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Science Teachers' Understanding of Practical Work

Fen Öğretmenlerinin Laboratuar Çalışmaları ile İlgili Görüşleri

Esin ŞAHİN-PEKMEZ*

ÖZET

Bu çalışma fen öğretmenlerinin laboratuvar çalışmaları ile ilgili düşüncelerini belirlemiştir. Veriler öğretmenlerle yapılan görüşmeler ve öğretmenlerin derslerinde nasıl deneysel çalışmalar yaptığını anlamak amacıyla yapılan sınıf içi gözlemler ile toplanmıştır. Veri analizleri sonucunda elde edilen bulguların yeni fen öğretim programının uygulanmaya başlama sürecinde ve öğretmen yetiştirmede faydalı olacağı düşünülmektedir. Sonuçlar, fen öğretmenlerinin, deneysel çalışmaların fen eğitiminde rolü konusunda, özellikle de bilimsel süreç becerileri açısından yetersiz olduklarını göstermiştir.

Anahtar Kelimeler: fen eğitimi, fen eğitiminde laboratuar.

ABSTRACT

This study identifies science teachers' ideas of practical work. The data were collected by interviewing teachers and also conducting some classroom observation involving practical work to see teachers' actual practices. With the analysis of the data, it is hoped that findings would be utilised in informing a new science curriculum and teacher education programme in Turkey. The findings show that they have not got adequate knowledge of the role of practical work, especially in terms of procedural understanding.

Keywords: science education, practical work.

* Esin Şahin-Pekmez, Yrd. Doç. Dr., DEÜ Buca Eğitim Fakültesi, İzmir. esin.pekmez@deu.edu.tr

1. INTRODUCTION

The focus of this study will be on the teachers' perspectives on practical work in terms of what it teaches and in terms of how teachers use practical activities. The research explores their ideas on a conceptual basis. The use of practical work in school science in Turkey is still quite rare, but there is a willingness to develop such strategies. A clear understanding of teachers' approaches to practical work seemed a valuable opportunity to consider and incorporate their ideas.

Basically the aim of science education can be classified as helping students understand the concepts of science as learning theories (substantive understanding) and the process of science (procedural understanding) (Şahin-Pekmez, 2000). Second one is related to practical work, which is the issue that has been considered as an important factor in school science curriculum in every country. However, the emphasis and the understanding of it would be different in different countries based on the countries requirements. The meeting of these requirements stated in the curricula mostly depends on teachers. What is stated is actually being taught by teachers? What are their classroom practices? What they teach children during practical activities? What meanings do they attach to practical work? To answer these questions the understanding of teachers should be known. That is why this study attempts to reflect on the perceptions of teachers, since their ability to do practical work relies on their own understanding of practical work. This would be essentially the grounding for improving a science curriculum. It is believed that taking into account teachers' ideas, as much as students', will be necessary for curriculum development. That kind of information will also be helpful for improving teacher-training programme. Both teachers and those who are responsible for training teachers need to know clearly what to teach and why to teach it. Knowing their ideas about this will also give ideas about what practice might look like.

Although there has been many studies about the role of practical work in science teaching (e.g. Woolnough and Allsop, 1985; Lazarowitz and Tamir, 1994; Gott and Duggan, 1995; Hodson, 1990, 1996; Wellington, 1998; Hofstein and Lunetta, 2004) there have been relatively few systematic studies of teachers' understandings of its nature and purpose. In the early 1960's, Kerr (1964) conducted a major study of teachers' views on the nature and purpose of practical work in English schools and found that teachers did not use laboratory work for the aim of using scientific process skills. Similar results have also been found by other research (Şahin-Pekmez et. al., 2005).

In the literature when asking science teachers' ideas some problems identified, this can be divided into two. Problems about what teachers actually say which is mostly about the conditions in the schools, and the problems about teachers' understanding and application of practical work. For example, Wilkinson and Ward (1997a) reported that the most common problems in the conduct of laboratory work were related to poor conditions, insufficient equipment and the long preparation time. They concluded that such problems tend to reduce a teacher's desire to conduct more lab work. Regarding time, there is a criticism that practical work is too time consuming and teachers have difficulty in fulfilling the requirements of the science curriculum within the time limits (Barton, 1998).

