The effect of higher-order questioning on pupil understanding, as assessed using mind maps and the SOLO taxonomy

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Abstract
This paper looks at the role of higher-order questioning in developing pupil understanding from the Scottish education perspective. Literature indicates that higher-order questions deepen pupil understanding through the development of critical thinking skills, so should be prevalent in every classroom. Additionally, the SOLO framework and mind maps have been shown to be novel, yet effective, tools for assessing pupil understanding. As such, I included a range of higher-order questions in my practice and asked the pupils to create mind maps to demonstrate their understanding of a given topic. Using the SOLO framework as a marking rubric, I scored the mind maps to determine the effect of questioning on understanding. Higher-order questions had a positive effect on pupil understanding as the mind map scores increased post-implementation. This enquiry would benefit from repetition over a longer time period to further determine the effect of questioning on pupil understanding.

Part 1

Professional enquiry is a fundamental part of teacher training programmes. Practitioners should use it as an opportunity to implement meaningful changes in their teaching practice. The General Teaching Council for Scotland (GTCS) have embedded enquiry into the Standards for Registration, highlighting its importance in improving teaching practices and learning experiences. This review aims to provide a rationale for my own enquiry, which is focussed on the effect of higher-order questioning on pupil understanding in the Science classroom.

Teachers have a "professional commitment to develop their skills and expertise in classroom practice". (Scottish Executive Education Department, 2001, p.28). One way in which teachers can do this is through participation in professional development activities, which have been found to increase the prevalence of activities designed to develop critical thinking skills, as well as pupil understanding (Her Majesty's Inspectorate of Education, 2009). Dana and Yendol-Hoppey (2014) suggest that whilst professional development activities are worthwhile, they do not bring about such meaningful changes in teaching practice as enquiry does. In Donaldson's (2011) report on Scottish teacher education, he highlights that teaching is expected to become a research-based profession, so it is essential that teachers develop enquiry skills. In response to this, most Scottish teacher training programmes now require student teachers to carry out their own enquiries as part of their professional learning and development (Education Scotland website, undated; Donaldson, 2011). Participation in professional enquiry has been found to improve the teacher training experience as student teachers are now more conscientious about the impact their chosen pedagogies have on the pupils (Dana and Silva, 2001, cited by Dana and Yendol-Hoppey

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2014). Transformative changes in practice can be gained through professional enquiries (GTCS, undated), and practitioners should consider how the findings would influence the learning experience of their pupils.

As a training teacher, I am extremely aware of my development as a reflective practitioner. As such, I consistently reflect on my teaching practice and consider the impact that it has on my pupils. Pupils have the right to experience teaching practices which are based upon current research (British Education Research Association, 2014), and I ensure that I am up-to-date with new strategies and policies as they arise. Whilst reflecting on my practice, I noticed that my use of questioning was a source of contention. I am confident in planning and implementing questions in my lessons, but I do not believe that I am providing enough challenge for my pupils. For example, during a lesson with my S1 class I found that I asked numerous questions that required simple recall and avoided questions that required extended responses. I gave the pupils little time to think about their responses, and moved on quickly once a correct response had been given. In addition, I would like to develop my use of assessment strategies. I frequently make use of 'Exit Passes' as a formative assessment strategy to determine whether success criteria have been met, however I often find it difficult to quantify the depth of pupil understanding. I have found that mind maps are effective in visually representing knowledge, so would like to enquire as to whether they can be quantified to meaningfully assess depth of understanding.

As a result of my reflections, my professional enquiry question is:

> *'What happens to pupil understanding of 'Body Systems' when I ask questions designed to promote higher-order thinking skills in an S1 Science class?'*

