



Can Science Pedagogy in English Schools Inform Educational Reform in Turkey?

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ABSTRACT

This paper discusses the nature of science education in England, where constructivist principles have informed science education for several decades. A series of lesson observations were carried out to explore the extent to which English science lessons match the 'ideal' of constructivist teaching that has now become the expected approach recommended by the Turkish government. Four schools and a sixth form college were visited to meet staff and observe some teaching. Two lessons in each of the schools, and five in the college, were observed. An observation guide developed from the research literature was used to focus observations on aspects of teaching and learning considered most relevant to a constructivist approach. In particular eight areas were identified that might potentially distinguish between the more traditional teaching common in Turkey and the recommended ideal of 'constructivist' teaching. The overall characterization of the science teaching observed was that it was generally 'progressive' when compared with the traditional lessons that make up the common practice in Turkey. However, this study suggests that science teaching in England does not fully match the ideal of constructivist teaching. The conditions needed to bring about a major shift in classroom pedagogic practices are considered, with special reference to how the situation in England can inform Turkish science education.

Keywords: Constructivism; Observation; Science Education; Traditional Teaching.

INTRODUCTION

1) Constructivism

In recent decades science and mathematics education as international research fields have been dominated by constructivist ideas (Fensham, 2004; Taber, 2009). Indeed constructivism has been considered as an orthodoxy or dominant paradigm within science education (Jenkins, 2000). However, constructivism in science education has also been the subject of serious criticisms, including questioning of the extent to which the enthusiasm of

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many in the academic community has been reflected in the daily work of science teachers (Millar, 1989; Matthews, 1993; Solomon, 1994; Scerri, 2003). The present paper reports a study exploring some of the barriers that may impede the adoption of constructivist practices in the science classroom. It does this by considering the current situation in an educational context where there is a long-standing broad acceptance of constructivist ideas among science teachers (England), as the basis for informing the adoption of constructivist teaching approaches in a context where teachers are being strongly encouraged to shift towards more constructivist pedagogies (Turkey).

The term 'constructivism' has been used with a wide range of overlapping meanings by different authors, and indeed is often associated in the social sciences with 'qualitative' or 'interpretive' approaches to developing public knowledge (Potter, 1996). Such ambiguity can be the source of significant confusion, and indeed some of the common criticisms of constructivist ideas in science education derive from the association of constructivism with perspectives (for example, relativism) (Matthews, 1993; Scerri, 2003) that are not central to the thinking of most science educators who would consider themselves 'constructivists' (Taber, 2009: 178-183).

Whilst recognizing the importance of some of the debates around such questions, the present study is concerned with a view of constructivism as a pedagogic movement, based upon a psychological perspective on student learning that can largely be examined without reference to the broader philosophical stances taken about the nature of knowledge and knowing.

For the purposes of the present paper, then, constructivism should be taken to a perspective on learning and teaching which acknowledges how human learning is subject to the way human brains process new information (Taber, 2009: 122-146). The key points are;

(a) that although it may be possible to 'rote' learn information which may represent complex ideas, such rote learning is not meaningful, so the ideas are not understood and cannot be applied;

(b) meaningful learning involves interpreting new information in terms of existing cognitive resources;

(c) there are severe restrictions on the amount of material that can be processed at any one time.

The implications of this perspective for teaching are enormous. Learners interpret new ideas in terms of their existing knowledge and understanding. A teacher introducing a scientific idea such as photosynthesis, refraction, valency, organelle, alkali or pulsar needs to be able to relate the new idea to existing ideas that are sufficient and suitable to allow the learner to acquire something of the intended meaning of the scientific concept. If assumed prerequisite knowledge is absent, or is not clearly activated, the intended links do not form, and the new idea is not meaningfully understood. If the student's existing ideas include alternative conceptions, or if they activate an inappropriate connection for the new knowledge, it may come to be understood in ways at odds with the intended scientific meaning (Taber, 2009: 301-303). A lot can go wrong, but at least a constructivist teacher is aware of this and can be alert to the 'learning bugs' that can occur.

