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An Investigation of the Educational Potential of Pupils' Written Questions in Science Teaching

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ABSTRACT

A technique was developed that invited and encouraged pupils to write down their questions during science lessons. The results showed that pupils did have questions to ask and were able to write them down during class. Most of the questions were meaningful and at a higher cognitive level than typical oral ones.

The educational potential of pupils' written questions was explored. It was found that pupils' questions could be used positively as teaching/learning tools. Teachers were able to adjust their approach to improve individual pupils' learning. It also helped teachers to be more reflective about their own practice and self-diagnose the daily teaching and learning in their classes.

INTRODUCTION

Recent teaching/learning theories have been focusing attention on the pupils as the main subject of study (e.g. Karplus, 1977; Erikson, 1979; Nussbaum and Novick, 1981,1982; Renner, 1982; Rowell and Dawson, 1983; Cosgrove and Osborn, 1985). This has shown a need for the development of methods for following and understanding better the pupils' behaviour in the classroom. Written and oral questions asked by pupils during their lessons have been seen as providing important information, not only about learning difficulties but also about other relevant aspects of the teaching and learning processes (Susskind, 1969,1979; Dillon, 1982,1988; Pedrosa de Jesus, 1991). If those queries could be registered in a naturalistic situation, they might also reveal some of the pupils' reasoning processes. Knowledge of pupils' existing ideas and uncertainties is essential to develop better teaching strategies. Since teachers cannot control what pupils are thinking, they have to relate their teaching to a best judgement of pupils' ideas and difficulties. The process of formulating and asking a question implies the gathering and organisation of available information. Encouraging pupils to write questions during their

classes, could be a technique with great potential to improve teaching and learning in schools and so a
 technique was developed that invited and encouraged pupils to write down their questions during science lessons. The effects of the technique on the teaching and learning processes and the possibility of using it as teaching/learning tool was investigated.

EXPERIMENTAL DESIGN

Teachers were requested to stop one, two or three times during each lesson for approximately one minute each time, and invite pupils to write down questions about the subject being learned. The pause should be in silence and should emerge naturally.

Many questions might be stimulated when the teacher is talking and these could be forgotten. So, pupils can continue to ask all the oral questions they want. Also they should be encouraged to write down questions outside the pause, at any time. The "question-sheets" were to be collected by the teacher at the end of each lesson. All of the questions would be read carefully and the answers prepared for the next lesson.

The method was explained to the teachers in detail. In particular, the need to motivate the pupils on the importance of their questions and for the teachers to show genuine interest in pupils' doubts and/or difficulties about the subject being taught, or about anything related with it, were stressed.

It was also stressed that the teacher should stop the lesson and ask the pupils to write their questions in silence. All the teachers agreed to use the method with one of their class groups for a minimum of five lessons.

The sample of teachers was eleven female secondary school teachers in training who were students of the University of Aveiro, Portugal, in their last year of the "Licenciatura" in teaching of Physics and Chemistry, in the

academic year 1989-1990. They had a mean age of 23 years and were teaching in four different schools, three of them in the same town (Aveiro).

Each teacher had two classes at different school levels - 8th and 9th year (pupils aged from 13 to 18 year old). Each of them was observed teaching several lessons in just one of the classes. The study was performed with seven classes from the 9th year, who were learning Physics at that time, and with four classes from the 8th year who were learning Chemistry. Each teacher used the technique in between five and eight lessons. The total sample of lessons recorded was 74. The total number of pupils involved was 302, 191 from the 9th year and 111 from the 8th year. Each class had about 27 pupils and all of them were mixed in ability, age range and sex.
All the student teachers in the final year of the "Licenciatura" in teaching of Physics and Chemistry from the University of Aveiro and their respective secondary school supervisors were contacted to take part in the study.

RESULTS AND DISCUSSION
The data analysed were collected from the researcher's daily classroom observation, the on-going interviews with teachers and from two final questionnaires (one answered by the teachers and another one by the pupils).

The number of questions asked, per pupil per lesson, was not recorded by the teacher or the researcher. However, each pupil asked about one question per lesson , on average.

Some pupils showed a great difficulty in writing anything. This situation was particularly evident among the youngsters (8th year) at the beginning of the experiment. All of the pupils would quite often write statements instead of questions:

- "I did not understand anything that is related with the electrolysis of water."
- "I do not know how to expose doubts by writing. I do not find the proper words."

-"I asked very few questions because I think that I can explain myself better orally".
-"I have very confusing doubts and do not know how to express them".
-"I do not know what to write".

These results seem to show the pupils´difficulty in changing from their usual role of answering questions to the new situation in which they have to formulate questions. Though the pupils were asked for questions, everything that they wrote, whether a question or a statement, was analysed in the same way. The general expression of difficulties associated with the writing of questions could also be seen through some pupils' declared preference for oral questions.

The knowledge problem was also identified as one of the reasons for the small number of questions written by some pupils. For a question to be raised, it is necessary to have considerable knowledge. To pose a question it is essential to organise ideas and identify what we don't know. The relationship between knowledge and the ability to raise a question is a very complex one. Pupils need time to think and to study. Sometimes teachers try to teach too much in too little time and pupils need more time to "absorb" knowledge.