1.I: Questioning

Teachers ask approximately 300 questions during a single day (Levin and Long, 1981), and can ask between 30-120 questions per hour (Graesser and Person, 1994). Questioning can be used to assess prior knowledge, demonstrate current understanding, or develop relationships between concepts (Barden, 1995; Chin, 2006). Two main types of questions have been identified: closed and open. Closed questions often require single word responses, whilst open questions allow pupils to apply their current knowledge and develop a deeper understanding through discussion (Erdogan and Campbell, 2008). For questioning to be effective, pupils should have the learning intentions and success criteria for the lesson explicitly stated to them so that they know what depth of understanding they should be developing (Hodges and Harvey, 2003). One of the greatest misconceptions regarding questioning is that its sole purpose is to assess what pupils already know and understand, in order to determine whether they have met given learning objectives. Black and Harrison (2004) emphasised that while questioning can be used for this purpose, it is also important to use it to identify misunderstandings that pupils may have to ensure appropriate next steps for their learning are implemented. As questioning is a natural part of teaching practice, teachers are often unaware of the impact that their questions can have on pupil understanding (Biggs, 1996; Chin, 2006). The development of low-order skills, such as recall, appears to be the main focus in most classrooms, whereas the primary aims of education tend to be focussed on developing higher-order skills, such as evaluation (Krathwohl, 2002). Bloom's Taxonomy is often used to determine the skills that pupils should demonstrate when responding to questions (Zheng, Lawhorn, et al., 2008). Bloom's Taxonomy (Bloom, Engelhart, et al., 1956) is a taxonomy of educational objectives consisting of six hierarchical levels: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation. In order to progress through the taxonomy, pupils should be competent in performance at the level preceding it. The top three categories (Analysis, Synthesis and Evaluation) are commonly

known as 'higher-order' (Bissell and Lemons, 2006, cited by Zheng, Lawhorn, et al. 2008), with the remaining categories being 'low-order'. Controversially, some studies have argued that the higher-order levels of the taxonomy are not actually hierarchical; in that to answer evaluation questions, a pupil does not need to have fully developed their analytical skills (Crowe, Dirks, et al., 2008). Anderson, Krathwohl, et al. (2001) developed a revised version of Bloom's Taxonomy which included sub-categories within each level of Bloom's, creating more overlap between levels but maintaining the hierarchy.

For pupil understanding to improve, and participation to increase, teachers should ask questions of varying complexity within a lesson (Wilen, 1991; Hodges and Harvey, 2003). Kaya, Kablan, et al. (2014) carried out a study into questioning in the Science classroom, and found that 65% of questions asked tended to focus on the lower levels of Bloom's Taxonomy. These findings are in agreement with Myhill (2006) who found that whilst teachers are aware of the benefits of higher-order questions, they prefer to ask low-order questions in order to more easily cover curricular experiences and outcomes. Additionally, Oliveira (2010) found that low-order questions tended to be more prevalent amongst teachers with poor subject knowledge. In contrast, Erdogan and Campbell (2008) found that Science teachers ask more higher-order questions than teachers in other disciplines, allowing pupils to respond in a variety of ways and further develop their understanding. Developing understanding requires more emphasis on high-order, open questions and avoiding over-use of low-level, closed questions (Harlen, 1999). A study by Huelser and Metcalfe (2012) looked at pupil responses to teacher-centred questions and found that understanding improved when incorrect responses were given. In order to be effective, questions should be student-centred and focus on deepening pupil understanding and developing critical thinking skills (Oliveira, 2010).

Questions are only as effective as their implementation, so teachers should consider how the phrasing and context of questions could influence pupil understanding (Barden, 1995; Chin, 2006). The traditional method of questioning is known as Initiation-Response-Evaluation (IRE) (Mehan, 1979). Using IRE, teachers ask questions, pupils respond, and the teacher evaluates the responses given; but not all pupils participate and questions tend to be spontaneous (Wiliam, 2014). To overcome these shortcomings, strategies such as 'No Hands Up' can be used to randomly select pupils to respond to questions, resulting in increased pupil engagement (see Wilen and Clegg, 1986). One of the continuous issues with questioning is the time given for pupils to respond. On average, teachers wait less than one second before asking for a response or giving the answer themselves (Black, Harrison, et al., 2004). Rowe (1974) found that three to five seconds is sufficient wait time following a question to allow pupils to develop understanding and provide a meaningful response. For higher-order questions, longer responses are expected, thus wait time should increase accordingly (Black and Harrison, 2004). Kaya, Kablan, et al. (2014) found that higher-order questions tended to elicit average wait times of 3.89 seconds, in comparison to 1.88 seconds for low-order questions. Crucially, wait time should not exceed ten seconds as pupils tend to lose focus and become disengaged (Sachdeva, 1996).

For the purpose of my enquiry, higher-order questions will be defined as questions within the upper levels of Bloom's Taxonomy (Analysis, Synthesis, Evaluation). In line with the findings of Crowe, Dirks, et al. (2008), these levels will be non-hierarchical, and pupil understanding will be measured as a result of the implementation of these questions.

