Evaluating the potentials of Bloom's Taxonomy as a tool for developing year 8 (Key Stage 3) science students' questioning skills in a UK secondary school

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Abstract

This case study research employed a mixed method approach to evaluate the effectiveness of Bloom's taxonomy in the development of questioning skills of a cohort of year 8 science students in the UK. Designed along the intervention and evaluation framework, the research compared the level of use of questioning skills by these students after they were introduced to Bloom's taxonomy as a prompt. Students' use of questioning in their classes pre-and post-intervention were recorded and compared through observations and field notes. In addition, the views of the teachers involved in teaching these students were collected through a survey questionnaire and discussions. The study found improvements in the quality of questions and feedback provided by the students. It also found that, teachers, through the process of modelling using Bloom's Taxonomy prompts, contributed significantly to this improvement. It also found that a major block to teachers' use of the model is teachers' lack of pedagogical knowledge. The study concludes by advocating the need for appropriate CPD to enable teachers to develop the skills required for helping their learners to develop the essential questioning skills which is acknowledged as useful for promoting learning in science classrooms.

Keywords: Boom's taxonomy, Questioning, feedback, prompts, science learning

Introduction

Questioning is perceived as a sole responsibility of teachers who are required to assess students' learning and progress (Pratt, 1994). Teachers are concerned that science students find it difficult to ask questions during lessons (Lemke, 1990; Wragg & Brown, 2001; Cowie 2005; Mahmud 2015). When they do, the questions are low order and do not involve thinking (Wragg & Brown, 2001; Eshach, Dor-Ziderman & Yefroimsky, 2014). Reinsvold and Cochran, (2012, p748) note that although

> "teachers have the *power to provide questioning strategies that allow students to evaluate their understanding, to provide evidence for their claims and ideas, to apply what they know to a novel topic, and in general to reason at a higher level about what they know about science, it is questionable whether they use it and how well does this power relate to classroom questions?"*.

Nonetheless, it is argued that questioning strategies that support science students to develop their questioning skills rather than their teachers' are crucial to quality learning and motivation (Chin, 2006) and can encourage whole class discussions and sharing of ideas (Eshach, 2010). Furthermore, the use of questioning strategies in assessment can promote shared responsibility and co-generate knowledge between teachers and students (Black & Wiliam, 1998; Black et al., 2003; Harlen, 2009; Dixson & Worrell, 2016). The obvious question, therefore, is if teachers are aware of the importance of student-led questions, why is it not more commonly used to support science students' learning? Given the obvious effectiveness of questioning in the learning process, why has it been used so sparingly (Harris et al., 2012; Reinsvold & Cochran, 2012).

Factors such as teachers' attitudes; a limited acknowledgement of students' prior knowledge and the cultural capital that they may bring into the classroom (Reeve & Bell, 2009; Cowie et. al., 2011; King and Glackin, 2010); a reluctance to teach science students how to ask questions and investigate their own questions (Harris et. al., 2012); time constraints induced by the density of curriculum contents (Phillips et. al. 2010; Harris et. al., 2012; Davies et. al., 2014) and the nature of questions and strategies used by teachers (Beatty et. al. 2006; Reinsvold & Cochran, 2012; Harris et. al., 2012) have been linked to this failure. An effective development and use of questioning will promote science students' ability to differentiate between various types of questions such as low and high order questions and a resultant effect on their performances in exams (Jensen et al., 2014). The salient question is, how can we help science students to develop this skill?

The development of low and high order questions is embedded in the framework provided by Bloom's taxonomy and this, it has been argued, is a good way of developing students' questioning skills (Bergman, 2009). If this is true, a question arises which forms the basis for the research question to be answered in this study: how effective is the use of Bloom's taxonomy in developing science students' questioning skills? Engaging in this research will provide evidence for validating the use of Bloom's taxonomy as an instrument for enabling teachers to reflect on their practices in terms of promoting and using questioning and improving the questioning skills of science students.

Statement of the problem

There is evidence that the use of questioning leads to higher levels of achievements amongst science students (DFES, 2004; Smart & Marshall, 2013; Kiemer et. al., 2014). Yet, this strategy has been used rather sparingly in science classrooms. It is argued that the sparing use is informed by teachers' inability to help students develop their questioning skills (Harris et al., 2012; Reinsvold & Cochran, 2012). The use of Bloom's taxonomy (Lord & Baviskar, 2007; Zheng et. al., 2008; Bergman, 2009) has been offered as a strategy for developing this skill amongst science students. Before we wholesomely advocate the use of Bloom's taxonomy, it is appropriate that we establish its effectiveness and the limitations to its use. The problem this study aims to resolve, therefore, is finding empirical evidence of the effectiveness of using the taxonomy to develop science students' questioning skill.

The role of questioning in science students' learning

Science learning thrives on the use of questioning (Lemke, 1990; Chin, 2006; Harris et al., 2012; Kiemer et al., 2014; Jensen et al., 2014). Teachers often use questions as a means to scaffold students' learning, and different question types are informed by the intended learning outcomes that students are required to achieve (Black & Wiliam, 1998; DFE, 2012). Just as teaching and learning resources are differentiated to meet the needs of all students, the types of questions posed by both teachers and students may also be differentiated (DFE, 2012). Many studies have focused on developing teachers' questioning skills (see Wragg & Brown, 2001; Black et. al., 2003; Clarke; 2008; TLRP, 2010; Smart et. al., 2013; Van Booven, 2015) with teachers asking twice as many questions as their students (Eshach, Dor-Ziderman & Yefroimsky, 2014). This may be seen as an affirmation of the supremacy of teachers' questioning over students' questioning and may ignore the contribution to learning that can evolve when students are given opportunity or trained to develop own questions (Hodgen et. al., 2008; Wilson & Mant, 2011; Kiemer et. al., 2014). Teachers' dominance of questioning leads to the normal form of classroom interactions that are teacher-led and centred on a learning model of Initiation, Response and Evaluation (IRE) (Cazden, 2001). However, evidence abounds to support the claim that questioning in the classroom should be a joint responsibility of the teacher and students to improve dialogic interaction and promote learning.