Constructivist classrooms

Constructivist teaching, therefore, is not primarily concerned with presenting as much science as possible, but rather with finding ways of engaging students in the learning process so that they are actively making sense of new material and building links with what they have previously learnt (Taber, 2009: 298-313). 'Constructivist' science teaching

has been discussed and described by a range of authors (Driver et al., 1994; Fensham, Gunstone, & White, 1994; Mintzes, Wandersee, & Novak, 1998; Russell & Osborne, 1993; Scott, Dyson, & Gater, 1987), but it is possible to characterize what an 'ideal' constructivist classroom would be like. So, an observer in a constructivist classroom would expect to see:

- the students being active in the lessons, being involved in a range of activities;
- the students heavily involved in the classroom talk: asking as well as answering questions; giving extended answers and explanations in dialogue with the teacher, and talking in pairs or small groups;
- much of the work of the classroom being collaborative, with students working together, and involved in discussion;
- the teacher eliciting and clearly valuing the students' ideas and linking them to new information being presented;
- scientific ideas being presented through familiar contexts, and being actively linked to learners' own experiences and concerns;
- where possible the physical layout of the room being set-up to allow group-work and active learning, rather than being set out for listening to the teacher;
- teacher questions that explore student thinking and understanding, and genuinely seek their views and perceptions on topics;
- assessment tasks that are integrated into learning activities and designed both to facilitate further learning, and to explore deep understanding (rather than to produce objective and reliable data on surface features of learning).

2) The Turkish National Education System

Within the Turkish education system, formal education is defined as the regular education conducted within a school or other establishment for individuals in a certain age group and at the same level, following programs developed to meet identified learning goals. Formal education includes preschool education, elementary education, secondary education, and higher education institutions.

The objective of preschool education (3-5 years) is to ensure that children develop physically, mentally and emotionally and acquire good habits and skills so that they are prepared for primary education – such as speaking Turkish sufficiently. A common education environment is provided for all children, including those who come from a disadvantaged background.

The objective of elementary education (6-13 years, grades 1-8) is to ensure that every Turkish child acquires the necessary knowledge, skills, behavior and habits to become a good citizen and is raised in accordance with the concept of national morals and that he/she is prepared for life and for the next level of education in accordance with his/her interests, talents and capabilities. Elementary school education has duration of 8 years.

Secondary education includes all education institutions of a general or vocational and technical character of at least three years duration beyond primary education. The objectives of secondary education are to provide students a common minimum overall

level of knowledge, to familiarize them with basic problem solving skills, to prepare them to contribute to the socio-economic and cultural development of the country, and to prepare them for higher education, and for employment, in line with their interests and aptitudes. Secondary school education has a duration of 4 years (grade 9-12), i.e. for 14-17 year-olds.

Higher education comprises of the education institutions providing courses of at least two years duration for those completing secondary education. The purpose of higher education is to develop the students in line with their interests, capabilities and skills, and in doing so to meet the needs of society. This includes providing suitably qualified workers to meet the needs of the government's policy for developing science based capacity in areas such as research and development. Higher education institutions include universities, faculties, institutes, higher schools, vocational higher schools, conservatories, and research and application centers in Turkey.

2.1) Science Education in Elementary School (Grade 1-5)

In 2004, the Ministry of Education and Board of Education introduced a curriculum change for elementary education. The aim of the revised curriculum was to ensure that young people will enjoy learning, acquire the basic knowledge and skills for life, be reconciled with their environment, be flexible enough to adapt to changes in their lives, and that they will love and always seek to exalt their family, country and nation. The basic recommended learning approach in this curriculum is based on a constructivist learning approach.

The basic skills emphasized in the curriculum include critical thinking, communication and problem solving; and the curriculum is intended to facilitate pupils developing personal attributes such as self-esteem, and self-efficacy as well as acquiring interdisciplinary knowledge in such areas as health education and human rights.

Students take their first science lesson during 1st grade. They take "life science" lessons from 1st grade to the 3rd grade. In this lesson basic knowledge about living organisms is developed. The students take science and technology lessons during 4th and 5th grade.