1.II: Assessment

Acquisition of knowledge can be categorised as being quantitative or qualitative. In the

quantitative sense, more knowledge means better learning and the focus is on attainment and recall of information (Biggs, 1996). Qualitatively, however, the focus is on building upon prior knowledge and applying this knowledge to different situations in order to deepen understanding (Biggs, 1996). The quantitative style of teaching is still prevalent in some classrooms, and this is largely due to the type of assessments presented to pupils. Assessment can be used to monitor pupil understanding and development of skills, and pupils should be involved in every aspect of the assessment process (Education Scotland website, undated; Young, 2005; Earl, 2013). In *Building the Curriculum 5,* the Scottish Government (2011) outline that, under Curriculum for Excellence, pupils should be assessed not only for progress in knowledge and understanding but also the development of skills for learning, life and work. This being said, the majority of assessments still focus on recalling facts, with little focus on constructive feedback to guide next steps for learning (Black and Wiliam, 1998). Interestingly, Black (1986) investigated assessment policy in Scottish schools and found that only 29% had formative assessment policies, with 87% having policies for summative assessment. Earl (2013) noted that formative assessment, such as questioning, should be implemented during lessons to allow pupils to develop understanding and involve them in their learning. In *Inside the Black Box,* Black and Wiliam (1998, p. 10) state that self-assessment is "an essential component of formative assessment". It is an undervalued formative assessment tool, which can provide useful feedback for both teacher and pupil (Harlen, 1999). Pupils are constantly self-assessing their own work, and those who frequently self-assess have increased likelihood of progressing to higher education (see Boud, 2003). Self-assessment leads to increased pupil engagement and motivation, thus this practice should be adopted in the classroom to improve understanding and learning experiences.

1.III: Mind Maps and SOLO Taxonomy

Assessment should give pupils opportunities to demonstrate the skills they have developed, as well as the knowledge and understanding they have retained (Crowe, Dirks, et al., 2008). Visual representations of information have been found to be most effective in developing understanding and for long-term memory retention (Davies, 2010). Assessments should, therefore, allow pupils to visually demonstrate their understanding and mind maps are an effective tool for doing this. Mind maps were developed as a method of making relationships between learned concepts in order to develop higher-order thinking skills (see Davies, 2010). Mind maps are a useful assessment strategy as they appeal to different learning styles, especially kinaesthetic and visual, and are individualistic so provide accurate representations of the depth of pupil understanding (Kinchin, 2000; D'Antoni, Zipp, et al., 2010). The main limitation in using mind maps is that to be effective, pupils need to be taught exactly how to develop them which can be time-consuming for teachers (see D'Antoni, Zipp, et al., 2010). Buzan and Buzan (2010) suggest that mind maps should include diagrams, a central theme, or topic, at the centre and make use of colour to link information. In order to create a mind map, pupils need to have high-order thinking skills as they are required to make links between concepts they have learned to deepen their understanding (Long and Carlson, 2011). To overcome the ambiguous qualitative data provided by mind maps, a quantitative scoring system can be implemented to make assessment easier. Novak and Gowin (1984) argued that scoring of mind maps tends to focus on a range of aspects, including number of branches, which could devalue the score given. When assessing the maps, it would be beneficial to focus on links made, as well as accuracy of information presented to make the score given more valid (McClure, Sonak, et al., 1999; Long and Carlson, 2011).

Using the Structure of the Observed Learning Outcome (SOLO) framework as a rubric, Boulton-Lewis and Dart (1994, cited by Boulton-Lewis 1995) quantified mind map data to assess pupil understanding. Their findings indicated that there was 75% agreement between SOLO scores for mind maps and the written responses given by pupils. The SOLO Taxonomy was developed by Biggs and Collis (1982) as a method of assessing the level of understanding pupils held about a given topic. The taxonomy comprises five hierarchical levels of understanding: Prestructural, Unistructural, Multistructural, Relational, and Extended Abstract. The SOLO framework takes into account the different ways in which pupils develop their understanding to reach the same end goal, making it an effective assessment framework (Lucas and Mladenovic, 2009). Chan, Tsui, et al. (2002) found that SOLO is an adaptable measurement tool that can be used across multiple disciplines, stages, and assignments. It is not limited to subject-specific content as Lake (1999) demonstrated when he used SOLO as a tool to develop and assess pupil understanding of critical numeracy in Biology. The SOLO framework provides clear objective criteria for assessing understanding at each level (Lake, 1999), and Biggs (1992, cited by Biggs 1999) used the framework to develop a hierarchical grading system, where A=Extended Abstract and D=Unistructural. Boulton-Lewis (1995) notes that the levels of SOLO should be contextualised within subject disciplines to ensure that appropriate learning objectives are met. Due to its flexibility and adaptability, the SOLO taxonomy is a useful framework to quantify qualitative mind map data to provide a more accurate measurement of pupil understanding.

