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'Question moments': a rolling programme of question-opportunities in classroom science

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table

TABLE 1 **-** Number of written questions per lesson from two classes

	Class A				Class B		
Lesson	16th March	30th March	6th April	27th April	22nd March	29th March	26th April
Nº of written questions	37	7	1	1	49	1	8

table

TABLE 2 - Pupils' oral and written interventions

	Class A		Class B			
	16th March		22nd March			
	Shift 1		Shift 1		Shift 2	
Type of intervention	Oral	Written	Oral	Written	Oral	Written
Nº of interventions	77	25	156	28	136	21
Nº of pupils	14	14	13	13	13	13
Nº of pupils who did not intervene	5	1	3	0	4	2

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'Question moments': a rolling programme of question-opportunities in classroom science

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table

TABLE 3 – Class discussion on sublimation phenomenon

T: […] Today I brought you a substance that everybody knows and which sublimates easily. [...] Have you never seen these little balls in your wardrobes at home?

S1: Aaaah, I have!

T: It is usually used to repel moths… and other insects and it is called naphthalene. […] Well, what evidence do we have that naphthalene is passing from a solid into the gaseous state?

S2: It is slowly disappearing.

S3: What?

T: Well, the naphthalene ball will get smaller and smaller, yes, and what else? There is another piece of evidence.

S3: (…)

T: The smell! If I leave this ball here for a while, if I leave it here in this corner, in a while you students will be able to detect the smell of naphthalene back there, in the other side of the room. Why is that? What do you think that happens?

S1: Because while… the… the naphthalene is transmitting … its particles.

S2: Because it will pass into the air.

S4: (…)

T: Yes, because sublimation has occurred! Part of the naphthalene molecules has passed from the solid state into the gaseous state, haven't they? Be careful, it didn't occur, how did you say Pedro, a… a transmission of particles, but a change in the physical state of some of the particles of naphthalene – from the solid state into the gaseous state. In which of the physical states will the molecules of naphthalene have a greater mobility – in the solid state or in the gaseous state?

S1: In the gaseous state.

S5: Solid.

S6: No, gaseous!

T: Exactly! They will have a greater mobility in the gaseous state and can go from here to the Maria's nose!

All: [Laughter].

T: This is evidence that there was a physical state change. But at no no moment do we see naphthalene in the liquid state, right?

S7: No, we don't.

T: It is for that reason that we can use naphthalene to keep moths away from our clothes – because it is never in the liquid state, it does not wet our clothes.

table

TABLE 4 – Class discussion on pupils' written answer

T: […] One of the groups wrote this answer: «*Water is in the solid state because the room temperature is minus 5ºC*». So when the room temperature is minus 4ºC, is the water no longer in a solid state? **S1:** No, it is. That happens only if the temperatures are negative. **T:** That is, at any temperature below 0ºC? **S2:** Yes, it has to be lower than the fusion point of the water. **T:** Ah! That was the point most of the answers lacked! Let's see, imagine that here in the	classroom we are at 15ºC. Why is sodium chloride here in a solid state, and yet the water is in a liquid state? Look carefully at the list. **S2:** Because the temperature needed to… melt… to fuse sodium chloride is at 801ºC. **T:** Very good! Now identify a substance that would be here in the room in a gaseous state. **S3:** Oxygen. **T:** And your justification for that is… ? **S3:** Because the boiling point of oxygen is lower than the temperature that… that we have here in the classroom.

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ABSTRACT

This naturalistic study integrates specific 'question moments' into lesson plans to increase pupils' classroom interactions. A range of teaching tools has explored students' ideas through opportunities to ask and write questions. Their oral and written outcomes provide data on individual and group misunderstandings. Changes to the schedule of lessons were introduced to discuss these questions and solve disparities. Flexible lesson planning over fourteen lessons across a four-week period of high-school chemistry accommodated students' contributions and increased student participation, promoted inquiring and individualised teaching, with each teaching strategy feeding forward into the next.

Keywords

Student questions; teaching strategies; lesson planning, student participation

INTRODUCTION

Chomsky (1995) has argued that the formation of questions is an essential, integral part of a Universal Grammar: forming questions is part of the blueprint for language that is hard-wired into the human brain. In this vein, Jordania (2006) has suggested that the ability to ask questions is in fact the central cognitive element that distinguishes humans and animals. The position we adopt in this paper differs - not in the essentially human qualities of asking questions, but by directing our research from within a constructivist perspective. In this, we are akin to Dabrowska & Lieven (2005) for whom question-asking – hard-wired or otherwise - is an act of meaning-making. Question-askers, they say, build questions by recycling and recombining previously experienced 'chunks' of language, knowledge and understanding.