2.2) Science Education in Elementary School (Grade 6-8)

In 2004, the Ministry of Education and Board of Education introduced curriculum change for elementary education grades 6-8. One aim of the new curriculum is to support the development of science and technology literate students. This is intended to be achieved through a focus on seven dimensions: the nature of science and technology, key science concepts, science process skills, science-technology-society-environment connections, scientific and technical psychomotor skills, the values forming the essence of the science, attitude and values concerning science

In the curriculum, student-centered and constructivist teaching strategies are recommended. A constructivist approach provided the basic philosophy to inform the curriculum as well as being the intended basis of teaching and learning activities.

Traditional measurement and evaluation techniques (multiple-choice tests, true-false questions, matching, fill-in-the-blanks, short answer questions, written exam) and alternative measurement and evaluation techniques (performance-based evaluation, portfolio, concept maps, project, drama, interview, poster design, self-evaluation) are used in order to evaluate students' learning.

Science and technology lessons were constructed within the four learning fields of 'living things and life'; 'matter and change'; 'physical events'; and 'earth and universe'.

There is an examination after the 8th grade which is used to select pupils for entrance to the more prestigious high schools such as the Science and Anatolian high schools.

2.3) Science Education in Secondary School

The Ministry of Education and Education Board have also introduced on-going curriculum change in the high schools. In 2006, the duration of high schools was changed from 3 years to 4 years.

The aim of the science curriculum is to produce productive individuals who can solve problems that they meet by using scientific methods, can analyze the relationship between science-technology and the environment, and can develop positive attitudes and behaviors to themselves and environment. Again, a constructivist approach not only informed the preparation of the curriculum but is also expected to form the basis of teaching and learning activities. The difficulty and depth of the concepts studied in topics increase with grade level. Under the new arrangements, assessment puts less emphasis on traditional measurement and evaluation techniques which measure what can be recalled, and rather puts more emphasis on the assessment of meaningful learning.

At 9th grade every student takes science lessons in physics, chemistry and biology. At the end of the 9th grade, students choose their major field. There are 4 major fields:

1. Science Field: In this field, major lessons are physics, chemistry, biology, mathematics

2. Social Sciences Field: Turkish Language and Literature, geography, history

3. Literature and Mathematics Field: Turkish Language and Literature, mathematics

4. Foreign Language Field: Turkish Language and Literature, foreign language

Since the students choose their major fields at the end of the 9th grade, after the 9th grade some students do not take any further science lessons. Therefore, in this curriculum, 9th grade science lessons need to complete the learning of science (chemistry, physics and biology) considered necessary for all individuals to be scientifically literate adults.

At the end of high school, the students enter the “Student Selection Exam”, which is a multiple choice examination and the only way to enter a university in Turkey. 1,510,000 high school graduates took the Student Selection Exam in 2006.

3) The English Educational System

The National Curriculum in England applies to pupils of compulsory school age (5-16) in all state funded schools. It is planned on the basis of four key stages (URL-1, 2009).

Key stage 1: Ages 5-7 (Years 1-2)

Key stage 2: Ages 7-11 (Years 3-6)

Key stage 3: Ages 11-14 (Years 7-9)

Key stage 4: Ages 14-16 (Years 10-11).

At key stages 1 and 2 the statutory subjects that all pupils must study are art and design, design and technology, English, geography, history, information and communication technology, mathematics, music, physical education, science, and religious education. The stated aim of the primary curriculum (Key stage 1-2) is to ensure all children gain a good foundation in reading, writing, speaking, listening and numeracy (URL-2, 2009).

The stated aim of the secondary curriculum (Key stage 3-4) is to enable all young people to become successful learners who enjoy learning, make progress and achieve, to become confident individuals who are able to live safe, healthy and fulfilling lives, to become responsible citizens who make a positive contribution to society (URL-3, 2009).