There is evidence of disciplinary disparity in the use of questioning in the classroom. Turner, Ireson & Twidle (2010) and Darlington (2012) found that students are more engaged in asking questions and giving feedback in Drama, Physical Education, English and Art lessons than in science. In addition, students in the former disciplines were found to be more likely to challenge other students' views. Consequently, there are calls for more effort and research to support science teachers in engaging students in questioning and classroom discourse (Harris et al., 2012). But how can teachers achieve this in the face of an increasing workload and the need to cover wide curriculum contents, both of which have been a concern for science teachers in England for a long time? (Ofsted, 2002; Clarke, 2005; Hosp et al., 2008). To answer this question, there is an obvious gap that requires filling in the context of science teaching and learning that may require improvement in teachers' pedagogical knowledge.

Whereas teachers' questioning may involve recalling scientific concepts, finding out what pupils know, or challenging their thoughts processes as a way to promote thinking skills and cognition among students (Chin, 2006; Adey and Serret, 2010; Smart et. al., 2013), a student-centred questioning approach enables students to take responsibility for learning (Windschitl, 2003; Kiemer et. al., 2014).

The literature on questioning suggests that students find it difficult to ask questions. Although questioning is fundamental to science, most students do not know how to ask and investigate their own questions because they have not been equipped to do so (Harris et al. 2012). Therefore, science teachers need to create opportunities to involve students in classroom discourse (See Van Zee et al., 2001; Sawyer, 2006; Cowie et al., 2011; Kiemer, et al., 2014) and develop their questioning skills in this process, in order to limit their dependence on teachers' questions (Anne & Richard, 2010).

Accomplishing this requires a transformation in teachers' pedagogical approaches, to enable them to guide students towards identifying what good quality questions look like. We suggest that one way of doing this is through the use of Bloom's taxonomy (Bergman, 2009; Zheng et al., 2008), which involves the provision of question prompts for deciding the type of questions to ask. This range from Knowledge (low order) to Evaluation questions (high order), see table 3. Open or high order questions can invite "wonderment thinking, hypothesising and predicting, explaining and clarifying, and making sense of investigative experiences and results" (Harris et. al., 2012, p 778). High order questions can also enable students to interact with their teachers and peers by responding to questions, which will in turn, allow the teacher to scaffold

the process and follow up students' responses with further questioning (Smart et. al., 2013). High order questions can enhance students' ability to engage with science concepts at a deeper level, formulate hypotheses and use evidence to draw conclusions about the phenomenon (Smart et. al., 2013). In essence, this type of question will engage students cognitively and encourage them to think and construct knowledge (Chin, 2006; Harris et. al., 2012). This may allow students to reach a point in their learning where they can probe each other's views and become confident in challenging facts even when they are correct (Osborne & Dillon, 2010; Maskiewicz & Winters, 2012).
The preceding arguments imply that allowing students to develop and use their own questions can develop their curiosity and their familiarity with the inquiry nature of science within the framework of the joint roles they share with teachers in their own learning and assessments.

Using Bloom's taxonomy in developing questions

The first of the two models of Bloom's taxonomy is arranged hierarchically from low order questions (closed questions) to high order questions (open questions; see figure 1) with the key components of Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation (Kissock & Iyortsuun, 1982; Lord & Baviskar, 2007). While Knowledge and Comprehension questions are considered to be low order questions (DFES, 2004), Application is at an intermediate level (Crowe et. al., 2008) and Analysis, Synthesis, and Evaluation questions are considered high order questions (DFES, 2004). The second model (see figure 2) focuses on the order of cognitive development with the key components of Remembering, Understanding, Applying, Analysing, Evaluating and Creating (Anderson et al., 2001). In this study, our focus is on the first model for the simple reason that it is the most commonly used and most familiar to teachers (Lord & Baviskar, 2007).

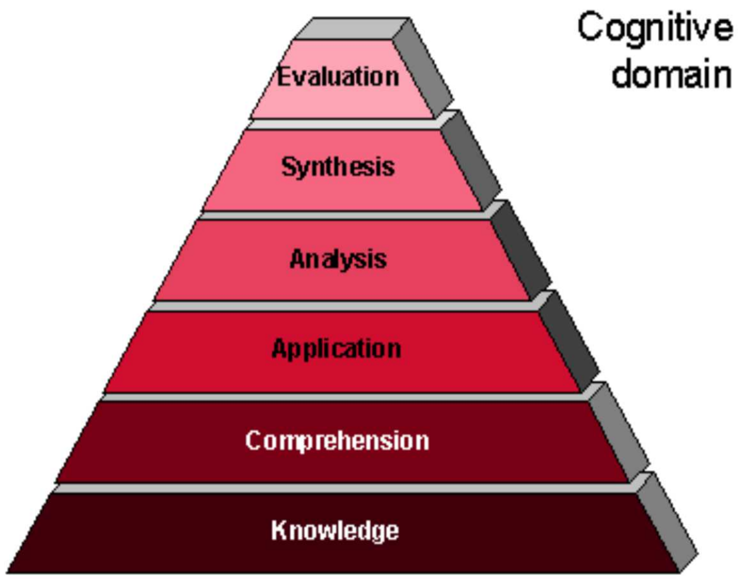

Figure 1: Bloom's taxonomy
Source: http://www.learningandteaching.info/learning/bloomtax.htm