In this paper we explore everyday classroom mechanisms for enabling that construction to take place. The teacher (of chemistry, in this case) explores a range of approaches to encourage question-asking with young adolescents in school-time lessons. She (SL) uses student-generated questions while designing teaching to cover the required curriculum (Hagay et al. 2013), and works to provide 'question-moments' when the members of the class have opportunities to turn the tables: to ask the teacher questions rather than just the other way round. Such student-centred approaches are commonly challenging for teachers, not least because they 'require teachers to assume a guiding role and to simultaneously attend to many different aspects of the classroom' (Brush & Saye, 2000, p.8). This naturally results in a broader set of teacher 'management responsibilities' and skills than the ones held in more traditional classrooms (Mergendoller & Thomas, 2005, p.8). These approaches also demand a predisposition to understand students' points of view about the matters discussed in classrooms. In order to do this, the teacher must adopt, on the one hand, a reflective attitude towards the interpretation of data and, on the other, an investigative attitude to collecting questions and answers. In this study there is a third requirement: she must also develop and implement tools and strategies fitted to improving the process of teaching and learning in future lessons.

In order to do so we have combined these three dimensions (reflection on practice, collection of data about that practice and the creation of strategies to improve it), interrelated in a continuous process of mutual feedback. Action research or in this case, teacher action research, was the most appropriate approach to tackle this in practice. In such research, the teacher studies her own situation 'to improve the quality of processes and results within it' (Schmuck, 2009, p.19). In other words, the teacher conducts research on practice in order to improve the experiences of her students (p.21). This kind of research differs from traditional approaches in that it studies personal practice, seeks continuous change, is reflective about thoughts and feelings and strives for development and improvements through planed change (Schmuck, 2009, p.21) In this way, the traditional gap between researcher and research subject is removed because they are one and the same person (p.21).

Action research may be divided into several steps, although it would be a misleading to suggest strict order and linearity in work of this kind. We organised our study through three phases: the exploratory or 'pre-study' phase as defined by Craig (2009), a question-generating or 'data collection phase' as defined by Henning et al. (2009), and an implementation or 'intervention phase' (Meyer, 2010). In our case, the exploratory phase comprised three separate tasks: (i) observing the situation and the subjects in order to uncover problems, issues and concerns, (ii) deciding upon a focus by asking questions such as: 'What do I want to find about these specific students or situation?' 'What do I want to improve?' and, finally, (iii) 'reviewing helpful theories in order to gather information to make informed decisions and to design the action plan' (Craig, 2009 p.17). During the 'question-generating' data collection phase, new teaching strategies were put into action. During the implementation phase, a number of 'spirals of activity' emerged comprising periods of planning, acting, observing, reflecting and re-planning and often 'leading to other spin-off spirals of further work' (Meyer, 2010, p. 265).

In this paper we describe a teacher fostering the participation of students in her class, collecting their ideas and queries and reflecting on the information collected with the intent to make adaptations for the next tranche of lessons. After each lesson, she designs flexible instruction that takes account of the questions collected and these designs are then implemented in the next series of classes. More responses are collected, a further stage of re-design takes place – and so on as the series of lessons progress. Our report captures the adoption of such approaches and, by doing so, we chart the forging of educative interventions informed by the teacher, the subject matter, and the students involved. That is, we have provided opportunity for 'question moments', collected their questions, identified their individual learning needs, and implemented suitable strategies to deal with these. This is essentially a co-constructivist approach to teaching (Authors et al., 2005), where knowledge and understanding is built, developed and tailored to particular needs within a classroom community.