At key stage 3, students take art and design, citizenship, design and technology, English, geography, history, ICT, mathematics, modern foreign languages, music, physical education, science, personal, social, health, and economic education, and religious education courses. At key stage 4, the required areas of learning are citizenship, English, ICT, mathematics, physical education, science, personal, social, health, and economic education, and religious education (URL-4, 2009). Citizenship in the UK curriculum context includes a global dimension: that is pupils are expected to consider they are part of a global community of people who share the world and its resources, and who are all accorded basic human rights which are recognized in international law.

3.1) Science Education in England

Up until the 1980s there was considerable variety in the amount and nature of science learnt by students in England (Jenkins, 2004). Science has been a core subject and so for all pupils a mandatory part of the compulsory years of schooling (i.e. from ages 5 to 16) since a National Curriculum in England was phased-in during the early 1990s (S I, 1989). For most of this time the teaching of science was organised throughout both primary and secondary phases in terms of four teaching areas (known as ‘attainment targets’) of scientific enquiry, life processes and living things, materials and their properties, and physical processes (DfEE/QCA, 1999). The organisation of teaching material was based on the principle of a spiral curriculum (Bruner, 1960), with key ideas being met at increasing levels of detail and complexity during schooling.

During the period since the introduction of the National Curriculum there has been considerable criticism of aspects of the curriculum. One issue was the relative neglect of nature of science themes by teachers, which led to some modification of curriculum specification and assessment model (Taber, 2008). Criticisms that the science curriculum was too packed with content, and too inflexible, to meet the needs of teachers and pupils and to allow in-depth exploration of topics, were widespread (Cerini, Murray, & Reiss, 2003; House of Lords Science and Technology Committee, 2006; Osborne & Collins, 2000).

The government responded to various concerns about the curriculum by introducing a wide range of guidance for teachers, including materials suggesting how science teaching could be arranged around a limited number of central themes (Key Stage 3 National Strategy, 2002a). Much of the guidance issued (Key Stage 3 National Strategy, 2002b, 2003a, 2003b, 2004) offered a basic constructivist orientation. Indeed an analysis of various guidance documents issued to English teachers shows that “over a period of less than a decade basic constructivist principles ... have become widely incorporated into the ‘model’ of teaching and learning that has been established as officially approved pedagogy” (Taber, 2009: 214).

Ultimately it was found that recommendations for constructivist teaching approaches proved inconsistent with a prescribed content-heavy curriculum based on an assumption that all learners needed much the same science education to age 16. Widespread dissatisfaction with the curriculum led to revisions of the English science curriculum for 14-16 year olds (QCA, 2007b) and 11-14 years olds (QCA, 2007a). These changes were being phased-in at the time of the present study.

Teaching in English schools uses information technology heavily. Most schools have dedicated computer rooms as well as computers in teaching rooms. However, in most schools, it has certainly not been the case that there are sufficient computers for all pupils to work independently on a computer whenever the teacher might feel this is desirable (Crawford, 2000). In recent years Interactive Whiteboards have been installed in an

increasing number of classrooms in England (Cuthell, 2005), and many teachers base their classroom presentations upon material written or compiled on, and presented from, a computer.

3.2) Constructivism and Science Education in England

Constructivism has never been formally adopted as an official philosophy or perspective in English education. However research projects that were undertaken in primary (Russell & Osborne, 1993) and secondary (Driver & Oldham, 1986) school contexts in the 1980s were widely reported and have been very influential. This has allowed the development of official pedagogic guidance incorporating constructivist thinking (as discussed in the previous section) which has been formally adopted and widely disseminated almost without comment – reflecting what most teachers have come to understand is just good practice (Department for Education and Employment, 1998). Among the basic principles reflected in government guidance are (Taber, 2009: 213-214):

- Learners build up their understanding based on previous learning;
- Learners hold everyday meanings for technical words;
- Learners come to class with alternative conceptions;
- There are common misconceptions that may be found reflected in the thinking of a significant proportion of students
- Some misconceptions may actually derive from teaching;
- Being aware of learners' alternative conceptions can inform teaching;
- There is value in eliciting learners' ideas as part of teaching;
- There is a need to take students' thinking into account in planning effective lessons;
- Effective teaching responds to learners' ideas.

