Auto-Reflection Through Classroom Interaction: The Role of Pupil's Individual Differences

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Abstract

To create conditions for significant learning to take place, it is necessary that teachers take into account students' previous knowledge and expectations, their questions and ideas, before planning teaching strategies. In doing so, it is essential to promote pupils' interactions either with the teacher or with pears, acting as partners in the teaching and learning process by expressing their ideas, questions and expectations.

In this study we have tried to increase pupils' interaction by designing and integrating into the lesson plan specific moments and tools to encourage them to become more involved, participating and exploring their ideas - specifically, giving them opportunities to write their own questions. All pupils' oral and written 'productions' were subjected to analysis, being the core of the teacher-researcher's auto- reflection and taken into account for the next lesson's planning. The analysis of such productions also allowed access to the individual perplexities and concerns in a private manner.

Data was collected through participant and non-participant observation, field notes, pupils' written questions and answers, and also by audio-taping some classroom lessons, in order to register oral interactions. The nature of this research is qualitative and can be considered as a case study. It was developed in two different secondary classes (year 7, 12-13 year olds), during 14 lessons and has 54 pupils involved, in a four weeks period, when they were learning chemistry. In some lessons, pupils were working in groups specifically designed for this purpose. The overall results of this naturalistic study suggest that the strategies used, designed and implemented in order to accommodate individual differences, with a strong emphasis on teacher auto reflection, stimulated and increased pupils' participation, increased pupil-teacher classroom cooperation, helping the teacher to individualize teaching, that is, to be aligned with pupils' learning preferences.

Keywords: Questioning, students' questions, student-centred teaching, individual differences, teacher-researcher.

1. Introduction

1.1 Individual Differences

Educators are intrigued why some students seem better equipped to learn than others, and why all students cannot learn all skills equally well. Jonassen & Grabowski (1993) argue that one reasons for differences in learning is that student learning traits differ, i.e., "individuals vary in their aptitudes for learning, their willingness to learn, and their styles or preferences for how they learn if they choose to" (p.3). In order to explore the maximum potential of a class, teachers must involve all pupils by attending to their individual differences, to "search

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for the individual approach that seems to work with particular students, in gaining their attention and interest, in finding particular ways to analyze the tasks they find difficult, in responding to their successes and failures" (Crozier, 1997, p.xii). That is, to recognise that "the students may understand what he or she intends to teach in different ways, thus achieving different learning outcomes" (Ling & Yan, 2005, p.11). The corollary is that individual differences, and therefore the individual needs of each student, can be met by making use of these differences, i.e., by focusing on students' differing perspectives as a "resource for learning rather than as a constraint to learning" (Ling, Yan & Yuk, 2005, p.29). From this perspective, interaction and communication between students and teacher become vital first, for the recognition of individual differences and, second, for the discussion and exploration of those differences.

Student-centred approaches are commonly very challenging for teachers, not least because such approaches "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 management responsibilities" than the ones held by teachers in more traditional classrooms (Mergendoller & Thomas, 2005, p.8). These approaches also demand a predisposition to understand students' point of view about the matters discussed in classroom. In order to do this, the teacher must adopt, on the one hand, a reflexive attitude to the interpretation of data, and, on the other, an investigative attitude to collect data and develop and implement tools and strategies fitted to improve the process of teaching and learning. In this paper we argue that teachers must foster the participation of all students in their class, collect their ideas and doubts, and finally reflect upon the information collected. Then, s/he must design flexible instruction attending to those individual differences. Our investigation was driven by the adoption of such attitudes by one of us (SL) and, by doing so, we have forged educative interventions informed by the students involved. That is, we tried to identify their individual differences and needs and implement suitable strategies to deal with these.

At a surface level, it would seem rather straightforward to ask students about their uncertainties and difficulties. However, as Maskill & Pedrosa-de-Jesus (1997) pointed out, pupils do not feel at ease when answering teachers' questions because they link questioning to assessment and perhaps fear exposing ideas that might reveal learning problems. Hence, we needed another route to reaching pupils' states of knowledge. Maskill & Pedrosa-de-Jesus (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, keeping their doubts and uncertainties to themselves (Dillon, 1988; Maskill & Pedrosa-de-Jesus, 1997; Watts & Pedrosa-de-Jesus, 2010). Watts et al. (1997) state that one reason for this may be 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 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).

2. The study design

2.1 Context

The present naturalistic research was developed with a total of 54 pupils (year 7, 12-13 year olds) belonging to two different classes. It comprises a total of 14 lessons, in a four-week period of high-school chemistry. The curricular matters addressed were ‘Physical and chemical transformations’, ‘Physical properties of materials’ and ‘Separation of mixtures’.