STUDENTS ASKING QUESTIONS

At a surface level, it would seem rather straightforward to ask students about their uncertainties and difficulties. However, as Authors (1997) have pointed out, pupils do not feel at ease when answering teachers' questions because they link questioning to assessment and perhaps their fear of exposing ideas that might reveal learning problems. Hence, we needed a secondary route to reaching pupils' states of knowledge. Authors (1997) have claimed that pupils' questions can reveal even more about their thinking than their answers. However, research shows that students seldom ask questions in the classroom, commonly keeping their doubts and uncertainties to themselves (Dillon, 1988; Authors, 1997; Authors, 2010; Moreira, 2012). Authors (2012) explore some of the reasons for this and suggest that asking a question in class can give rise to feelings of exposure and vulnerability that may prevail over curiosity, doubt and uncertainty, and prevent the act of questioning. Therefore, pupils need to feel relatively safe before they risk asking any important question. Another factor pointed out in literature that might hinder question is the lack of time to reflect and elaborate a question (Chin & Brown, 2000; Dillon, 1988).

To overcome some of these difficulties, Authors (1997), Silva (2002), Authors, et al. (2001), Teixeira-Dias, et al. (2005), Neri de Souza (2006) and Moreira (2012) all suggest that teachers might use learners' written questions. These can be used as a 'secure' and private way of exposing doubts and knowledge gaps, providing also a longer time for reflection than the short time commonly prevailing in oral interactions (Authors, 1997). Etkina (2000) discussed the use of a weekly report, a structured journal in which students answered three questions: (a) 'What did you learn this week?' (b) 'What questions remain unclear?' and (c) 'If you were the teacher, what questions would you ask to find out whether the students understood the most important material of this week?'. Etkina's suggestion was that this not only encourages students to think about the gaps in their current knowledge, but also serves as an assessment tool and allows the instructor to modify subsequent instruction to address students' needs. The difficulty here is that these were teachers' questions, not students', and little is offered by way of discussion of how subsequent instruction was actually modified. Teixeira-Dias et al. (2005) do describe how they used students' questions as the springboard for instructional interventions. They collected questions using a 'question box' within classrooms for anonymous written questions and an email facility for 'out-of-hours' questions. In this instance teachers were able to respond to direct queries, and created a series of special lecture sessions to tackle obstinate issues. Students broadly welcomed these although the pace of curricular change was difficult to maintain. In other studies (for example, Kulas, 1995), students recorded their 'puzzle questions' in a diary or learning journal, setting out their 'I wonder' questions; Dixon (1996) used a 'question board' to display students' questions and suggested that these questions could be used as starting points for scientific investigations. In Authors et al. (1997), we argued for a question 'brainstorm' at the start of a topic, a 'question box' on a side table where students could put their questions, turn-taking questioning around the class where each student or group of students must prepare a question to be asked of others, and 'question-making' homework. The two gaps in this literature, then, relate to (i) the provision of specific in-lesson time for students' question, and (ii) a systematic approach to using student questions as part of the systematic plans of forth-coming lessons. In Authors (1997), we suggested including specific times for questions such as a period of 'free question time' within a lesson or block of lessons, but failed to carry this through and explore the outcomes. With Teixiera-Dias et al., (2005) we designed instructional interventions but lacked a systematic form of iterative lesson planning. In the study described here, we sought to remedy both issues by testing the situations that best generated questions with these students, providing vehicles for question-asking in class, and then acting thoughtfully and reflectively on the questions they asked.

THE STUDY DESIGN

Context

The present research is naturalistic, was conducted in situ with two parallel classes and a total of 54 pupils (year 7, 12-13 year olds) in a Portuguese secondary school. The timescale covers fourteen one-hour lessons across a four-week period of high-school chemistry. Both classes were taught by the same chemistry teacher (SL) while she was undertaking Masters' research in education. These circumstances helped in establishing a bridge between academic research and professional practice. The curricular matters addressed were 'Physical and chemical transformations', 'Physical properties of materials' and the 'Separation of mixtures', all fairly traditional components of the science curriculum at this level. Within the study we identify three distinct phases: (i) an initial exploratory phase; (ii) a question-generating phase, and (iii) an implementation phase. At all points, data were collected through participant and non-participant observation, field notes, pupils' written questions and answers, and also by audio-taping classroom lessons in order to register oral interactions.

The initial exploratory phase

This initial exploratory phase lasted 5 months and during this time data were collected on the students' characteristics and the class dynamics through both participant and non-participant observation. We also sought issues that were problematic for students' learning and therefore worthy of study in more detail. The key observations of both classes during the exploratory phase related directly to problems of pupil non-participation: very few students asked very few questions. There are three aspects to this:

- Pupils' participation was low in general, and this was reflected in the very sparse level of their question-asking

- Most student contributions followed a request from the teacher, i.e., few of them were spontaneous
- Those spontaneous contributions that did arise came almost always from the same pupils.