Such principles are taken as commonplace, and may almost be 'taken-for-granted' by many teachers, rather than seen as part of innovative or progressive pedagogy. Indeed when Kaymaz undertook a case study of the teaching of one English secondary science teacher identified as an effective practitioner, she was able to identify clear features of a constructivist approach in the teacher's practice. When asked about constructivism, however, the teacher was unable to recall having encountered the term itself (Kaymaz, 2007).

One of the purposes of this study was to examine the extent to which science teachers in England use constructivist teaching strategies, and – where used – how such strategies are operationalised in the classroom. It was considered that a study exploring science teaching in a context where constructivist ideas are generally accepted and seen as unremarkable (England) could be informative in informing teachers, science educators and policy makers in the Turkish context where it is hoped to bring about a major transition in science teaching by officially adopting constructivist pedagogy.

METHODOLOGY

1) Research Design

In this study, semi-structured observation was used. Semi-structured observation is informed by an agenda of issues but will allow the observer more flexibility in deciding what to record than when a fully structured predetermined schedule is adopted (Cohen, Manion, & Morrison, 2001).

2) Sample

This study was undertaken in 2008 (between January and June) in England. Four schools and a sixth form college were visited to meet staff and observe some teaching. Two lessons in each of the schools, and five in the college were observed (see Table 1). This was a modest sample of teaching, but included lessons across the secondary age range, and a mixture of biology, chemistry and physics topics.

Table 1: *Observations undertaken during visits to schools*

School	School Year	General topic area	Length of observation /minute
C	12	Biology - osmosis	20
C	13	Biology - tissues	20
C	12	Biology - membranes	25
C	12	Chemistry-reactions of carbon dioxide	65
C	12	Physics-the electromagnetic spectrum	65
S1	9	Food molecules	53
S1	7	Plant roots	60
S2	8	Classification of living things	50
S2	11	Recycling	50
S3	11	Electromagnetism	60
S3	8	Convection	50
S4	11	Enzymes	60
S4	11	Presenting experimental data in graphs	60

C= sixth-form college; S1-4 are different secondary schools

The sample of lessons was not extensive, but we felt offered enough diversity to give the researchers a feel for the nature of typical science teaching in England. Moreover, individual lesson activities need to be understood as parts of planned sequences, and to be interpreted in a temporal context where today's activity and teacher comments make sense in terms of what has gone before in a particular class. This would be a serious limitation had the intention been to characterise the work of teachers with particular classes. However, here the aim was rather to observe individual lessons as part of a sample reflecting a spread of science teachers in a small range of schools.

3) Instrument

Semi-structured observations regarding science teaching in England were executed during the Spring and Summer school terms in 2008 (corresponding to the second Semester in Turkey) by the first author (Bektaş). Four secondary schools and one college in the East of England were observed in order to examine science teaching in terms of the extent and nature of application of constructivist teaching strategies. A simple observation guide was devised in discussion between the two authors to focus on aspects of teaching and learning considered to be of relevance. In particular eight areas were identified that might potentially distinguish between the more traditional teaching (T) common in Turkey and the ideal of 'constructivist' teaching being recommended there (C). In this way it was intended to get a feel for the extent to which science teaching in England could be said to be 'constructivist' in nature. The indicators can be summarised as:

- How active were the students in the lessons: were they largely passive (T); or were they involved in various activities (C)?

- Who did most of the talking in the lessons: did the teacher do most of the talking as ‘telling’ (T); or were there significant levels of student talking, and more extended teacher-student interactions (C)?
- How were the students interacting: were they largely taking notes and listening to the teacher (T); or were they involved in discussion and collaborative work (C)?
- What sources of information were given authority in the class: was there heavy use of a textbook as a source of knowledge (T); or was there elicitation of students’ own ideas, and attempts to relate new material to prior knowledge (C)?
- How was content presented: were scientific ideas introduced as formal and abstract concepts (T); or were they contextualised, e.g. in terms of familiar applications or historical examples (C)?
- How was the classroom organised: was the teaching room set up for lecturing (T); or was there an arrangement reflecting a more informal approach that could facilitate greater student participation (C)?
- What kind of questions did the teacher ask: were these primarily to check recall of facts (T); or did they include questions to explore understanding, and more open questions inviting genuine student contributions (C)?
- What forms of learning and assessment tasks were used: were these primarily based around reviewing notes and testing factual learning (T); or were they more varied, including creative and extended tasks (C)?