We identify two distinct phases in this study: (i) an exploratory phase and (ii) an implementation phase. During the first, data were collected on the students’ characteristics and the class dynamics. We also sought issues that were problematic for students’ learning and therefore worthy of study in more detail. The observation of both classes during the exploratory phase revealed some problems with pupils’ participation: (i) pupils’ participation was reduced; (ii) most interventions followed a request from the teacher, i.e., few of them were spontaneous; (iii) spontaneous interventions came almost always from the same pupils. In the second phase we implemented educational strategies planned on the basis of the information collected in phase one. Therefore our research questions were the following:

- How to stimulate 7th grade pupils’ interaction during chemistry lessons, in the context of auto-reflexive teaching practice.
- How to integrate in the lesson planning the differences implicitly or explicitly communicated by pupils through their interactions.

To find answers for these questions, the following objectives were defined:

1. To stimulate pupils’ participation in class, both in oral and written format
2. To promote ‘moments’ of time for pupils to generate and explore questions
3. To integrate pupils’ questions and ideas in the teaching and learning process

4. To develop an investigative self-reflexive teaching practice.

Data were collected through participant and non-participant observation, field notes, pupils' written questions and answers, and also by audio-taping some classroom lessons in order to register oral interactions. During the implementation phase, efforts were made to increase pupils' interaction. The following specific 'moments' and tools were designed and implemented to encourage pupils to be more involved, participate, ask questions and explore their ideas:

2.2 Written questions

To overcome some of the difficulties noted above, Maskill & Pedrosa-de-Jesus (1997), Silva (2002), Pedrosa-de-Jesus, et al. (2001), Teixeira-Dias, et al. (2005) and Neri de Souza (2006) all suggest that teachers might use pupils' 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 (Maskill & Pedrosa-de-Jesus, 1997). Hence, here we made small changes to the usual planning and development of the lessons by adding an extra task: Question Sheets and Question Moments (a pause in proceedings for question writing) for students to write their questions and doubts. Pedrosa-de-Jesus, et al. (2001) and Neri de Souza (2006) developed a similar approach in their studies but included specific sheets to register written questions. We found both these strategies were suitable to promote pupils' intervention. While Question Moments were intended to collect students' individual questions, students were nevertheless encouraged to write and ask questions whenever they wished. 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.

2.3 Discussion of students' written questions, written answers and oral interventions

The Question Sheets were collected at the end of every lesson and all questions were read and analysed. The written answers given by students during the group work were also gathered and organised according to the key ideas they presented. The recorded oral interventions were transcribed and subjected to analysis.

All these 'research productions' were objects of reflection and interpretation in an attempt to gain insight into pupils' states of knowledge, their doubts and possible lack of knowledge and understanding. The problems identified in this way then served as a basis for planning the next lessons. These productions were also presented to the class as matter of discussion, helping to revisit topics previously addressed and 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 set criteria for selecting the ones that would be discussed. Our choice was supported mainly by two reasons: the number of pupils who expressed a similar doubt, concern or curiosity and the relevance of that production to the systematisation of or the approach to the curriculum matters.

2.4 Open-ended questions

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 too much richer and meaningful answers. Also, these questions 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). For this study we created a set of open-ended questions, which were part of the sheets handed out to each group. These were designed in a way intended to foster discussion and hypothesizing. Closed questions were also included in order to identify possible gaps at the conceptual level, which could render difficult the development of deeper reasoning and explanations.

2.5 Moments for discussion of students' proposals

After working in groups, pupils shared their answers to the open-ended questions with the class. Then, students presented 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.

3. Results and Discussion

The overall results suggest that the strategies used, designed and implemented in order to accommodate individual differences, with a strong emphasis on teacher auto reflection, stimulated and increased pupils' participation, increased pupil-teacher classroom cooperation, helping the teacher to individualize teaching, that is, to be aligned with pupils' learning preferences.

3.1 Written questions

The moments for writing questions allowed the collection of a varied set of questions (a total of 105). Analysis of those showed that they fit the picture described by other authors (White & Gunstone, 1992; Pedrosa-de-Jesus & Maskill, 1990; Graesser & Person, 1994; Chin et. al., 2002,), that is, most of the questions were factual 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 elaborated, trying to establish connection between things 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, we can 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?».*

Further analysis of the data provided important information concerning the time factor in the writing of questions. Table 1 shows the number of questions written in lessons where there was a pause for that activity (in grey) and lessons where that pause was not made (in white).

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

Looking at Table 1 we can see that the number of written questions is substantially higher in the lessons where specific Question Moments were provided. These results agree with those found by other authors, such as Watts & Pedrosa-de-Jesus (2005), who support the view that the inclusion of a specific moment for writing questions in the class planning, together with encouragement of students to do so, clearly favours the writing of questions. 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.