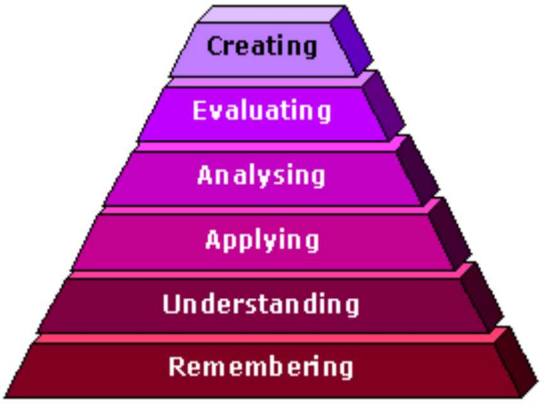

Figure 2: Revised version of Bloom's taxonomy
Source: http://www.learningandteaching.info/learning/bloomtax.htm

Bloom's taxonomy question prompt (Zheng et. al., 2008; Bergman, 2009) is used in this study to guide students in developing differentiated questions that other students can respond to (See table 3 for examples of question prompts for each category). This enables students to develop and understand different types of questions, challenge them to think and improve their scientific knowledge, thus lifting their learning beyond the superficiality characterised by rote learning. In addition, it prevents students from relying on and responding to teacher questions (Anne and Richard, 2010) thereby promoting independent learning. We, therefore, see Bloom's taxonomy as an instrument which could help students move away from the total dependency on teachers' questioning (Lord & Baviskar, 2007; Bergman, 2009).

While age/class have been considered as significant in the use of Bloom's taxonomy in the way described above, Adey and Serret (2010) argue that it is right for teachers to initiate complex learning tasks for students in year 8 (13 years old) rather than wait until their cognitive ability is fully developed for such activities. This, therefore, justifies our use of this instrument with our subject group, year 8 students, who are 13 years old, as it is essential for students, even at that age to begin to engage with the complexity associated with science learning.

When students are engaged in solving problems requiring high order questioning they achieve their attainment target and above (at Key Stage 3) and grade C and above (at GCSE, Key Stage 4) in England (DFES, 2004), as the high order questions (open questions) they engage with lead to quality feedback among students and their teachers, and improve classroom interactions (Harris et. al., 2012; Smart, 2013).

Methodology

Research design

This case study employed a mixed method research approach. Although predominantly a qualitative study, some data were analysed quantitatively (Creswell and Plano Clark, 2007). The quantitative element of the research was informed by the need to establish a distributional pattern amongst the sample population thus creating the opportunity for preliminary generalisations. Three techniques were used in collecting data; lesson observations, questionnaires and field notes. The collection of data from three different sources enabled us to triangulate our findings and also to confirm the reliability and validity of our findings (Schostak & Schostak, 2008; Newby, 2010). For example, the process of collecting and analysing question types was done collaboratively with the teachers. As such, reaching a consensus regarding classifications has helped to enhance measurement validity (Check and Schutt, 2012), as the teachers' inputs introduce an element of authenticity.

Research participants

The students

The study was carried out in a Co-education secondary school in London, UK. The school is located in one of the most deprived Boroughs in London. It is a large school characterised by socio-economic problems, parents with low to no income, mixed ethnicity, a high number of students on Free School Meal (FSM), limited resources available to students, and a high crime rate (UK Crime Stats, 2017). The school's progress eight score is 0.1 considered as one of the lowest in schools in the Borough and across the country (progress eight is used to measure the performance of schools in England) (DFE, 2017). Although it requires a score of -0.5 for a school to be below the floor standard, a score of 0.1 is sufficiently low for such a school to be classified as a "coasting school" which fails to ensure pupils reach their potential. In choosing this school, we took into account the issue of representativeness. In most essential details, this school is representative of schools classified as worrying both regarding pupils' demographics and performance. What is crucial for us, however, is that the school is representative of similar schools which are targeted through government policy to improve students' performance. There is a general focus on developing teachers and improving resources in order to achieve improvement in outcomes. Another important feature of the school which contributes to its representativeness as a sample is its inner -city urban location. Many of the 'so-called' coasting schools are located in the inner city. As such, using this school as a sample is sufficiently representative for us to advance the course of generalizability and, therefore, validity (Check & Schutt, 2012).

A total of 52 students in Key Stage 3 (year 8, 13 years old) were involved. This was a purposive sampling (Cohen, Manion and Morrison, 2007) that involves choosing a group of students considered to be underperforming in science and that are representative of similar students. For example, the group is made up of mixed gender with different abilities ranging from grades as low as 1 to 4 in the current progress 8 and attainment 8 grading system in England (DFE, 2016). This grade is similar for other underachieving students in the school and across schools in London that are located in a similar deprived area as reiterated.

The teachers

Two teachers were involved in this study. The two teachers were self-selective (Cohen, Manion and Morrison, 2007), as we could only include teachers who teach the participant students. In a way, they are also representative of other teachers in similar schools with similar problems with science learning. They have a similar workload, and a shared desire to see that their students achieve. More importantly, as they taught the participant students, they were the only ones in the position to provide answers to some of the questions asked in this study.

Process

The study started with the two teachers being introduced to the purpose of the research. Emphasis was placed on the fact that involvement will help them to reflect and improve their practices, and will also support the development of their science students' questioning skills. Brief information is given below about the teachers, as this is necessary to establish their experience and ability to give the relevant support to students. The names are pseudonyms.

Lucy (pseudonym), a Biology teacher and deputy head of the department responsible for assessment and moderation of schemes of work recently re-trained to be able to teach Physics as an added advantage to the department and as part of her professional development. She teaches all science subjects in Key Stage 3, Biology in Key Stages 4 and 5 and Physics in Key Stage 4. She was graded a good teacher by Ofsted standard and has been teaching for over 12 years.

Jane (pseudonym) is a Biology and Chemistry teacher with some responsibility for A-level provisions. She teaches all science subjects in Key Stage 3 and Biology and Chemistry in Key Stages 4 and 5. She was graded an outstanding teacher by Ofsted and has been teaching for over eight years.

The two teachers were trained on how to support students in using Bloom's taxonomy to develop questions. A process of joint planning, reflection and lesson observations was also agreed with the teachers. Also, it was agreed with the teachers that data collected would be jointly discussed and evaluated periodically. The teachers were, therefore seen as co-learners with the researchers and not just as a medium for data collection.