The second question-asking phase

In this second phase we sought to implement question-asking strategies and therefore our research question became the following:

- How to stimulate 7th grade pupils' question-asking during chemistry lessons, both in oral and written format?

During this phase, efforts were made to increase pupils' interaction. Specific tools were designed and incorporated in lessons to encourage pupils to be more involved, to participate, ask questions and explore their ideas. These tools consisted of:

Students' oral questions

A noted earlier, these were elicited during the process of the classes, which were audio-recorded for this purpose. The recorded sessions were transcribed and carefully read for content analysis - in order to identify possible doubts, wrong ideas or concepts that needed to be re-discussed in class.

Written questions

Three changes were made to the usual conduct of chemistry lessons. These were:

- <u>Question Sheets</u>: drawing on the work of Authors et al. (2001) and Neri de Souza (2006) who developed a similar approach in their studies and included specific sheets to register written students' questions. The Question Sheets were introduced at the start and collected at the end of every lesson and all questions were then read by the teacher and analysed for content and issues
- <u>Group open-ended questions</u>: For this study we created a set of open-ended questions, which were part of the sheets handed out by the teacher to each group. These provided questions were designed to foster discussion and hypothesising. Open-ended questions are defined as questions that have multiple possible answers. This kind of question allows students to take their previous experiences into their explanations, contributing to much richer and meaningful answers. Such questions also require students to justify their statements and explain their underlying logic. Hence, they help develop argumentative skills and provide deeper information about students' state of knowledge. They may even

reveal that students have a broader understanding of a particular topic than the teacher might have imagined (Lund & Kirk, 2010)

- Closed questions: These were also created by the teacher and included in order to identify possible gaps at the conceptual level, which could render difficult the development of deeper reasoning and explanations. The written answers given by students during the group work were also gathered and organised according to the key ideas they presented.

Question Moments

For us, a question moment is a pause in proceedings to allow students to write their questions and doubts. While Question Moments were intended as short breaks in normal class time to collect students' individual questions, students were nevertheless encouraged to write and ask questions whenever they wished. Importantly, they could also write questions about any topic - even if that had nothing to do with the matters addressed in the classroom. We expected these questions would provide some insight into pupils' wondering, reasoning, doubts and difficulties.

During this second phase we explored the effect of such Question Moments and so varied their inclusion. As Table 1 shows (in grey), Class A had two lessons where Question Moments were provided, Class B had one. The results are clear: perhaps unsurprisingly, the number of written questions is substantially higher in the lessons where specific Question Moments were provided, far outstripping lessons where no Moments were provided.

TABLE 1 **-** Number of written questions per lesson from two classes

Group discussion time

After working in groups, pupils shared their answers to the open-ended questions with the class, presenting their arguments for and against each of the alternatives presented. The main aim of this discussion was to choose procedures that could provide solutions for the problems addressed by the open-ended questions. These discussions, we hoped, would also provide greater insight into pupils' minds as well as allow them to put their ideas to test by confronting them with those of their peers.

Oral and written questions

Each class was divided in two (shift 1 and shift 2), each having lessons at different times of the school day.

TABLE 2 - Pupils' oral and written interventions

As shown in Table 2 above, in both lessons the number of pupils who wrote questions was higher than those who made oral interventions. This means that some of the pupils who did not participate orally during those lessons wrote questions, which suggests that those pupils are more disposed to write rather than to tell their doubts out aloud.

The third implementation phase

In this phase our question became:

- How to systematically shape lesson planning to incorporate responses to their questions and integrate pupils' questions and ideas in the teaching and learning process?

Two main approaches were adopted to explore this. First, all the 'research productions', the written and oral questions, the group open and closed questions and the audio records, were objects of content analysis, interpretation and reflection in an attempt to gain insight into pupils' states of knowledge, their doubts and possible lack of knowledge and understanding. Content analysis is widely used in naturalistic qualitative research (Hsieh and Shannon, 2005) to interpret meaning from the content of text and observational data. In this study we used conventional content analysis, isolating and coding categories derived directly from the recorded data. This allowed us to count instances and make comparisons. This allowed us to identify any student problems, which then served as a basis for planning the next lessons. Second, these productions were presented to the class as matters for discussion, as a form of respondent analysis, helping to revisit topics previously addressed and to clarify doubts.