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 shows the results[2] :

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

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, what suggests that those pupils are more disposed to write rather than to tell their doubts out aloud. This may be due to factors explained before - 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. So, this strategy allowed us to identify two groups of pupils whose preferences were distinct: those who would rather speak out their doubts and reasoning – the 'oral askers' - and those who preferred writing their ideas in a more private manner - the 'question writers'. 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 for themselves for all that time and only exposed them when they had the opportunity to write them down.

[2]*Each class was divided in two (shift 1 and shift 2), each having lessons at different moments.*

All this data supports the idea put forward by several authors (Dillon, 1988; Maskill & Pedrosa-de-Jesus, 1997; Watts & Pedrosa-de-Jesus, 2010) that pupils do have questions to ask and are able to ask them if the right conditions are provided. It is therefore important to find out what those conditions are and promote a varied set of activities) in order to meet students' preferred ways of expression.

3.2 Discussion of students' productions

Reflection upon students' productions provided the teacher-researcher with relevant information about individual knowledge gaps, doubts and perplexities, either implicit or explicit in pupils' writing and discourse.

To address the identified problems, the teacher-researcher promoted class discussions initiated by presenting the referred pupils' productions. In order to illustrate how teacher used the collected information and managed discussions, we are going to present an example of pupils' written question and pupils' written answer and extracts of the discussions they triggered.

3.3 Written question

In one of the lessons (30th of March), four of the seven written questions were related with sublimation, the topic taught for the first time in that lesson. Example:

> *«How can it 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?».*

In order to help pupils to understand of the phenomena, for the next lesson was decided to take, a sphere of naphthalene, since it sublimates at room temperatures and was a familiar example for pupils. Table 3 shows a small extract of the subsequent discussion.

This discussion, built upon the pupils' written questions, addressing their doubts, also allowed other pupils to express their ideas and revealed 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 comprehension of the phenomenon.

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 the wardrobes?

S4: Aaaah, I have!

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

S6: It is slowly disappearing.

S2: What?

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

S: (…)

T: The smell! If I leave this ball here for a while, if I leave it here in this corner, in a while the student S9 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.

S: (…)

T: Because a sublimation occurred!, part of the naphthalene molecules passed from the solid state into the gaseous state, isn't it? Be carefully, it didn't occur, how did you say S1?, 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.

S8: Solid.

S6: Gaseous.

T: Exactly! They will have a greater mobility in the gaseous state and can go from here to the S9's nose!

All: [Laughs].

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

A7: No, we don't.

P: 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.

3.4 Written answers

As referred, one of the pupils' tasks was to answering a set of open-ended questions, using appropriate working sheets. The analysis of the answers allowed the teacher to characterise their main difficulties for understanding the concepts involved, choosing some she considered relevant to stimulate the discussion on the following lesson. For example, on March the 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 the water in the solid state [at normal pressure and ambient temperature of -5ºC» . These answers required pupils understanding the concept of boiling point. So, the teacher decided to start the discussion using one of the answers to that question: «*Water is in the solid state because 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

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, the water is no longer in the solid state?

S4: No, it is. That happens only if the temperatures are negative.

T: That is, at any temperature below 0ºC?

S3: Yes, they have to be lower than the fusion point of the water.

T: Ah, it was that what most of the answers lacked! Let's see, imagine that here in the classroom we have 15ºC. Why do sodium chloride here is in the solid state and the water is in the liquid state? Look carefully to the list.

S2: Because the temperature needed to… mel… to fuse sodium chloride is only at 801ºC.

T: Very well! Now identify a substance that would be here in the gaseous state.

S9: Oxygen.

T: And the justification…

S9: Because the boiling point of oxygen is lower than the temperature that… that we have here in the classroom.

Similar analysis, for further classroom use, was done with the recorded pupils' oral interactions, when they were solving practical activities. Several examples could illustrate very rich discussions.

3.5 Open-ended questions & Moments for discussion of students' proposals

The two activity sheets comprised a total of six (out of nine) open-ended questions. For each of four of these open-ended questions were proposed at least two valid solutions. That is, those questions were answered in (at least) two different, yet valid ways. We believe this diversity of proposals may have been favoured by group work, that is, by having many heads thinking of an answer to the same question and also by the questions themselves, which allowed a great margin of exploration.

Some of the proposals that students made, and that could be considered viable, had not been foreseen by the teacher-researcher. For instance, two groups suggested separating the 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 fillings. 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 could have been a useful starting point for the introduction of the density concept, incorporating students' own ideas as matters of the instruction plan.

The 'expected' answer 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*». In order to choose the more efficient proposal to separate, in practice, the components of the flour and iron fillings mixture, it was promoted a class discussion. We believe this procedure helped getting involved a greater number of students, because it incorporated their different ideas and presented reasons for choosing one proposal over the other, instead of simply neglecting the 'not-expected' one.

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