Phase 1: Pre-intervention lesson observations

Before the commencement of our intervention, four random lesson observations were carried out by the researchers to gauge the extent to which students were involved in using questioning in the classroom. At this stage, the teachers were not informed of the focus of the observations. This enabled the researchers to get a true picture of what goes on in the classroom and to avoid a situation in which the teachers introduce practices that they feel the researchers were keen to find. The findings from the lesson observations will be used to compare outcome from our questionnaire. The teachers observed are those that will be involved in this study. Field notes were generated and recorded from these observations.

Phase 2: Questionnaire

A questionnaire was administered and completed by ten science teachers in the school.

Questions 1-8 (table 2a) were closed questions requiring yes /no/sometimes answers. The goal was to find out teachers' views on why they do not engage students in developing questions. A related goal was to validate existing views from the literature.

Questions 9-13 (table 2b) were open questions which enabled us to capture the views of teachers about the types of questions students ask and the extent to which teachers encourage students to ask and respond to questions they have created.

Phase 3: Lesson observation intervention

Science lessons were delivered over a period of seven weeks by the two teachers who were direct participants in this study. This duration was the officially designated period for covering teaching unit. The lessons were observed and audio recorded by the researchers with the goal of being able to identify the number of questions asked by the students, as well as the number of feedback offered by the students. During this period students were assigned projects which required them to find solutions to problems based on the topic, Food and digestion/enzyme action, which is a standard topic in the National curriculum for year 8 in England. The students used resources such as textbooks, exercise books, internet and previous homework projects (Cowie et al., 2011) to develop their knowledge of the topic. This information gathering was completed in weeks 1 and 2 of the intervention with students working in groups. Each week had three lesson periods with each lasting 55 minutes. A total of twenty-one lesson observations were carried out.

In week 3, students presented their outcomes from the tasks to their peers and were encouraged by their teachers to ask questions.

Following this, the teachers introduced Bloom's taxonomy to the students and supported them to learn how to frame questions. Students were further asked to classify the type of questions they have generated using the structure provided in Bloom's taxonomy.

At the end of week 3, the researchers and teachers met and discussed the findings from the week's lesson observations, agreed strategies for further supporting the development of the students' questioning skills, because the majority of the questions developed at this stage were low order. Information from the discussions were collected as field notes based on teachers' reflections and comments made after each lesson observation. This was fed into the design of the the next teaching session.

In week 4, the teachers continue to model how to develop various types of questions using Bloom's taxonomy question prompts (Bergman, 2009) with more focus on high order questions. Peer support and peer-correction was encouraged amongst the students. Students were supported to refine their questions in order to make them better understood by others. They were also encouraged to give feedback to each other in response to the questions asked. This sequence continued through to week 7 with the researchers and teachers meeting weekly to review findings.

Data analysis

Data analysis is essentially content analysis. The recordings from the lesson observations were transcribed and eanalysed. This gave an indication of the interactions between the students, the types of questions they developed, as well as samples of feedback they gave to each other. As shown in table 1, these were then subjected to qualitative analysis using NVIVO 10 to sort out the various groupings (Penna, 2013). Samples of students' feedback to each other from various questions (low to high order) were compared to determine the depth and adequacy of responses that ensued.

The questionnaire was analysed in two parts. Table 2a shows the analysis of responses to questions 1-8 which were closed questions requiring yes/no/sometimes answers, while table 2b shows the analysis of responses to questions 9-13. The responses to this part of the questionnaire were analysed, coded and subjected to content analysis (Gray, 2009). The codes were created around patterns and themes that were established (Cohen, Manion & Morrison, 2007). The frequency of codes developed was counted (Creswell, 2012; Denzin & Lincoln, 2013) to show the distributional pattern of questioning among students.

Findings

Findings from the data collected are framed in the context of the research question, how effective is the use of Bloom's taxonomy in developing students' questioning skills? This question is answered drawing upon evidence from questionnaire analysis and lesson observations. Selected samples of students' questions and feedback were presented in addition to field notes that were collected as supporting evidence. We present our findings and the accompanying discussions before making an overall conclusion.

Findings from lesson observations

The pre-intervention lesson observation shows that little opportunity was given to students to develop own questions as, teachers' questions dominated it. Majority of the questions asked by the teachers were low order. The questions included "can you tell me the difference between respiration and photosynthesis", "can you repeat what I have just said", "what is respiration", "state the difference between compound and mixtures", "what is an element". Also, the teachers made comments such as "does anyone have any question to ask", "are you all okay", and "do you have any problems". Students' questions included "miss can you tell me where plants get water?" and "what is stomata? These questions came up when one of the teachers insisted that the students must ask questions.

It was evident that our teachers were themselves struggling to find ways of helping their students. For example, during one of our pre-intervention discussions, one teacher said; *"I am considering ways that I can make them to develop their own questions and ask other students but it has been difficult"*. Another teacher said *that "I can't see my students asking questions let alone trying to encourage them to ask one"*.

Throughout the intervention period, students were involved in finding solutions to questions by researching and finding information from various sources. Our observations show that progressively, students were becoming more engaged in the development of various types of questions using Bloom's taxonomy as seen in table 1 and also (see evidence from weeks 3-7 below).