All the teachers, without exception, found the technique to be very useful, giving them a better view of their own teaching and of their pupils' learning. The way found by each teacher to reflect on and explain their feelings varied from one to another.

Six teachers considered that the collection of pupils questions will **always** contribute to the teacher's activity, while the remaining five teachers considered that it will **frequently** contribute to better activities in the classroom. Three of the teachers gave the following explanations for their points of view:

- " Because the pupils' questions are their reaction to the way a topic was presented";
- " For a teacher at the beginning of her career, it is difficult to perceive all the doubts since the classes are very big. This method is very useful, because

it is easier for the teacher to become aware of certain kinds of difficulties which could only be identified otherwise in an assessment test".

Their opinions show that being more aware of the pupils' difficulties, questions, uncertainties, etc, during their lessons, improved their teaching. The pupils' questions not only reveal the pupils' difficulties but they may also be a reflection of a teacher's strategy or general activity. All the teachers stated that the technique allowed them to identify pupils' difficulties that they could not have detected otherwise. Some of the teachers exemplified what happened in some specific lessons. Others wrote statements such as:

- "Yes, and you can't imagine how it helps!" (she provided some examples).
- "One of the consequences was to be able to identify some alternative concepts held by pupils that sometimes prevent them learning" (she was teaching Chemistry to the 8th year).

Teachers emphasised many points about insight into their teaching and learning. The main points were that the technique:
. showed that pupils have questions, even when they don't speak; pupils doubts exist
even when no oral questions have been asked;
. revealed non-identified pupil difficulties and learning problems;
. provided feedback from pupils;
. enabled the teachers to judge if their teaching methodologies and strategies were   adequate for the class;
. helped teachers to reorganise teaching sequences according to pupils' reactions;   . helped to identify occasional serious conceptual confusions;
. allowed the teacher to have a better knowledge of each individual pupil;
. served as a basis for a teaching approach based upon pupils' ideas.

These were just some of the points considered by teachers, as positive consequences of the use of the technique.

Much was written spontaneously by pupils on the "question-sheet", giving a variety of different kinds of feedback about the teaching/learning

process, not necessarily concerned with the scientific topic but related to other kinds of things. For example:

- "Now then, what conclusion can we take after 50 minutes of lesson?"
- "I did not understand more than half of the lesson."
- "I have doubts about the purposes of the diagnostic test that we have done today."

Or suggesting different teaching tactics as follows:

- "I think that you should teach more slowly and explain better".
- "I think that you should solve more problems, so that we will understand better".

These pupils were certainly interested in learning. By suggesting different teaching strategies they were trying to communicate, with the teacher, in a non-conventional way. By using the technique teachers have the opportunity to receive some meaningful suggestions from their pupils.

The kind of suggestions or comments made by pupils varied. The statements were dependent on the teacher performance and on the subject taught. For instance, one of the pupils said : "You should give more exercises" in two (not sequential) lessons.

Other pupils from the same class made the same kind of suggestion, either directly or indirectly. The teacher of this class did not have great difficulty in organising lesson plans, however she had difficulty putting it into practice. The pupils' remarks called attention to these difficulties. Another pupil, from the same class, provided the following information:

- "Teacher, I'm not understanding anything, but it is my fault. However, it is not all mine, since I think that the lessons have been too noisy. Nevertheless, I decided to study all the material until next Friday and I intend to make an appointment with you to clarify all my doubts".

This pupil´s class was very noisy and it seems the pupil was attempting to establish a dialogue with the teacher. The "question-sheet" was considered to be personal and this pupil probably preferred to start interacting with her teacher through it. In some ways, this could be related with a "shyness problem", but referring also to classroom organisation problems.

Teachers must have the courage and the willingness to understand, accept and use the information, making the best of it. Pupils must also have enough courage to inform the teacher about their real difficulties.

It is clear from this experiment that if the pupils are given the **conditions** and **sensible** opportunities to express their feelings and opinions, they can do it. The literature view is that pupils do not do this (Susskind, 1969, 1979; Dillon, 1988). In this study, teachers only told the pupils to express their own difficulties/doubts. The pupils decided spontaneously to call the teacher's attention to teaching tactics, etc. It might be speculated that if all pupils were informed from the very beginning that the "question-sheet" might also be used to give suggestions about teaching, probably more insights would appear.

Some pupils' comments about the teaching were:

- "Sometimes I did not have doubts, however most of the time I did not manage to follow your explanations";
- "I'm not used to the way you teach" (pupils from different teachers);
- "You have progressed too quickly with the subject".

Many pupils, from all the classes, declared that one of the main advantages of the technique was the opportunity to expose their doubts in private, to inform the teacher about their own difficulties and therefore to have more chance of getting help. Pupils feel that this method is very useful both for them and their teachers:

- "I think that the method was good because we have the opportunity to expose our doubts";
- "It must be continued in order that you know our difficulties";

- "I think that it is a good method to clarify doubts".

