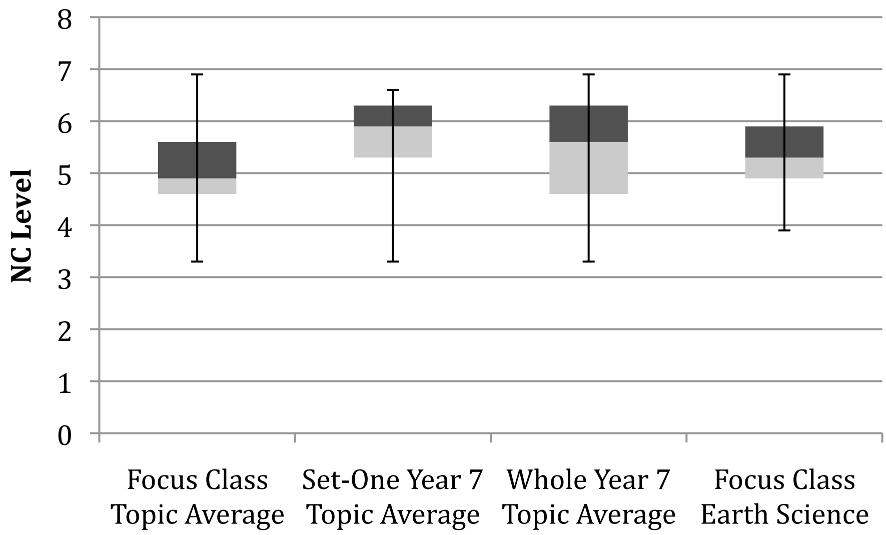

Figure 1. Box-plots enabling comparison between the intervention class (set-two) Earth Science test results, the intervention class test results for other units and another Year 7 class results

The impact on learning within the two focus-groups

Group 1 were composed as the most levelled group and Group 5 were the least (Group 6 were composed at a later stage by removing individuals from each of the existing groups). Prior to the intervention, pupils in Group 1 were working at NC levels ranging from 3b to 6b. In comparison, those in Group 5 were all working at 4a or 5c. Post-intervention, the levels within both focus groups had increased on the whole (by an average of one sub-level, apart from one pupil in Group 5 whose level decreased by one sub-level), however the difference between pre- and post-intervention attainment levels was not statistically significant ($p>0.05$ returned by Wilcoxon Signed-rank test).

The three most able pupils in Group 1 all experienced large increases in NC level pre- to post-intervention (based upon difference between Forces test and Earth Science test). The result is still valid when taking into consideration the fact that across Year 7 Forces test levels were two sub-levels lower than Earth Science results, with one pupil moving up four sub-levels and another moving up seven sub-levels! A book-mark supported such results with these two pupils in particular displaying higher-order thinking and extending themselves in group-work tasks. These findings indicate that differentiated group-work strategies were beneficial in helping the more able pupils within the groups learn and understand the concepts of Earth Science, as supported by Tudge *et al.* (1996) and this idea is discussed in more detail in the *Impact of practical and discursive group activities in the science classroom* section.

The overall impact of group-work on pupil engagement

Post-intervention questionnaires returned a slightly higher mean score than pre-intervention questionnaires (55 compared to 52, to two significant figures, out of a possible 75) implying that pupil appreciation of group-work and their engagement in science lessons has improved during the intervention period. Although the range of questionnaire scores remained the same (39 for both pre- and post-intervention), the distribution of scores shifted towards a higher result, as is illustrated in Figure 2. As the questionnaires were not completed anonymously the non-parametric Wilcoxon Signed-Rank test can be used to test for significant differences between pairs of values. The hypothesis (H_1) would be that there is a significant difference between individual pupils' pre- and post-intervention questionnaire scores. In this case the Wilcoxon test returns a statistically significant result ($p=0.04$). This indicates that we can reject the Null hypothesis of no difference

(H_0) and accept the hypothesis that there is a significant difference between questionnaire scores before and after the intervention period.