Table 1: Breakdown of questions developed by students using Bloom's taxonomy

Bloom's taxonomy	Number of questions developed by students and percentages in bracket (%)	Samples of questions developed by students in each category
Knowledge	51 (32)	What is obesity?
Comprehension	51 (32)	State different ways that you can stop obesity among people?
Application	23 (14)	You said that carbohydrates are really good for your body but like what will happen if you ate too much of it?
Analysis	8 (5)	Can you explain the relationship between the large and small intestines?
Synthesis	11 (7)	What would be the possible solution to helping someone who is allergic to some types of protein to keep on having the same life-style they would like?
Evaluation	17 (10)	What changes would you recommend to eating fat foods or is there a better solution for us to be healthy?
Total	161	

As indicated in table 1, the number of Knowledge and Comprehension questions developed by the students is 51 (32%) each; Application questions 23 (14%); Analysis 8 (5%); Synthesis 11 (7%); and Evaluation 17 (10%). The data also shows that more questions were developed under Knowledge and Comprehension categories, which accounts for 64% of the total questions developed by the students while high order questions were 36 (22%). The result confirms difficulty involved in creating questions and sustaining classroom discourse led by students and their teachers (Lemke, 1990; Blumenfeld et. al., 2006; Beatty et. al., 2006), as exemplified by the low number of high order questions developed by week 4. By week seven of intervention, there was a recovery in the Synthesis and Evaluation question types, both of which increased (11 and 17 respectively) when compared to Analysis questions (8) which is the baseline for high order questions (table 1). This outcome, it can be argued, shows that there is a scope for the development, if both students and their teachers recognise that students have to be trained by their teachers on how to ask questions while teachers have to consciously model questions (Williams, 2011) using Bloom's taxonomy (Zheng et al., 2008; Bergman, 2009).

Examples of questions developed by students in week 3 of the intervention are highlighted below:

Student 1 question: What is the symptom of obesity?
Student 2 response: you will be fat and {looking} too big
Student 3 response: its true but I think the person will be overweight
Student 4: what is enzyme?
Student 5 response: it is something in the body that helps to break down foods so that we can absorb them easily

As seen above, these low-level questions are similar to that we observed during the pre-intervention lesson observations earlier discussed. The low-level questions show a similar trend in the exposure of students to questioning despite giving these group of students the opportunity to research the knowledge required before the lessons. This again highlights the need to provide structured guidance to students to help them develop their questioning skills.

Low order questions and feedback from students - week 4

In week four, following the modelling of high order questions to students by their teachers, there was an improvement in the quality of questions asked by students, especially the application questions (which is an intermediate level question and not considered as high order, table 1). Nonetheless, the noticed progress is tempered by the number of low-level questions developed (Knowledge and Comprehension, table 1) which remains considerably high.

The excerpt below illustrates a combination of Knowledge (K), Comprehension (C) and Application (A) questions and the feedback that accompanied them from students that was recorded in one classroom dialogue:

Student 1 question: State in your own words what obesity means? (K)
Student 2 response: *Obesity means someone bigger and slightly overweight*
Student 3 question: What do you think might happen to someone obese? (C)
Student 4 response: *If you carry on eating and are obese, you could have a heart attack, diabetes and may die.*
Student 5 response: You can also have high blood pressure.
Student 6 question: What changes do you suggest for an obese person? (A)
Student 7 response: Do more exercise, diet or eat a balanced diet.
Student 8 response: Eat a little bit of everything, vegetables and so on.
Student 9 question: Can you state what must have happened before getting obese? (A)
Student 10: no, no, I don't think that is right. You need to include "explain" instead of "state" as that will make it a better question. This student refined the question.
Student 11 response: Lack of exercise, eating wrong foods and too much of it.

Student 12 question: what can you do to help them? (K)
Student 13: miss can I clarify that question? It should be, is there any solution you could give to help them? This student refined the question.
Student 14 response: *Eat sensibly.*
Student 15 question: What are the difference between obesity and anorexia? (C)
Student 16 response: Obesity is when you are too fat and anorexic too skinny. Student 17 response: *Obesity is when you are overweight.*

Most of the questions asked by the students in the excerpt above are mainly knowledge and comprehension questions. Providing answers to them, therefore, does not require in-depth analytical engagement. Questions within the sequence of interactions are essentially low order questions which largely require factual recall (DFES, 2004) and do not require students to think deeply before responding. For example, one of the questions required the students to state the difference between obesity and anorexia. It is safe to assume that most students in attendance would be able to provide short answers to this question. Questions such as those in the excerpt above have been found to be predominantly used by science teachers and students (Blumenfeld et al., 2006). We may, therefore, argue that with the preponderance of such low order questions, teachers are likely to find it difficult to engage students in developing own questions. Although teachers do ask varying levels of questions, developing and encouraging questioning skills amongst their students rely heavily on the use of particular question types (Beatty et al. 2006; Reinsvold & Cochran; 2012; Harris et al., 2012). By implication, it could be argued that the kinds of questioning strategies teachers use may hinder students from asking and investigating their own questions. A good response would, therefore, require a platform where students can both be self-regulators and assessors of their own learning within a student-led and student-centred context.

It is, however, important that we recognise that this evidence was gathered at the early stage of intervention. It is, therefore, probable that the high amount of low order questions is a direct reflection of the stage of intervention. In this case, this was a stage when students were trying to get used to asking and investigating their own questions, a skill that they were not previously familiar with.

Comments by teachers from our field notes acknowledge this possibility. One of the teachers noted during our reflective discussion that;

> "*we can see that some of them wanted to ask the high order questions and also answer them. But some still struggle with the lower order questions. If they practice over time, they will get better at it". (Teacher 1)

What is clear, however, is that for students to ask appropriate high order questions, they need to understand the questions and what the questions require. For example, the question "*What changes do you suggest for an obese person",* depicts an application question. However, the students can easily confuse this for a high order question simply because it requests for changes to the lifestyle of an obese person. This is where the use of Bloom's taxonomy as a guide may be useful because it offers students the opportunity to engage with the right prompts in framing their questions as promoted in this study.

In general, what the data we have explored in this section shows is that students have the potential to ask questions, give feedback and also help each other to clarify questions. However, it is also evident that low order questions do not pose difficulty to them and therefore do not require teacher intervention. Whether this will remain the case as the intervention progresses remains to be seen.