Apart from the practical difficulties, it seems that the most important problem is the teachers' understanding of science. Gott and Duggan (1995) found out that there has been a tendency for teachers to accept that doing practical work regularly is a good thing without thinking about its purpose or learning outcomes. Lederman (1992) and Munby (1982) reviewed a number of surveys on teachers' conceptions of the nature of science (which ultimately rests on procedural understanding). According to the conclusions, science teachers do not possess adequate conceptions of the nature of science. Ryder et. al. (1999) did a longitudinal interview study with 11 science students in their final year at university to find out the images of science which undergraduate science students hold. Again it is found that these future teachers were confused about the understanding of science. Nott and Wellington (1999) investigated the views of pupils, students, teachers, advisers, and inspectors on school science at key stage 3 and 4 by conducting a survey. Data were collected from teachers by means of questionnaire (308) and interviews (22). Two of the main issues were investigations and practical work, and the teaching of the nature of scientific ideas. For instance, teachers used practical work not because they found it effective (in terms of

helping understanding) but because pupils expected it. As a result it seems that teachers' views should be developed before or this could lead to the consequence of misleading pupils in science teaching by conducting practical work. That is why it is important to know teachers' ideas.

2. METHODOLOGY

The research participants were 30 science teachers, chosen randomly, from 10 participating schools, five of which are mixed 11-17 comprehensives, two of which are mixed 11-17 privates, two of which are high-ability (the students are chosen by an examination) 11-17, and one of which is a high-ability 14-17 science-based secondary school. These types cover the range of different schools in the area. The schools have no technicians and the average number of lab is two. Teachers had more than ten years experience ranging 10-30.

It was difficult to convince teachers to be interview participants. The excuse of most was discomfort with the use of a tape recorder during the interviews. Some also said that they were not experienced enough to make conversation at that level. Because of the factors stated above, the researcher interviewed whoever volunteered. Data collection was done in a developed city, and the schools reflect the typical specifications of secondary schools in the country.

2.1 Data collection methods

Semi-structured interviews and some non-participant classroom observations were made. During the research only three practical activities could be observed. One of the practical activities was to find the melting point of naphthalene. It was totally a recipe-type experiment. The second one was to demonstrate that different gases produce different colours when conducting electricity under low pressure, using Geiessler tube. It was a teacher demonstration. Finally, the third experiment was again a teacher demonstration showing pupils how a weight stretches a spring. Although it was done as a demonstration, the teacher gave importance to procedural ideas such as deciding variables and making a fair test.

The use of interviews has been seen as the best choice of data collection, as it was anticipated that using a face-to-face interviewing method would result in gaining a more in-depth understanding of the ideas of teachers (Cohen and Manion, 1994, Drever, 1995, and Mertens, 1998). Also, in an interview the researcher can correct any misunderstandings of the questions and can probe for clarification, which is why interviews give high-quality data (Drever, 1995). A questionnaire, for instance, would not give the chance to ask follow-up questions in order to obtain rich data. As a result, the semi-structured interview method –since it is an open situation, having greater flexibility and freedom – was chosen to elicit opinions from teachers about practical work.

A date and time for the conversation was agreed upon with each teacher, and having gained the interviewee's consent, each interview was recorded and then transcribed for more detailed examination. The interviews began with some close-ended questions, with the aim of gathering some general knowledge such as their experiences, if they use practical work or not, and the amount of the time they spend by carrying out practical work.

After general informative questions then the teachers were asked to explain the purpose, and the types of practical work. The prompting questions were 'what is the value of doing practical work?' 'what do/should students learn from it?' 'do you find it useful?' 'what kind of activities do you use/prefer?' 'do different kinds of practical work have different purposes? 'can you give some examples?' It has been tried to find out if teachers aware of the specific aims of practical work and if they emphasise the procedural outcomes of practical. Finally, the researcher even more probing in order to make teachers talk about procedural knowledge with some shown experiments which are examples of four main types of practical work (based on Gott and Duggan, 1995):

Skill: The aim is 'to acquire a particular skill' like connecting up a simple circuit (physics), using separation techniques (chemistry), and measuring objects under a microscope (biology).

Demonstration: It can be used when an experiment is dangerous like radiation from a hot plate (physics), the reaction between sodium and water (chemistry), and respiration (biology).

Illustration: The aim is 'to prove or verify a particular concept, law or principle' like refraction in a glass block (physics), preparation of copper sulphate from copper oxide

(chemistry), and to test for sugar as a glucose (biology).

Investigation: The aim is 'to provide opportunities for pupils to use concepts, cognitive processes and skills to solve a problem' like slope investigations (how speed depends on slope, by rolling a ball down a ramp) and how strong is a magnet (physics), the reaction between marble chips and acid (How does the strength of the acid affect the rate of reaction between limestone and an acid?) (chemistry), and the effect of pH on the reaction between pepsin and egg white suspension and to find out how the amount of light affects how fast your seeds grow (biology).

The experiments are stated above are from Sahin-Pekmez (2000). The teachers were asked to explain the purposes of them and to tell how they would carry out the shown experiments to reach stated purposes.