We hoped that integrating pupils' productions of this kind into the lesson would increase their motivation to participate. Given the number of these productions, it became necessary to select the ones that would be discussed. Our choice was supported principally by two criteria: the number of pupils who expressed similar doubts, concerns or curiosity, and the relevance of those worries to the organisation of, and the approach to, the curriculum matters in hand. A first example of this is the lesson of 30thMarch when, from a total of 7 written questions, 4 were focussed on the phenomenon of sublimation, and these were:

«How can it [a substance] pass from the solid state into the gaseous state and vice-versa?»

«How can the solid state transform into gaseous and vice-versa and not pass through the liquid state?»

«How can it [a substance] pass directly to the gaseous state?»

«How can the ice transform into water vapour and not pass through the liquid state and vice-versa?»

These are essentially the same question, and about a relevant aspect of the topic - physical transformation. Therefore we thought it was important to promote class discussion on this in order to address these questions.

A second example is drawn from the lesson of March 22nd, when two similar written questions were received about the concept of pressure:

«I did not understand the explanation about pressures»
«I did not understand very well that part of the lesson about pressure»

Again, these two questions concern the meaning of the word pressure - the two students had simply not understood the explanation offered to them. There was no oral intervention (no question or comment of any kind) from any student during either class, no questions asked of the presentation of the concept of pressure at the time. One possibility is that the concept was so abstract that these two students (at least) felt too uneasy even to comment/question it at the time. So, although these two questions were only a small fraction of the whole set of questions (49), we thought it was appropriate to discuss this concept again. Besides, pressure is a term used to define boiling and fusion points, both central concepts of the programme, and therefore we thought students needed a 'palpable' understanding. This, then, prompted a class discussion on the concept while referring to a chemical reaction, where a balloon was inflated because of the pressure exerted by a gas formed during the reaction.

OUTCOMES AND DISCUSSION

The outcomes of this work are not straightforward, but then naturalistic research is seldom direct and clear-cut. While observing and recording people in natural, unstructured, settings come closest to what we all do in our daily lives, it can prove 'messy' with many of the key issues intermingled.

The initial exploratory phase allowed us to identify two groups of pupils whose preferences were distinct: the minority of 'oral askers' who would speak out and ask questions in class, air their doubts and reasoning, and the majority of 'question writers' in the two classes, who preferred writing their ideas in a more individual and private manner. The difference in the numbers may be due to factors discussed before – the social discomfort or fear of ridicule (Graesser & McMahen, 1993) or even the arduousness of asking a question in the short time that characterises oral interaction. These observations, though, do support the idea put forward by several authors (Dillon, 1988; Authors, 1997; Authors, 2010) that pupils *do* have questions to ask and are able to ask them if the right conditions are provided.

The second, question-asking phase, introduced a series of measures to promote students' questions. These are:

1. The classroom question moments

Table 1 above shows that the inclusion of a specific Question Moments for writing questions in class clearly favours the writing of questions (Authors, 2005). Interestingly enough, even in the lessons where no such moments where provided, some students did write questions, which suggests that the Question Sheet alone was also a meaningful tool for these students.

2. Students' written questions

The moments for writing questions allowed the collection of a varied set of questions (a total of 105 over the course of the study). Analysis of these showed that they fit the picture described by other authors (White & Gunstone, 1992; Authors, 1990; Graesser & Person, 1994; Chin & Brown, 2002), that most of the questions were acquisitive of factual information and concerned concepts or terms used in the classroom. Some examples:

> «*How can we know if the transformation is chemical or physical?»*
>
> *«What is the name of the temperature symbol* θ*?»*
>
> *«What is a reagent?».*

There were a few questions, however, which were more specialised and trying, for example, to establish connections between issues learnt in the classroom and pupils' previous knowledge, or imagining scenarios as a way of 'testing' the new information:

> «*When the water passes into the gaseous state, does it disperse in the atmosphere? If so, can we say that an ice cube is created from the liquid water that came from the gaseous state of several places?»*
>
> *«If water modifies its physical state (when it is too hot it evaporates and when it is too cold it solidifies) why are there more clouds in winter, when it is colder?».*

The number of questions written during two of the lessons where those moments were provided was compared with the pupils' oral interactions during the same lessons. Table 2 above shows the results. As noted earlier, in the lesson on March 30th four of the seven written questions were related to the idea of sublimation, the topic taught for the first time in that lesson. In that case, in order to help pupils to understand the phenomena, the teacher decided to break with her schedule in the next lesson in order to demonstrate sublimation with a sphere of naphthalene, since this sublimates at room temperatures and was a familiar example for pupils. Table 3 below contains a small extract of the subsequent discussion.