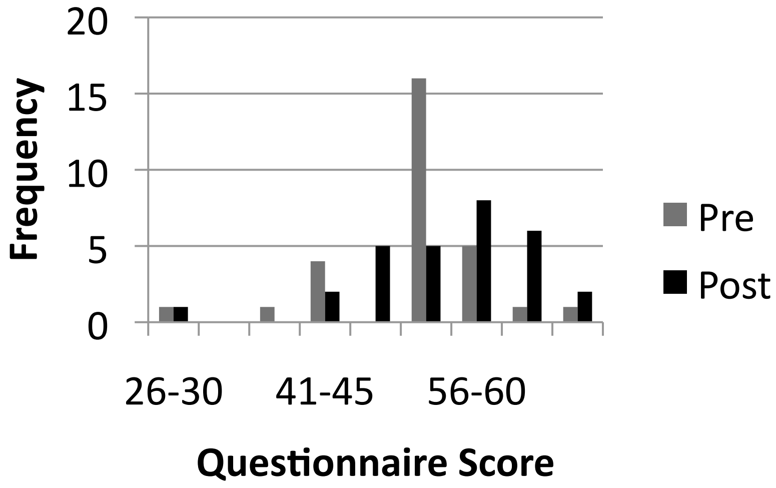

Figure 2. Histogram displaying pre- and post-intervention questionnaire score frequencies

As identified previously, one pupil from Group 1 was seen to move up four sub-levels in terms of his NC attainment grade (the second highest instance of progression in the class). Interestingly, this pupil, who shall be referred to as 'Pupil A', also had the highest increase in questionnaire score post-intervention (the median difference between pre- and post-intervention questionnaire scores was proven to be statistically significant at the 95 percent confidence level ($p=0.002$) by a Wilcoxon Signed-rank test).

Upon constructing the questionnaire, three of the questions featured were deliberately more heavily related to two of the research questions posed to enable a more in-depth analysis of responses. In particular:

- Question 8: Do other pupils explain their ideas to you?
- Question 10: Does it help you understand things if your friends explain it to you?
- Question 15: Have you enjoyed science lessons recently?

The pupil with the most statistically significant difference between pre- and post-intervention questionnaire responses also made the largest jump up the scale when answering these three questions. As indicated in Table 4, Pupil A's post-intervention scores given for the three focus questions were as high as they could possibly be, not only indicating an increase in engagement, but also an improvement in learning methods. Pupil A has indicated that pupils do explain their ideas to him and that it helps him understand Earth Science concepts. This result is supported in the *Impact of practical and discursive group activities in the science classroom* section by a dialogue transcription between Pupil A and another pupil.

Questionnaire Score (1 to 5) (to 2 s.f.)	Question 8	Question 10	Question 15
Overall Average Pre-intervention	3.0	3.6	3.1
Overall Average Post-intervention	4.0	4.0	4.4
Pupil A Pre-intervention	2.0	3.0	2.0
Pupil A Post-intervention	5.0	5.0	5.0

Table 4. Pre- vs. post-intervention questionnaire score descriptive statistics

Analysis of the pre-intervention open-ended question responses revealed 22 instances (from 29 questionnaire respondents) of *friends* or *people who like me* being recorded as *the kind of pupils you'd like to work in a group with*. At the pre-intervention stage only four pupils detailed *clever* as an attribute they would like to see in fellow group members. Post-intervention, 22 respondents had still recorded *friends* or *people like me* as preferred team members, but 12 had also listed *clever*. Pupils have recognised that although it may be more enjoyable to work in a group with friends, if those friends are also intelligent, higher levels of learning can be achieved.

A comparison between the learning demand probe Quick Quiz results revealed an increase in scores post-intervention. However, this increase was found not to be significant at the 95 percent confidence level ($p>0.05$). When focusing on the scores of individual groups, Group 1 made the biggest increase in score from pre- to post-intervention moving from five to 12 (out of a possible 16).

The engagement tracker and engagement observation grid

An analysis of engagement scores has shown an overall increase in pupil opinions of enjoyment with scores rising from an average of six to nine over the course of the intervention (scores given to one significant figure). It is clear that there are high correlations between 'enjoyment', 'working hard' and 'on-task behaviour' (see Table 5). This relationship was also highlighted on the engagement observation grids completed by teachers. When pupils were focused on the task in hand they naturally worked harder and enjoyed the activity. Although the analysis of engagement trackers found that pupils viewed themselves to be equally on-task during discursive and practical lessons, the analysis of engagement observation grids revealed that the percentage of on-task behaviour during practical activities was ten percent higher than during discursive activities. This may be due to the fact that during a practical many individuals can be actively involved at the same time, where as during a discursive task only one pupil can speak or write at once, which may provide opportunities for distraction. Although this finding addresses one of the research questions posed – supporting the role of practical group-work in improving pupil engagement – results should be interpreted with caution as engagement observation grids were only completed during four lessons, which is a very small sample.