Because of the lack of emphasis on practical work in schools, for example, just telling the name of the experiments was not a useful tool in encouraging discussion, as they did not necessarily realise different types or different outcomes of practical activities or even the existence of procedural understanding. After discussing the purposes of practical work and learning what kinds of activities they use in their lessons, there was an explanatory introductory session. The types of practicals with their different methodologies were explained by giving some examples, as in the experiments list. Then the teachers were asked the purposes of each type, and the reasons why and when they might use a particular one. For example, they would be asked why they might use an investigative activity rather than a demonstrative type. They were encouraged to talk about their way of doing the experiment, and why they would do it in this way. They were also encouraged to state the learning outcomes and the things that should be understood about the methodology of the experiment. The aim was to get the information that if they realise the difference between the types and to get them to talk about procedural ideas. If they said, for example, that, 'the aim is to develop skills', they would be asked follow-up questions such as "W*hat are these skills? Which strategies would you use to teach these skills? What do you expect from kids during the experiment?*" They were also probed with specific questions like "*...pupils will have some data at the end, how can they trust this data...?*" In this way their ideas were tried to be explored in detail. Apart from these, the conversations during the interviews mostly involved the problems they were having.

After discussing all the experiments, it was asked if any of them were better than the other one and why. They were thus given many chances to talk about procedural ideas. The researcher was very careful not to make teachers feel 'inspected' when asking about their ideas in order to get their understanding. They were always given the last chance to talk by concluding the interview with open-ended questions such as *"Is there anything else that you wanted to add?"* and *"Is there anything that I did not cover?"* The teachers spoke freely and often at length.

2.2 Analysing Data

To have relied on a method which yields quantitative data would not give in-depth and necessary information on teachers' ideas. For is reason, the data were analysed qualitatively. The qualitative data obtained in response to the open-ended questions were manually analysed by the researcher by categorising the answers. It is realised that there should be an acceptable level of agreement between people as to how to describe data (Cohen and Manion, 1994). That is why 50% of the sample were categorised by another researcher who was in the same area. A high degree of agreement was achieved. First, long statements were compressed into briefer statements in which the main sense of what was said was rephrased in a few words. These were then grouped into simple categories, which made it possible to present the large amount of data in a few tables. The main data were treated in three sections corresponding the areas of the questioning:

- Purpose of practical work
- Types of practical work and teachers' practices
- Ideas about the shown experiment

3. RESULTS

All of the teachers agreed that they should use practical work but because of some reasons, they stated that they could not find a suitable environment. Accordingly, the teachers tended to talk mostly about problems which they were having, as well as giving some suggestions at the end. Now the essence of the data will be

presented, beginning with the time they spent on doing practical work.

Table 1: Amount of time teachers spend on doing practical work.

Percentage of the total time	No. of teachers
<20%	20
20-40%	8
45%	2

In the table it can be seen approximately what percentage of the total time the teachers used for practical work. Most of the time was used in teaching theory.

3.1. The purpose of practical work

The teachers' responses regarding the reasons for 'why practical work?' are familiar and the answers can be categorised into three main groups: learning better, motivation, and developing practical skills. They are stated below as the most stated one to the less stated.

3.1.1. Learning better

This is the most mentioned category. All of the teachers agreed that some practical work helps students understand the concepts better so that the lesson will be fruitful, since they are learning the theory by experiencing and by doing themselves, using their senses like touching, watching, or smelling. They also added that students need to use all their senses when learning science, so that they can remember more easily.

3.1.2. Motivation

According to the teachers, practical work also makes students more interested in and curious about science, leading to positive attitudes toward science. It gives students an opportunity to think and create, and shows them they can actually do something by themselves. It encourages them to do something. Although, according to the table they hardly use practical work, it seems a contradiction what the teachers think.

3.1.3. Developing practical skills

Teachers' views show that with practical work, pupils gain some basic skills like using equipment, and knowing about materials and equipment.

Apart from these three reasons, the other purposes are as follows:

1. Practical work teaches students how a scientist works and thinks.
2. It improves their friendships: They learn how to discuss, how to share and how a team works.
3. With practical work, pupils can see what is going on in daily life and relate the science knowledge to this.
4. It helps to discover students' interests in science.

There are also tautological explanations like, "because science lessons should be visual" or "because the research says that it has a positive effect on learning". They do not really question the research; does it really motivate learning?

3.2. Types of practical work

3.2.1. Practices of the teachers

It is important to know what kind of activities the teachers use in order to find out what knowledge they have about practical work. Mostly, if they used practical work, they would prefer teachers' demonstrations and recipe-type ones. They also believed that giving examples from daily life was a way for teachers to be helpful instead of doing practical activities. The teachers, who did not use practical work at all, unfortunately had no idea what kinds they could use. It was understood that they did not have knowledge about different types of practical work. That was why it was necessary to explain the different ways of doing practical work, in order to get more information about their potential. Some explanation about meanings was especially needed for investigative and illustrative practicals. The ideas about each type will be presented in the next section.