Lack of clarity week 5

By week 5, the teachers had significantly modelled the development of high order questions beyond the level of week 4. However, it was observed that some of the students were still struggling with the process, as there was limited clarity in their questions when they attempted to move from low and intermediate questions to high order questions. Notwithstanding, some of the students have become confident in developing high order questions especially analysis type, with four questions developed in week 5, and increased to eight in week 7 (see table 1). Three Synthesis questions were developed and no Evaluation question. Below are some illustrations showing lack of clarity in student question:
Student 1 question: What will happen if you mixed enzymes to dissolved meat?
Student 2: What I don't understand what you mean? (This student exclaimed, showing the question was not understood)
Student 1 reframed the question: What will happen if you mixed like, enzymes and dissolved meat with another type of food group?
Student 3: What? Can you repeat the question again? (this was chorused by three students who requested that the question be reframed because they do not yet understand it)
*Student 1: There are different enzymes to dissolve different things in the body, what would happen if you mix two of them that don't work together (*the student finally repeats the question twice). This student experienced difficulty in framing relevant question related to the specificity of enzyme function as seen in the question developed. At this stage, student 2 was no longer interested in answering the question because he did not understand it.
Teacher: *now that the question don't seem correct, can someone help to reword it? Check our Bloom's taxonomy question guide for help and use the prompts to guide you. But ensure there is meaning to your question and think it through before asking.*
Student 4 refines the question: I think what he is trying to say is that what would happen to the different types of food we eat as we know that there are different types of enzymes in our body?
Student 5: Ok, I can answer the question now. An enzyme cuts up anything or any food molecule, basically, the enzyme travel and want to make the food go through the intestine.
Student 6: Basically, it's not just one enzyme, there are different types of enzymes, the one that wants to dissolve this one goes into this one, and the others act on different foods.
At this point there was a background noise from another student saying "*That is what I said, that is what I said"*.
Teacher: Be careful using the word dissolve to describe enzyme action, you should use the term breakdown and enzymes are specific in their actions. The teacher is acting as the knowledgeable order checking and ensuring that students are using Bloom's taxonomy appropriately to develop questions and also applying the right scientific key words.
Teacher: we want you to concentrate more on the high order questions but think about what you intend to achieve from such question and word it in such a way that other students can understand it. Remember to use Bloom's taxonomy guide and its okay for others to correct you.

Discussion

It is clear that the lack of clarity in the question developed by student 1 prevented other students from responding appropriately. Reflecting on the question; *"What will happen if you mixed enzymes to dissolved meat",* it would seem that the student was trying to find out the role of different enzymes in the body but had difficulty in making this clear to others. In our view, the reference to "*mixed enzyme*" suggests that the student was more interested in the specificity of the role of an enzyme. The need for clarity in questioning is vital to students' learning. There was a prolonged period of refining the question and some students appeared to have become disinterested and de-motivated. However, with the teacher's intervention, reminding students to use Bloom's taxonomy guide in developing questions, we noticed a difference. As the student tried to refine his question, he received peer-support from student four.

In the field notes collected after the lesson observation meetings, one of the teachers observed;

> *"we can see that some of them wanted to ask the high order questions and also answer them. But some still struggle with the lower order questions. If they practice over time, they will get better at it"* (teacher 1)

Another teacher commented;

> *"I think it is more pupil led, letting the learning take the direction the students want it to go rather than me giving them the questions I want them to answer and choosing the journey I want them to take. Their leading of it makes them take ownership of the learning and I think it is something that should be considered in normal lessons based on this project"* (teacher 2)

We can argue that creating such opportunities that engage students in questioning and sharing their ideas (Harris et al., 2012) has brought about an improvement in their questioning skills, ability to regulate their learning and support the progress of others. Because of this, they have been less-dependent on teachers' questions (Anne and Richard, 2010). Also we have also noticed an increased level of independence, confidence and social interactions among the students, for example, they were not afraid to challenge others' views (Osborne & Dillon, 2010; Maskiewicz & Winters, 2012), but were able to contribute to their learning and make corrections where relevant.

High order question and feedback from students - weeks 6 and 7

Following on from week 5 and our discussions with the teachers involved, we focused on helping students to overcome lack of clarity in their questioning and improvement in creating high order question by remodelling and reinforcing the use of Bloom's taxonomy as well as peer support. This led to progress, with Synthesis questions increasing from three to eight in week 6 and up to eleven in week 7 (table 1), while Evaluation question rose from zero to eight in week 6 and up to seventeen in week 7 (table 1). See below a sample of an Evaluation question (E) with its accompanying feedback:

Student 1 question: What changes would you recommend to eating fat foods or is there a better solution for us to be healthy? Sorry, I meant to keep healthy.
Teacher: what can you say about that question?

Student 2: miss em..em I think the question looks good and it is high order
Teacher: why did you say it is high order?
Student 2: she has used words like recommend and finding solution as the question will make us to think before we answer it.
Student 3 response: Eat small portion of fat foods with salads and drink plenty of water instead of soft drinks, because they are not very healthy for you and all these junk foods can make you become obese if you eat them too much. Eh… can I add something to that? I think you need to consider eating a balanced diet together with what I said before.
Student 4 response: miss, let me add to that answer. If you go to the shops buy those things so that when you fry your chips, it sucks out the oil so you get less fat in your body.

Discussion

After the previous lesson's observation and our reflection at the meeting (Week 4), we agreed to introduce high order questioning skills to students and this was met with lack of clarity in students questioning in week 5, which has seen an improvement in weeks 6 and 7. For example the teacher requested the students to decide if the question developed by student 1 was high order and to spot any error with it. Response from student 2 suggests and confirms an improvement due to agreement with the question developed by student 1. In the viewpoint of the teachers, this is a reflection of progressive development of the required questioning skill which is beginning to yield the required result. A comment from the field notes based on our discussions with the teachers encapsulated this;

> *"in this activity the students were positively challenging what they were talking about at the same time they were thinking is that question or answer right or wrong. It kind of removes any form of personalisation" (Teacher 1)*

Another commented;

> "t*hey are practising asking questions and looking at new materials but we need to start building up the skills and structure to begin with so that they can start practising it and get used to it early in their studies, and also how to do presentations" (Teacher 2)*

These comments suggests that the goal of helping students to develop their questioning skills is quite achievable.