Professional enquiry is an important part of a teacher's professional development, and the skills developed will be used throughout their professional career. Questioning is a commonly used teaching practice, and the use of higher-order questions has been well studied. Mind maps are an effective method of demonstrating pupil understanding of a topic, and quantifying them using the SOLO framework will allow for a more accurate measurement of pupil progress. Based upon the research in this review, and my personal reflections, my enquiry question focuses on my use of higher-order questions and the effect that these have on pupil understanding.

Part 2

2.I: Methodology

Professional enquiry is designed to develop a teacher's knowledge and understanding of methodologies to become an enquiring practitioner (GTCS website, undated). The methodologies employed depend on the nature of the enquiry question, and personal research should be carried out to determine whether the area of enquiry is worth investigating (Bell, 2005). Numerous factors must be taken into consideration when designing an enquiry, and in this section, methods and analytical tools for the current enquiry will be identified and discussed.

As the current enquiry focussed on the use of higher-order questioning, the development of questions formed an important part of the methodology. Questions were developed using Bloom's Taxonomy (Bloom, Engelhart, et al., 1956) and the Bloom's Teacher Planning Toolkit (Canterbury College website, undated). Bloom's is useful for creating questions as it gives clear definitions of the higher-order skills developed at each level. The Teacher Planning Toolkit identifies key terms which could be included in questions for each section of Bloom's. Teachers ask many questions during a lesson, and these are often low-order and closed in nature, requiring simple recall of facts by pupils (Kaya, Kablan, et al., 2014). For effective questioning that promotes higher-order thinking, teachers should plan questions into their lessons to ensure they are continually developing understanding throughout (Arce, Bodner, et al., 2014). Therefore, for the purpose of this enquiry, questions were embedded

into lesson plans and colour-coded to correspond with the level of Bloom's taxonomy being. The way in which questions are implemented can affect responses, and research has found that wait time plays an important role in the effectiveness of higher-order questions (Brophy and Good, 1985, cited by Wilen and Clegg 1986). Longer wait times have been found to lead to extended responses demonstrating deeper understanding, particularly for higher-order questions (Black and Harrison, 2004). In line with the findings of Rowe (1974), for this enquiry pupils were given at least five seconds of wait time after a question had been asked to ensure they had appropriate time to develop meaningful and well considered responses. Teachers often select the same, usually more-able, pupils to answer questions as they expect they will receive a correct response (Duckor, 2014). Randomly selecting pupils gives the less-able more opportunity to develop an answer and ensures that all pupils are paying attention (Wilen and Clegg, 1986). In this enquiry, pupils were randomly selected to answer questions using a 'No Hands Up' approach, which they had already been familiarised with, to give all learners the opportunity to consider a response.

Qualitative data can be difficult to analyse as it is often individualised, and so requires objectivity in analysis (Eppler, 2006). It is often beneficial to code qualitative data to make it easier to analyse and thus draw more valid conclusions. Miles and Huberman (1994, p.56) define codes as "labels for assigning units of meaning to the descriptive or inferential information compiled during a study". When developing a code, consideration should be given as to whether the code will be hierarchical, or simple random number assignment (Bell, 2005). Mind maps are an effective tool for assessing and developing understanding (Long and Carlson, 2011) and pupils were asked to create mind maps at both the beginning and end of this enquiry. Whilst mind maps provide individual representations of understanding, the qualitative nature of the data can cause problems when it comes to interpretation (Kinchin, 2000). In order to quantify the data provided by the mind maps, the SOLO Taxonomy of Understanding (Biggs and Collis, 1982) was used for analysis. Lucas and Mladenovic (2009) previously coded SOLO using a marking rubric, and found that the taxonomy was more effective as an assessment tool in its coded state. As such, for this enquiry the SOLO Framework was coded for use in the assessment of mind maps. The SOLO rubric contains a brief description of the different levels of understanding, as well as a written example of what is expected of pupils at each level. Mind maps were assigned a whole number score between one and five (with 1=Unistructural and 5=Extended Abstract) to provide a quantitative measure of pupil understanding.