3.2.2. Ideas about the shown experiments

3.2.2.1. Skill

16 out of 30 teachers said that this kind of practical work "makes pupils gain abilities and skills like how to use equipment" so that they can be prepared for future experiences. The other ideas are substantive or just general thinking such as "it consolidates knowledge" or "it makes pupils interested." Teachers suggested that this kind of experiments can be done at home or students can bring their own equipment and then do it individually, and also it can be

used at the beginning of each subject to teach about some particular equipment and at the same time to get students ready for the other experiments.

3.2.2.2. Illustration

The ideas about illustrative practicals are classified below:

1. "It supports the theory and consolidates knowledge because pupils see the theory in action."
2. "If the instructions are given then it is easy to do, so it is preferable."
3. "It is easy to manage the class because everyone does the same thing."
4. "Pupils gain manipulative practical skills."
5. There is one negative idea that "It is a waste of time, there is no value spending time with this because pupils already know what they are going to find."

3.2.2.3. Demonstration

It is clear that this type is used mostly by the teachers when they do practical work. They use demonstrations because classes are crowded, so in terms of management it is easy. They said there is not enough equipment and time, some experiments are dangerous and some pupils are of low ability. The teachers stated that there really was no alternative because of the reasons above, even though they realised that just watching was not enough for pupils.

3.2.2.4. Investigation

Teachers gave no different explanations at first. Why investigative activity was important, what kind of understanding was behind it were not stated. That is why some information about the structure of investigative work was given using one of the experiments. Teachers provided some ideas in relation to their situations and conditions. The first question in their mind was 'if they can do it or not,' instead of 'what is the outcome of this in terms of pupils' learning?' Actually, it was not fair to expect to hear about procedural ideas from them, as they do not have the background. The consensus was that *"it is more scientific and creative as pupils discover and find out something by themselves,"* and *"pupils use and develop their thinking as they have to make a plan and then carry out an experiment."*

The teachers also think that if the students are clever and high ability students, if they give the theory beforehand, they have enough equipment, if there is a good lab environment and enough time, then they could use this type. However, there was always a negative side. Except for two teachers, they all agreed that having investigative-type activities was an impossible mission. Additionally, the other reasons for that are given below:

1. It is time consuming, and the teachers already have difficulties finishing the syllabus.
2. Since pupils are doing different things at the same time, it is difficult in terms of classroom management.
3. Teachers believe that pupils cannot do everything by themselves; for instance, they cannot make plans by themselves. Pupils' abilities have to be high.

As can be seen, there were no procedural ideas coming from the teachers.

3.2.2.5. Summary of problems and reasons for not doing practical work

The biggest problem is the university entrance examination at the end of year eleven. It is evident that this is a major competition for pupils. The teachers feel obliged to complete all substantive concepts before the exam. Other problems include lack of equipment, absence of technicians, very crowded classrooms (at least 40 pupils), and lack of laboratory training for teachers. The teachers want some guidance and training materials. More emphasis on practical work must be given in pre- or in-service teacher training because teachers' responses did tell us that they have no understanding of the importance of practical work and therefore there is a great need in teacher training programmes. The teachers also admit that they themselves have to be more creative in terms of time and variety of experiments. Similar results we are also found by Asici (1992), and exactly the same findings by Cepni et al. (1995).

4. Conclusion

Like other studies, this research showed that the first stated reasons why teachers do practical work were always to support theories and to motivate students. The main problem, as identified by the research is the understanding of science. That the teachers generally acknowledge the benefits of practical work without thinking its purpose or learning outcomes is seen in this research, as has been noted by others (Gott and Duggan, 1995). The generally emphasised answer is that 'it helps

understanding'. When they say understanding they seem to mean mainly in a substantive sense as in learning theory better. They do not realise different outcomes of different kinds of practical work. For example, according to their understanding investigations are for pupils to do or find stg on their own, rather than developing the understanding of concepts of evidence.

It has been found that there are no practical activities going on. The lessons are based on theoretical knowledge. When teachers start to talk about practical work, all they can discuss are the problems they are having. First of all, they should be encouraged to carry out practical work in proper ways and teaching the right knowledge. It is believed that the biggest problem is the aspects of the system like the university entrance examination, which leads both students and teachers to do more theoretical work in order to prepare themselves for this examination. It is difficult to make changes in this selection system, at least now; but in terms of giving importance to teaching the nature of science, pupils could be asked questions about procedural knowledge in this examination. That is, they could be evaluated on their procedural knowledge so that, of course, the teachers have to learn and emphasise it as well. Of course, this is not the first thing that should be done. The first priority should be given to the curriculum and the teacher training programmes. This is good to have some development of science curriculum recently. The aim of science education has been clarified well and the emphasis is on scientific processes. The teachers also have been informed that the aim is not only to give substantive knowledge. The new developments are very inspiring.

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