TABLE 3 – Class discussion on sublimation phenomenon

This discussion, built upon the pupils' initial written questions, addressed their doubts and also allowed other pupils to express their ideas and reveal misconceptions. For example, the idea of 'the physical transformation of the naphthalene from solid state into gaseous state as a «*transmission of particles*» was deconstructed and given adequate feedback for a better understanding of the phenomenon.

Within this strategy it is worth noting that many of the questions that pupils wrote concerned matters discussed in lessons that had taken place two weeks before. This means that those pupils had kept their doubts to themselves for all that time and exposed them only when they had the opportunity to write them down.

3. Open-ended and closed question activity sheets

The group activity sheets used in the lessons comprised a total of six open-ended, and three closed questions. Four of the open-ended questions allowed for at least two valid solutions. That is, those questions could be answered in (at least) two different, yet valid ways. Our approach was that this activity was best suited to group work, so that there were many heads developing an answer to the question. They could also explore the issues involved by raising their own questions. Some of the proposals that students made, and that could be considered viable, had not been foreseen by the teacher. For instance, two groups suggested separating a mixture of flour and iron filings by adding water to the mixture:

> «*We could separate the iron filings from flour using water because the flour would stay at the surface and the iron filings would sink*»
>
> *«To separate the flour from the iron, we would have to put them in glassware with water. One stays on top and the other stays at the bottom».*

That is, students thought of taking advantage of the different densities of flour and iron filings. Although the density concept had not been formally taught, students seemed to have an intuitive understanding of the different behaviour that the two components of the mixture would display in the presence of water. Alluding to this proposal in the next lesson was then a useful ‘starting point’ for the introduction of the concept of density, incorporating students’ own ideas as part of the lesson plan. The ‘expected’ answer in this instance was the use of a magnet, and it was, indeed, the answer given by the majority of students (12 groups):

«*We could use a magnet and it would attract the iron filings*».

Class discussion was then used to help choose the more efficient means to separate, in practice, the components of the flour and iron fillings mixture. This process increased participation and involved a greater number of students because it incorporated their different ideas and presented reasons for choosing one proposal over the other, instead of dismissing or simply neglecting the ‘un-expected’ ideas.

Examples of the implementation phase of the research have already been included in the comments made above, and suggest that the strategies used, designed and implemented in order to accommodate individual differences, with this strong emphasis on teacher reflective practice, has stimulated and increased pupils’ participation, increased pupil-teacher classroom cooperation, helping the teacher to individualise teaching, that is, to be aligned with pupils’ learning preferences. As discussed, one of the pupils’ tasks was to answer a set of open-ended questions using appropriate work sheets. The analysis of the answers allowed the teacher to characterise their main misunderstandings of the concepts involved, choosing some she considered relevant to stimulate the discussion in the following lesson. For example, on March 22nd a lesson dealing with the concepts of boiling and fusion point was planned, taking into account the answers already provided for the following question:

«*Why is water in a solid state at normal pressure and ambient temperature of -5ºC?*»

The answers required pupils to understand the concept of boiling point. So, the teacher decided to begin the discussion using one of the answers to that question:

«*Water is in the solid state <u>because</u> the room temperature is minus 5ºC*».

The example presented in Table 4 is a small extract of the discussion raised by that answer.

TABLE 4 – Class discussion on pupils’ written answer

Similar analyses of classroom talk, for further classroom use, were undertaken from the recordings of pupils’ oral interactions, in the course of their practical activities.

4. The rolling programme

The classroom discussions above are examples of a 'rolling programme' of revisions and classroom interventions. In this instance, the teacher modified the lesson on March 30th (Table 1) in the light of the previous lesson, then the lesson on April 6th in the light of March 30th; the lesson on April 27th after April 6th, and so on, a series of previously unplanned departures from her curriculum schedule of lessons as a result of students' questions. Her reflective log at the end of each lesson served as a basis for the next lessons.