As well as producing mind maps, pupils were asked to self-assess their understanding. Self-assessment has been found to be a useful formative assessment tool which allows pupils to engage with their learning (Boud, 2003). Further to this, a study by Wilkowski, Russell, et al. (2014, cited by Vista, Care, et al. 2015) found that self-assessment ratings provide as accurate information about understanding as summative assessments. The use of scales has been recognised as an effective tool in generating data that can be easily analysed (Bell, 2005), and Likert rating scales are among the most commonly used. They are used to identify strength of attitudes about a given statement or question, using a hierarchical numerical scale (Jamieson, 2004). In this enquiry, pupils were given a questionnaire asking them to rate their understanding of the topic of 'Body Systems' on a scale of one to five (where 1=no understanding; 5=complete understanding). Additionally, pupils were asked to rate the effectiveness of higher-order questions in developing their understanding, using a similar scale (with 1=not effective at all; 5=extremely effective). Both were completed at the beginning and end of the enquiry.

Pupil self-assessment ratings, SOLO taxonomy scores of the mind maps, and pupil ratings of the effectiveness of questions were recorded in tabular and graphical formats.

2.II: Ethics

When carrying out any form of research or professional enquiry, ethical implications should be considered. The personal ethics of the researcher, as well as those of relevant professional bodies, should be taken into account to ensure all aspects of the enquiry are carried out in accordance with given guidelines (Cohen, Manion, et al., 2007). The Scottish Educational Research Association's (SERA) Ethical Guidelines for Educational Research (SERA, 2005) outline all ethical considerations for research carried out in educational institutions. Research should be carried out to the highest standards and adhere to strict guidelines to "protect the integrity and reputation of the educational research community" (SERA, 2005, p.11). Anonymity of collected data is fundamental to ensure that pupils cannot be identified, and that data is interpreted without bias. To ensure anonymity in this enquiry, pupils were randomly assigned a number as an identifier, and were instructed not to write their names on any questionnaire or mind map they provided. Pupils were not misled at any point, with the objectives of the enquiry being clearly explained, and pupils were encouraged to ask questions and express any concerns throughout. Voluntary participation is another important ethical issue, and pupils cannot be forced to provide data. Pupils were asked at the beginning of the enquiry process if they wished to participate, and were advised that they could withdraw from the enquiry at any point. As a result, out of a class of 19, 10 pupils were willing to provide data for this enquiry. In terms of next steps, the findings of this enquiry will be reported back to the pupils, as well as to any colleagues who express interest.

For the current enquiry, due consideration was taken regarding the methodologies used as well as the ethical implications. The design of the methodologies was based upon current literature and research, to ensure that they were as reliable as possible. Ethical issues were also discussed and every effort was made to ensure that this enquiry was carried out ethically from beginning to end.

Part 3

3*.I: Analysis*

Mind map scores, as well as self-assessed ratings of understanding and question effectiveness were recorded (see Table 1).

Table 1. Pupil scores and ratings for each measurement, pre- and post-implementation of higher order questioning.

	Scores and Ratings (/5)					
Pupil	**Mind Maps**		**Self-Assessment**		**Question Effectiveness**	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
1	1	5	5	5	4	3
2	3	4	4	4	4	4
3	4	5	5	5	4	5
4	2	4	3	4	5	5
5	2	4	2	3	4	4
6	3	4	3	4	4	5
7	3	3	4	5	5	5
8	2	5	4	4	4	5
9	1	4	3	3	5	5
10	3	4	4	4	5	5
Average	2.4	4.2	3.7	4.1	4.4	4.6

Higher-order questions were found to have a positive effect on pupil understanding. For mind maps, pupil understanding was higher after implementation of higher-order questioning (mean=4.2) than before (mean=2.4) (see Figure 1a). Self-assessment ratings were also found to have increased post-implementation (mean=4.1), when compared to pre-implementation (mean=3.7) (see Figure 1b). The effectiveness of questions in improving pupil understanding was also found to increase following implementation (mean before=4.4; mean after=4.6) (see Figure 1c).