	Enjoyment?	Work hard?	On-task?
Enjoyment?	1	0.92	0.69
Work hard?	0.92	1	0.74
On-task?	0.69	0.74	1

Table 5. Correlations between average engagement measure scores

Impact of practical and discursive group activities in the science classroom

Four of the nine intervention lessons included a discursive activity and although the engagement tracker highlighted that pupils believed they were equally 'on-task' during all group-work activities, the trackers reported a slightly higher 'enjoyment' score for lessons which featured practical activities.

Using Vanides *et al.,* (2005) rubric for marking concept maps, it was possible to compare the prepositions on the post-intervention concept maps produced by group. Concept map scoring ranged from 4 to 22, with the highest scoring map produced by Group 1, indicating that discursive practical activities do encourage higher-order thinking, but perhaps only in stances where groups are highly differentiated and more peer-assisted learning can occur. Unfortunately, the original pre-intervention concept maps completed during lesson one were discarded following a classroom move.

Audio recordings of discursive tasks were transcribed and coded for indicator words (Mercer *et al.,* 2004), which are associated with higher-level reasoning and the peer-construction of knowledge. The following example illustrates how two pupils from Group 1 are learning through 'symmetrical' communication during discursive activities. Indicator words have been made bold:

> **Pupil B:** "Miss, why do you get lots of fossils on the beach?"
>
> *[Comment is unheard by teacher who is addressing another group at the time]*
>
> **Pupil A:** "I know why. **Because** animals die underwater and **I think** they get crushed under the sand."
>
> **Pupil B:** "Yeah, there are layers in the cliffs. **I think** as the water hits it dissolves and they fall down onto the beach."

Although pupils have identified a misconception by using the term 'dissolved' when they mean 'eroded', the co-construction of knowledge can be seen. Pupil B, although working at a higher attainment level than Pupil A, uses Pupil A's response to develop his own thinking and a shared understanding is reached, highlighting the positive impact of discursive group-activities on peer-assisted learning.

Impact of role allocation

Five of the nine intervention lessons included complex instruction in the form of role allocation, with three of these lessons featuring practical tasks. Upon analysing the engagement tracker with reference to the particular role, pupils who were allocated the role of 'Resource Manager' recorded the highest scores to indicate that they 'worked hard' and were 'on-task'. Teacher observations supported this result reporting that pupils who were given the responsibility of collecting and setting-up the practical equipment were the most physically involved with the practical and therefore more likely to be on-task. Although it appears that there are no clear correlations between role allocation and an increase in pupil enjoyment, audio files recorded during Lesson 9 (when pupils assigned their own roles) uncover pupils requesting to be the 'Resource Manager'.

Summary of results

Although inconclusive in terms of proving an impact of structured group-work strategies on the learning of scientific concepts the results portray a statistically significant relationship between the introduction of structured group-work activities and an increased engagement in science lessons. In particular, activities with a practical focus have proven to be more enjoyable. With regards to pupil learning of Earth Science concepts, attainment levels did improve post-intervention, however a conclusive statement cannot be made due to the comparative level of the test being unknown.

Discussion

The aim of this investigation was to answer the three research questions posed with regards to the impact of group-work activities on pupil learning of Earth Science concepts and engagement in science lessons.