In some of the lessons (for example, April 6th, April 26th and 27th), the 'activity sheets' were used and the discussions in those lessons centred on students' oral inquiries and the written answers given there and then to the questions on the sheets. Lesson time was tight, to both undertake the activity and maintain momentum within the curriculum and, in some instances, students began to answer the questions on the sheets in one lesson (22nd March) but finished them in the next (29th March). Time was then made in that subsequent lesson to discuss student's written answers.

SUMMARY

Reflection upon students' oral and written questions, and subsequent classroom discussions, has provided this teacher-researcher with relevant information about individual and group 'knowledge gaps', doubts and perplexities, both implicit and explicit. The teacher created time in subsequent lessons outside of her normal curriculum planning to address the identified problems, and to promote class discussions initiated by presenting the pupils' 'questioning products'. The exemplar data above illustrates how the teacher used the collected information and managed discussions, based upon pupils' written questions and written answers to trigger conversations.

There is no doubt that promoting learners questioning demands more of the teacher than simply lecturing to a sea of blank faces; the price for prompting engagement and inquiry in the classroom is the development of a set of planning and organisational skills, alongside a willingness to receive, analyse, evaluate and address their questions. These examples are merely illustrative and in this function serve only to illuminate some of the key issues involved in inquiry-based practice of teaching. The data do not build theory but provide empirically grounded contexts for demonstrating both the advent of classroom questions, descriptions of the situations that give rise to them, and some of the possible ways in which teachers can mange them.

Limitations of this research and suggestions for future research

Qualitative investigators in general as well as teacher-researchers in particular maintain that research respondents must 'speak for themselves' (Sherman & Webb, 2001, p. 5). In this study, we have discussed only the teacher-researcher's viewpoint. While it is true that the main focus of this research is student's output, these have concerned mainly classroom discourse and did not include students' critique or opinions about the strategies we introduced. It would be important, in a future study, to allow students to express themselves more about the research itself, and the strategies used. Such studies might use also peer collaboration between a group of teachers and joint analysis of the data collected (van Kraayenoord et al., 2011).

One of the main concerns during the study was the limited classroom time to be spent with students. For example, wish as we might we could not include Question Moments for all students to write questions in every lesson. Aware that students do improve the quality of their questions with practice, it would have been desirable to use this strategy regularly and for longer periods of time. Meanwhile, it would have been interesting to follow each student's individual progress in writing questions. In this way, students' potential for writing questions could have been explored even further. Each student used the same Question Sheet for writing questions throughout the research timeline so they could therefore read their previous questions, think about them and 'act' upon them. For instance, in this research, one student took the initiative of later answering one of his own questions (written in a previous lesson). Inspired by this, it would be interesting to encourage all students to answer their own questions (and others') once they felt prepared to do so. This is not a new idea and has been suggested by Chin & Kayalvizhi, 2002; Gibson, 1998; Watts, Barber & Alsop, 1997). It does, however, deserve more attention. It is a strategy that might help students develop their metacognition, as defined by McClure & College (2004). For them, teachers who find ways to help students answer their own questions are helping learners become more knowledgeable and in control of their own cognitive resources.

The constraints of curriculum time also meant that, of all the alternative, creative solutions the groups put forward to solve problems, only one was actually tested in practice. This procedure was chosen as the most efficient and, importantly, the one that could be undertaken using the available laboratory materials. While the other different procedures suggested were taken into serious consideration, and their pros and cons debated, there was simply too little time and immediate resources to undertake these experimentally. This is the next step, to find curricular means, within a fairly standardized and regulated curriculum system, to enable students to enact and compare their alternative solutions to decide which was the most effective procedure based on their own question answers.

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Dear Journal Editors,
We are pleased to submit further revisions of our paper as follws:

Reviewer #1: we have included further indications of the students and teacher/researchers context, looking to add information that might help define the 'researcher context 'as requested. This appears on p5, in the first paragraph under the subtitle 'Context'. In addition we have looked to clarify the content analysis of the data collected. This appears on p8.

Reviewer #2': we have located the phases of the research within the paper's literature review with referenced to published peer reviewed literature. This appears as the paragraph 'Action research…' on p3.

We do hope this meets the requirements as stated