Other pupils also gave suggestions which referred to other teaching aspects:

- "... I would like to ask the teacher to give more work-sheets and correct them. Or else to explain the matter more slowly, because I think that you are teaching too quickly";

or, from another class:

- "We should do more practical exercises to vary problems and situations. This way, we will have the possibility to "extend the memory" and so to be better prepared for tests";

It can be concluded that pupils were enthusiastic and collaborative. It shows that if teachers offer an opportunity for pupils to have a say in their own teaching, they will take it. The results also suggest that pupils have their own ideas about what is good teaching and what is a good teacher. A good teacher is one who gives pupils the opportunity to expose their difficulties and then helps them to learn. These attitudes show a request to individualise the relationship and the learning.

Quite often it is not easy for teachers to accept this kind of feedback, which may easily be interpreted as "criticism". The sample of teachers from which those results were collected was probably favourable since teachers in training are particularly open-minded to all kinds of innovations. As one of them pointed out, for a teacher at the beginning of her career, all help will be welcomed. Everything was new and frequently these teachers also liked to please the supervisor and the researcher. The pupils suggestions or criticism to the teacher were always supported by the researcher.

With experienced teachers, it would be necessary to create conditions to provide some encouragement from colleagues, from their own pupils, from a working team, or from an external co-ordinator. Above all, teachers mustn't feel lonely and isolated. The dialogue and the feedback is indispensable.

CONCLUSIONS AND IMPLICATIONS OF THE STUDY

Most pupils are not used to stopping and thinking about what they are learning, or to reflecting about what they don't know and would like to know. They are used to silence during assessment tests when they have to answer what teachers want them to answer. In the experiment the pupils were expected to use their imagination to clarify ideas, or to examine the information provided.

Motivating pupils to write questions is therefore a new and unusual activity for these teachers and has particular problems. These varied from class to class and were related to the teaching process and the teachers' attitudes. Difficulties with expression of some pupils was also a reason for the small number of questions in some cases. This problem was particularly acute for pupils who were also not able to identify what they didn't know during the lesson. Most pupils, however, became strongly involved and attempted to write their worries, even if they often used statements instead of questions. The results suggested that the stimulus (provided in different ways) probably played the most significant part in the collection of pupils' written questions. Pupils lost inhibition and become more self-confident. The fact that their queries were treated with respect, made pupils feel less threatened and therefore more confident (Rowell and Dawson, 1983). The process of writing questions may also help to keep the pupils' attention on what they are learning.

The results suggest that the technique could be easily incorporated into the everyday classroom activity of both trainee and experienced teachers. There were significant effects on both teaching and learning. The insight provided was related both with the teaching process and the learning problems.

One general opinion was that the pupils' questions did strongly enhance the teacher's activity. Through the pupils' queries teachers became aware of the way they were presenting the lesson as well as the way pupils were following it. "Better" explanations for a concept or more convenient organisation of a topic become possible. Since specific learning problems were

also identified, teachers were able to adjust their approach to improve individual pupils' learning.

Teachers also emphasised the possibility of self-evaluation (self-criticism) of their teaching. With time to examine pupils comments and to reflect on the meaning of their queries, teachers will try to seek the reasons that might have caused the pupils to have difficulties. They can try different strategies and see the results.

Overall, the results strongly suggest that the technique can be successfully used as a teaching/learning tool and that this technique may be an important instrument for the study of teachers´and pupils´thinking in a naturalist setting. Experienced and novice teachers can become more "thoughtful professionals", an emerging image of the teacher which is becoming a more serious subject of study (Peterson, 1988).

According to Tobin (1988), teaching behaviours can always be changed when teachers are effectively involved in the identification of what needs to be changed and have the opportunity to review their practice and to receive support and encouragement. Tobin (1988) also emphasised that to succeed in the implementation of changes in on-going school programmes, teachers need to be effective self-diagnosticians and need continuous feedback, with advice and encouragement. The method used here seems to provide some of these conditions.

Trainee teachers should be sensitive to effective teaching, reflecting pupils' needs. Some of their expectations could be different from those of experienced teachers. The lack of real teaching experience, together with their recent pedagogical and methodological studies might have created different points of view and innovative ideas in the students. Learning to act as self-diagnosicians allowed them to prepare lessons with more confidence.

Educational researchers might also use the technique as a method for getting classroom insight. The interpretation of pupils written classroom questions is worthy of a more thorough study.

The implications for pupil learning can only be speculated on since they were not tested in this study. Most of the pupils' comments either revealed specific interests or requested information about situations in which they were personally interested. In order to ask meaningful questions the pupils had to reflect on their own understanding during classroom learning. By asking for questions from pupils, the teacher may also be creating a less threatening environment which must help the pupils.

In conclusion, pupils should be motivated to improve their questioning behaviour, since this may be a good way to improve their learning. They might become more engaged, the teacher-pupil relationship would improve and their "metacognitional knowledge" might also improve.

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