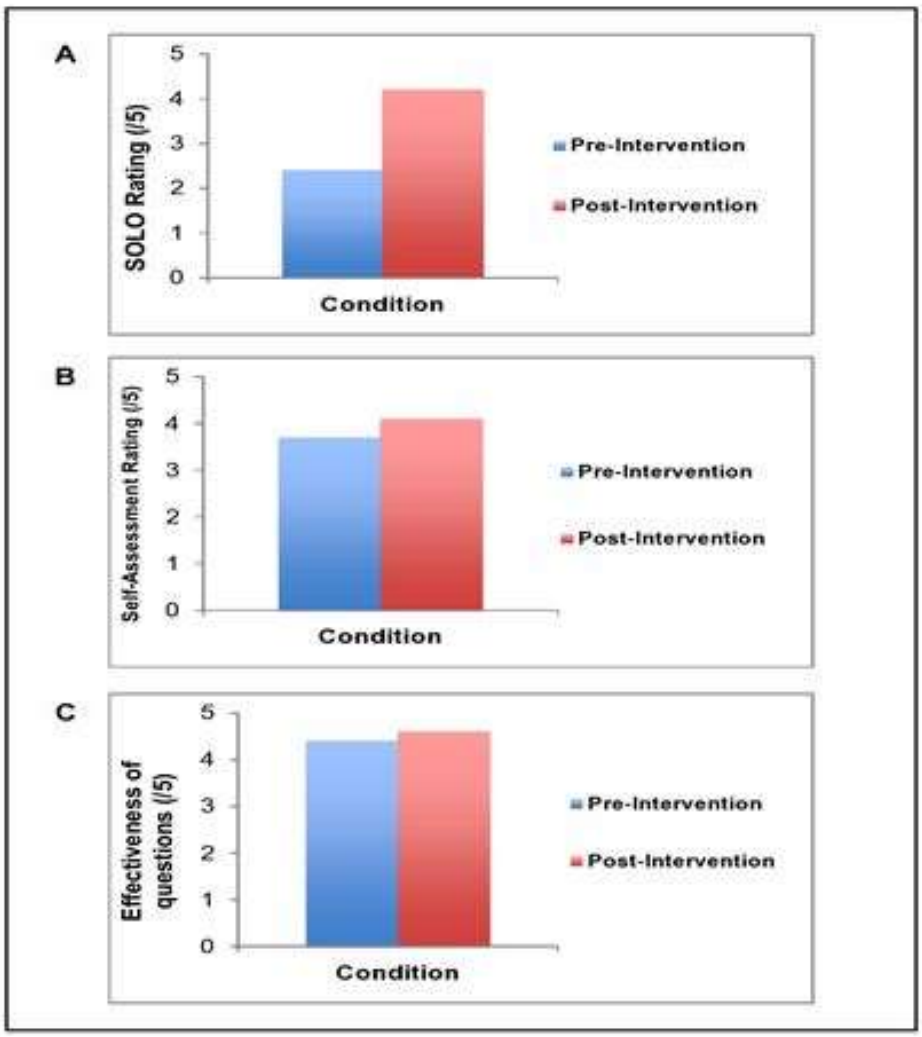

Figure 1. Graphs showing average SOLO ratings (for mind maps), self-assessment ratings, and ratings of question effectiveness. All ratings were out of five; with 1 being the lowest and 5 being the highest.

Based upon current literature and personal reflections, higher-order questions were expected to improve pupil understanding of the topic of 'Body Systems'. The findings of this enquiry support this expectation as both self and formatively assessed measures of pupil understanding were found to increase following higher-order questioning in an S1 Science class. In addition, the effectiveness of questions in improving pupil understanding was also found to increase. These findings are synonymous with those of Erdogan and Campbell (2008) and Harlen (1999) who found that the use of higher-order questions led to the development of deeper understanding by learners. Further to this, a combination of both low- and high-order questions has been found to be necessary to develop subject-specific understanding (Hodges and Harvey, 2003), and the current enquiry utilised questions of varying complexity to parallel this. Due to the small-scale nature of this enquiry, and the short timeframe given for data collection, it cannot be said with absolute certainty that higher-order questioning alone improved pupil understanding of 'Body Systems'. Various other factors could have influenced the findings obtained including, but not limited to, level of pupil engagement and acquisition of new information. Pupil engagement in classroom activities has been found to improve the learning experience, and deepen the understanding that pupils develop (McBer, 2000). The lessons in which the enquiry was carried out included a range of activities for pupils to complete, including 'fill in the blanks' and a