A further issue arising from our observation in weeks 6 and 7 is the development of the ability to provide in-depth feedback as evidenced in the contributions of students 1, 3 and 4. These students were involved in answering and giving feedback to the high order questions. For example, the contribution from student 3 shows that students are now able to generate evaluative and challenging feedback. What is crucial in this is the level of discernment that the feedback reflects. When student 3 said, "Eh… can I add something to that? I think you need to consider eating a balanced diet together with what I said before", there is an indication that the use of the word 'recommend' in the high order question has led the student to go beyond mere factual recount. The requirement of the question is such that the feedback will necessarily have to draw on a range of related knowledge in order to provide an appropriate response. Similarly, when student 4 built on the feedback provided by student 3, "miss, let me add to that answer. If you go to the shops buy those things so that when you fry your chips, it sucks out the oil, so you get less fat in your body", what has been shown is that the high order question has facilitated a process of application of knowledge. By transferring the knowledge gained about fat to a different context, the student not only helps their colleagues but also show the extent to which they now have a grasp of the topic. This demonstrates the potential of using high order questions which in this case has been enhanced through the use of Bloom's taxonomy.

Findings from questionnaire

In the section on methodology, we have set out the focus of the various questions and how they relate to the research questions. The tables below present a summary of the findings from the questionnaire.

Table 2a: analysis of teachers' responses to questions 1-8 on the questionnaire.

Respondents	Does questioning and feedback improve students' engagement and attainment in lessons?	Should students be given opportunity to develop their own questions in lesson?	Do you plan for student questioning in advance before your lessons?	Do you think that most students do not know how to ask and investigate their own questions?	How effective is student questioning in lessons?	I encourage students to express their own unique thoughts and belief	Do your students ask relevant questions in lessons?	Do you use Bloom's taxonomy in developing questions?
1	Y	Y	N	Y	4	Y	Y	N
2	Y	Y	N	Y	5	Y	N	N
3	Y	Y	N	Y	5	Y	N	N
4	Y	Y	N	Y	5	Y	N	N
5	Y	Y	N	Y	5	Y	S	N
6	Y	Y	N	Y	5	Y	N	N
7	Y	Y	N	Y	5	Y	N	N
8	Y	Y	S	Y	5	Y	N	S
9	Y	Y	N	Y	5	Y	N	N
10	Y	Y	N	Y	4	Y	N	N

Key to table 1- Yes = Y; No = N; Sometimes = S

Table 2b: analysis of teachers' responses to questions 9-13 on the questionnaire

Questions	Codes generated	Frequency
9. When is it appropriate to use group discussion during questioning?	Open and closed questions; Sharing ideas; Engagement; Open questions; High order Feedback; Engagement Open question; Open; Metacognition questions Long answers; High order; open questions; Thinking skills question; Sharing ideas	OQ = 10 CQ = 1
10. What sorts of questions enable your students to learn?	Open questions; Open questions; Open; Problem solving questions Open questions; Open questions; Open questions; test knowledge; Open questions Ones they won't know the answer; Open questions; developing questions; Open questions; thinking question; open; closed	OQ = 13 CQ = 2
11. What sorts of questions do students ask during lessons?	Insightful questions; Depends on pupils Clarification question; Closed questions Questions that do not allow them to think; Closed questions; Closed questions Closed questions; Things they have seen or heard; relate new concept Questions not related to the topic; Questions related to solving problems using other methods; Closed questions Closed questions	OQ = 1 CQ = 11
12. What are the strategies you use in your lesson to ensure students ask relevant questions?	Problem solving tasks; challenging work and questions; Group work for support; challenging tasks; Student modelling task; Students developing own questions and ask others; highlight key topics. Focused/difficult questioning; interesting facts; steps to solve problems or questions; questioning to help thinking; challenging tasks to help thinking	OQ = 10 CQ = 0
13. What are the strategies you use in your lesson to ensure students respond to questions and give feedback	Lollypop sticks to collect ideas; Targeted questions; Students expressing ideas; Lollypop sticks; Students appointing others to answer; Success criteria; Encourage and praise; do not put down wrong answers; Targeted question; Asking for peers views; responses; Think about question; Do not accept all answers as correct; engage with other students' answers	

Key to table 2- OQ = Open questions; CQ = Closed questions

Discussion

Findings presented in table 2a is consistent with the literature, as teachers agreed that students find it difficult to ask questions in lessons (Lemke, 1990; Wragg & Brown, 2001; Cowie 2005; Mahmud 2015). When they do, the questions often are not relevant or may fall into the low order questions which only require factual recall (Wragg & Brown, 2001; Eshach, Dor-Ziderman & Yefroimsky, 2014). The consensus is that students should be given the opportunity to develop their unique thoughts and beliefs in lessons. What we hope this study has shown is that Bloom's taxonomy prompts can be a useful instrument for achieving these goals.

While the findings explored above might be expected, what is rather strange is the fact that majority of the teachers in this study have not engaged with Bloom's taxonomy as a tool for helping students to develop their questioning skills. In reflection, however, perhaps this should not be so surprising. The questionnaire revealed that many teachers have themselves not been utilising this tool. It is therefore natural for them not to use the tool with their students. This, in spite of the fact that there is copious evidence of the effectiveness of this tool (DFES, 2004; Harris et. al., 2012; Smart & Marshall, 2013). The expectation is that teachers would model forms of learning that they want their students to achieve. Evidence from this study indicates that this has not been the case with our science teachers. This perhaps explains why there is a strong view that many science teachers mainly rely on prescribed published examination questions. In effect we can expect these teachers to give little support to their students in developing their questioning skills.