In agreement with Tudge *et al.* (1996), this study has shown that differentiated groups promote the co-construction of knowledge and higher-order thinking, which is indicative of advancement in pupil learning. Group 1 audio-recordings and prepositions made on their concept map support this conclusion. Within such mixed-ability groups, it appears that the more able pupils benefit from peer-assisted learning the most, as indicated by the significant increase in NC level and supporting book-work witnessed with three pupils. The attainment levels, engagement scores and audio recordings of Group 1, with particular focus on Pupil A, support this statement. However, I believe that peer-teaching can also benefit the less knowledgeable pupils, providing a platform on which lesser able pupils can safely vocalise their ideas without the embarrassment of *getting it wrong* in front of an authority figure (the teacher). It is noted that 'active talking increases the pupil's participation in his/her own learning and decreases boredom and frustration' (Parkinson, 1994, cited in Staples & Heselden, 2002, p.84). Such active talking can be facilitated by the teacher in group situations by using complex instruction and role allocation to ensure each pupil is able to contribute to productive discussions. Although in a mathematics context, Boaler (2007 cited in Frean, 2008) describes how pupils who were less confident were often able to tease out higher-order explanations from the more able students through their questions. A focus on the nature of group composition, and taking into consideration both ability and attitude to learning when assigning groups, will ensure that such interactions occur and that both higher- and lesser-achieving pupils can benefit.

In agreement with Wellington (1998) and Millar (1998), the practical group activities featured in the intervention lessons proved successful in supporting the theory behind the abstract concepts present in the Earth Science topic. Pupils were able to model the phenomena, such as the formation of crystals in rocks deep underground, within the classroom and draw shared conclusions. Such engagement in practical activities was witnessed during all practical lessons taught as part of this intervention, in particular the formation of sedimentary rocks where pupils had to discuss in groups which media should be combined to create the strongest sedimentary rock before testing their hypothesis. Over the course of the intervention, an increase in pupil engagement was noticed, with particular reference to the 'Resource Manger' role in practical situations. As described by Boaler (2007), active pupil participation during tasks enables more effective group-work and pupils can help teach other. The allocation of roles achieves this objective by creating a situation where the group cannot function effectively without the full commitment of all group members. Interestingly, engagement tracker results indicated that pupils assigned the 'Resource Manager' position were more likely to be on-task and work hard during the group-task. However, such a relationship may only be apparent due to the somewhat novel nature of practical activities in Year 7, when pupils are yet to have experienced many such tasks.

This investigation has been successful in highlighting the importance of group-work within the class-room when teaching a more abstract concept, such as Earth Science, in terms of pupils' engagement. However, the relationship between the introduction of regular group-work activities and an increase in pupil learning appears fairly weak and inconclusive. The final section of this report shall address future implications of this research and suggest additional study which can be conducted to provide more concrete evidence with regards to the improvement in pupil learning during group-work tasks.

Conclusion

Implications for myself and opportunities for future research

Over the course of the intervention lessons pupils embraced the practice of group-work and role allocation, engaging in more discussions with fellow group-members and fulfilling their role responsibilities automatically. For example, pupils recognised that only the 'Question Asker' was allowed to speak with the teacher and therefore discussed queries routinely as a group in the first instance. However, such a development in pupil behaviour took time and reminders. The Social Pedagogic Research into Group-work (SPRinG) programme, developed by the Teaching and Learning Research Programme, promotes successful group-work by providing training for pupils and ways in which teachers can encourage and evaluate group-work (Blatchford *et al.,* 2005a). The SPRinG agenda advises on persisting with groups of pupils who clash to enable pupils to build trust and respect for each other (Blatchford *et al.,* 2005b). In this situation, the short time-span of the project and pupil unwillingness to collaborate made such persistence unviable. However, if introduced with a new class at the beginning of an academic year it would be beneficial to educate pupils about how to work effectively in group situations.

Recommendations for teachers

Although transferable to a science context, complex instruction has not been widely trialled in the science classroom. Complex instruction would be useful when teaching Physics topics in investigative practical formats. Role allocation could be used to encourage peer-discussion in situations where pupils are required to experiment with equipment and theories to establish a principle (for example the use of masses and a balance-beam to identify the Principle of Moments). If one member of the group is assigned the role of the 'Question Asker', and given a card which must be shown to the teacher upon asking a question in order to prove their role, it obligates pupils to discuss the issue before asking for help. To encourage pupils to develop how they fulfil their assigned roles pupils should rotate roles on a project, rather than lesson-by-lesson, basis.

The general shift in education towards pupil-centred learning provides a platform for class teachers to integrate more structured group-work strategies during science lessons. As long as pupil expectations and roles are clearly defined and the group-task (be it discursive or practical based) actively encourages discussion between pupils of varying abilities, an increase in engagement and peer-assisted learning is likely to be seen.

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