practical experiment, which helped to keep them engaged. This level of engagement may have contributed to the increased understanding the pupils demonstrated through mind maps and self-assessment ratings. As Arce, Bodner, et al. (2014) found, planning questions into my lessons ensured that the lesson's success criteria was met, and left me feeling confident that pupils had developed their understanding at each level of the SOLO taxonomy. In addition, a minimum wait time of five seconds was implemented following a question to allow pupils to develop a meaningful response, in accordance with the findings of Rowe (1974). As a result, pupil responses were extensive with the usually quiet pupils eager to expand upon responses given by their peers.

Long and Carlson (2011) suggested that mind maps were a useful tool for assessing pupil understanding and the findings of the current enquiry support this. The mind maps provided visual representations of pupil understanding and allowed both myself, and the pupils, to assess the level of understanding they held. Contrary to the findings of D'Antoni, Zipp, et al. (2010), pupils were able to produce mind maps of a high standard without extensive teaching of the skills required to develop them effectively. This suggests that, with additional training, the mind maps could be used to further demonstrate higher-order thinking skills. In its coded state, Lucas and Mladenovic (2009) found that the SOLO taxonomy was an effective tool for quantifying qualitative data. The current enquiry also demonstrated that, in the form of a marking rubric, SOLO taxonomy can effectively quantify the depth of understanding held by a pupil. Allowing pupils the opportunity to self-assess their understanding gave them the chance to be more involved in their learning, as Boud (2003) previously outlined. When comparing pupils' personal assessments of their understanding with the objective mind map scores, a positive correlation was found following implementation of higher-order questioning. These findings are in parallel to those of Boulton-Lewis and Dart (1994, cited by Boulton-Lewis 1995), who found that SOLO scores correlated positively with formative assessment outcomes.

3.II: Next Steps

Professional Enquiry is intended to result in transformative changes in practice. As such, using the findings of this enquiry, I have identified some next steps for my professional development. Due to their positive effect on understanding, higher-order questions will become more prevalent in my lessons. I would like to familiarise my pupils with Bloom's Taxonomy and give them opportunities to develop their own questions to improve their critical thinking skills. Differentiation is something which I am always working to improve, and I am interested in investigating methods of further differentiating questions to meet the needs of my pupils. One strategy that I will try will include tailoring a higher-order question for a specific pupil, and if they struggle to respond at that level, I will regress back down Bloom's Taxonomy and allow the pupil to build their response from that point. In addition, I would like to include more collaborative learning activities in my lessons to allow pupils to develop their understanding using input from their peers. For these activities, I will create mixed ability groups to ensure that all pupils can contribute to discussions. In my lessons, I often make use of 'Show Me' boards and multiple-choice questions (MCQ) for starter and plenary activities to get an instant overview of pupil understanding. Research has found that higher-order MCQs are time-consuming to develop and so are less prevalent in the classroom (see Brady, 2005; Zheng, Lawhorn, et al., 2014). As such, my next steps will be to spend time developing a selection of higher-order MCQs, which can be adapted for use across all topic areas in Science. When responding to these MCQs, I will ask my pupils to either expand upon the response they chose, or explain how they came to the conclusion that their response was correct. This will allow them to deepen their understanding, as well as develop critical thinking skills. Lastly, I would like to look at using the SOLO taxonomy to

address literacy experiences and outcomes. In order to do this, I would ask pupils to look at two different pieces of work and score them using the SOLO marking rubric. I would then encourage them to compare the two pieces and highlight any differences and similarities between them, in order to develop their own responses and writing skills.

The current enquiry found that higher-order questioning improves pupil understanding, and allowed me to identify next steps for my own professional development. Working through the enquiry process has allowed me to begin to develop the skills and knowledge required to become an enquiring practitioner. Professional enquiry is an exercise that I will frequently engage in throughout my teaching career to ensure that my pupils receive the meaningful learning experiences they are entitled to.

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