This, therefore, raises the issue of the need to develop science teachers'pedagogy (ASE, 2006; Reiss et. al., 2011). Beatty et. al (2006) argue that the kinds of questions and strategies used by teachers can encourage and motivate students to develop their own questioning skills, so that they can move beyond low order questions which have been found to be commonly used in science learning by teachers and students (Blumenfeld et. al., 2006). We may therefore conclude that the failure to engage with the use of questioning skills by students is partly due to the lack of modelling by teachers.

Furthermore, it has been established that some teachers may find it difficult to support classroom discourse (Lemke, 1990). In a way, it can be argued that there is some prospect that the difficulty these teachers encounter can be alleviated through the use of Bloom's taxonomy to develop questions. It should also help to create an interactive and dialogic science classroom (Aguiar, Mortimer & Scott, 2010) that is void of the normal forms of interactions (IRE) which is always dominated by the teacher (Cazden, 2001).

Findings as shown in table 2b indicate that teachers use strategies to ensure students respond to questions and give feedback such as seeking other student's views, probing each other, not accepting all answers as correct and using success criteria. However, these activities are always in the aid of responding to the teacher's question. Drawing on the findings from this research, it would seem that this pattern of engagement is likely to miss out on the development that can be achieved through the use of open questions which are high order, which, when developed by students, can promote quality learning and improve students' cognitive skills.

Conclusion

The central goal of the research was to answer the question "how effective is the use of Bloom's taxonomy in developing students' questioning skills? Our findings show that teachers can help students to develop their questioning skills through the use of Blooms' taxonomy. Essentially, this can be achieved by using the prompts offered by Bloom's taxonomy to model and design high order questions in lessons. In effect, the questioning strategies teachers use can encourage students to ask and use similar questions.

One interesting finding is the indication that the limitations to teachers' pedagogical knowledge may be one of the factors that impede them from helping students to develop questioning skills. There is, therefore, an indication that the lack of engagement with questioning is not purely a problem with students. Rather, there might be the need to look at teacher development with a focus on developing their pedagogical awareness in the context of using questioning skills.

What the findings from the intervention administered in this study show is that questioning can be seen as a useful tool for scaffolding learning, encouraging and sustaining classroom interactions. It should, therefore, not be left as a sole responsibility of the teacher, as students should be regarded as co-learners in the classroom. Teachers, therefore, can train students to develop questions as we have presented in this study and also encourage them by modelling quality questioning (Williams, 2011), especially the high order questions that can help to improve interactive and dialogic communication (Aguiar, Mortimer & Scott, 2010).

The progress made by the students in this study is evident from the weekly improvement seen in the types of questions they develop, that is, from low to high order and the quality of feedback that ensued in such discussions. As Sawyer (2006) points out, students learn better when they express their developing knowledge. In this case, questioning and feedback, and an opportunity to reflect on the teaching and learning process reflect their engagement with the knowledge development process. Also, it can be argued that the ability of the students to resolve the questions developed, suggests an inquiry experience (Windschitl, 2003) that further reflects the progress they have made. This achievement is significant because our discussion with the teachers before the commencement of the study shows elements of doubts around the ability of students to accomplish this task. As demonstrated in Adey and Serret (2010), a good use of questioning and feedback can result in an improvement in cognitive developments of students in years 7 and 8. Evidence from this study suggests that the participants might also produce a similar outcome.

While there was evidence that the use of Bloom's taxonomy is effective in developing science students' questioning skills, it is important to note the importance of the support given to the teachers by the researchers. The need for this support raises the issue of teachers' professional development. What this study appears to have highlighted is the need to provide CPD sessions to train teachers on how to use Bloom's taxonomy to support students' development of questioning skills. As implied this study, teachers lack the pedagogical knowledge to implement such learning experiences among their students. It is, therefore, important that support is provided to teachers to enable them to develop the requisite knowledge and skills through professional development engagements. These engagements might be in the form of more experienced teachers that have been trained in using this approach supporting less experienced teachers.

To achieve consistency in teacher development and use of this approach by students, the resources utilised in this study or other purposely developed materials can be used to model support facilities for teachers and embedded into the Key Stage 3 schemes of work. This would promote consistency in its use by science teachers in the science department. Leaving the decision on when to use the resources to teachers may not be effective because some may ignore or forget to use them. This view is corroborated by one of the teachers who said:

> *"Yes I think this is something we can incorporate in our schemes of work but we need to start building up the skills and structure to begin with so that they can start practising how to ask questions and get used to it and how to do presentations. This is something we should be doing. They learn well enough from each other and I will be interested to see how they get on doing it over and over again. It will also help them develop transferable skills not just for science but to transfer to other subjects"* (Teacher 1).

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APPENDIX

Cognitive domain	Knowledge	Comprehension	Application	Analysis		Synthesis	Evaluation
Question prompts	-Who, What, Why -Can you tell why -Describe	State in your own words -What do you think might happen next? -What does this mean…..? -What is the main idea? -Give an example -Can you define? - Can you provide a definition for…..? -can you distinguish between…..? -Classify -What difference exists between........?	-predict what will happen if.......? -what factors would you change if......? -can you apply the method used to some experience of your own......? -Tell how, when, where, why........? -What questions would you ask of......? -What would result.....? -Do you know another instance where..?	-How is ... similar to........? -Can you compare your…… with that presented by.........? -What do you see as other possible outcomes? -What motive is there.......? -What conclusion can you make…? -What is the relationship between.........? -What are some of the problems of.........? Can you explain what must have happened..........?		What would happen if.......? -How many ways can you.......? -Can you create new and unusual uses for…….? -Can you make up..........? -Can you design a ...... to …….? -Can you develop a proposal which would….? -can you see a possible solution?	Is there a better solution to.......? -Judge the value of........... -Can you defend your position about......? -What changes to......would you recommend? -What do you think about.....? -How would you feel if.........? -Compare or defend........?

Adapted from Maynard (2012)