Clearly in undertaking this work, we were aware of a number of serious provisos. Firstly, we did not expect observed lessons to necessarily fall at the poles of these dimensions; rather Bektaş was considering *the extent* to which lessons fitted these indicators. Also, as suggested above, ‘constructivism’ is a much and variously used term, and may not be universally considered an appropriate descriptor of the more ‘progressive’ pole on some of these dimensions. None-the-less, we feel that taken together these indicators offer a good impression of what is *understood* as ‘constructivist’ teaching in the Turkish educational context.

4) Procedure

Schools and colleges were emailed to ask if an observation visit could be arranged to see science teaching. In the UK such permission is a matter for an individual school. For convenience, schools approached where near to Cambridge, where Bektaş was an academic visitor in the University Faculty of Education. Four secondary schools and one sixth form (i.e. for 16-19 year olds) college were visited in order to observe the science lessons. The observer took notes informed by the observation schedule and prior consideration of what the features of constructivist teaching would be.

FINDINGS

The schools and college visited were set in green spaces with many trees. They were organized into departments such as art, classics, design and technology, drama, English, geography, history, mathematics, modern languages, music, religious studies, chemistry, physics, and biology. Moreover, there were theatres, canteen facilities for students and staff, recreational spaces, internet facilities, library, and course working areas for students.

In school S2, 45% of students were of Pakistani backgrounds and other students were from South Africa and China as well as England. The classes observed had between 16 and 31 students, so even the largest class was noticeably smaller than typical secondary classes in Turkey.

In all but two of the classes the general atmosphere was relaxed and informal. Teachers issued supplementary materials (such as worksheets) in eight of the observed lessons. For instance, a biology teacher in school S1 distributed a sheet with a diagram of a flower to the students. He also displayed it on the computer. Students stuck this picture into their notebooks. The teacher discussed the diagram and the students made notes beside the picture. Similarly, other handouts had been glued into their notebooks by students.

All of the teaching rooms had display materials (e.g. posters, pictures, periodic tables) relating to science, and included bookcases with books that students could refer to.

The classrooms were equipped as laboratories with chemicals and equipment. Teachers were supported by technicians, who prepared materials in advance and cleaned away after practical activities. (This contrast with Turkey where schools do not employ technicians who help teachers prepare for practical work.)

The organisation of seating arrangements varied, only seeming ideal for constructivist teaching approaches (i.e. allowing a high level of interaction between groups of students) in the college and one of the four schools. In many English schools, science rooms are equipped with laboratory furniture (such as work benches that are fixed because they are equipped with gas, electricity and water services) that cannot be rearranged to facilitate different modes of classroom teaching.

All the teaching rooms were kitted-out with communications equipment such as television monitors, video players, and computers with projectors and interactive whiteboards.

Significant note-taking by students was observed in five of the lessons. For example, in the college, when the topic of the session was osmosis, the teacher mostly sat on his own chair, but he sometimes stood up in order to write something regarding the topic on the board. Students sat in their places and took notes. Therefore, the teacher was active, but students seemed passive during session. We acknowledge that observations do not offer a clear indication of whether pupils' brains are actively engaged with the topic even when they seem to be passive (Millar, 1989) – effective teachers can facilitate active learning by engaging pupils' minds through the way they structure and pace teacher-talk, and link their presentations to students' interests and prior learning. In general, however, school age children are not most effectively taught by extended periods of teacher talk. The teacher occasionally used a question-answer method, but only during parts of his lesson. Moreover, some note taking was seen in six of the other lessons. Only in two of the lessons was none of the observed time spent making notes.

For example, in the college chemistry session, the teacher used questions to start her lesson, such as “what are the reactions of carbon dioxide?” However she then shifted from a dialogic to an authoritarian approach (Mortimer & Scott, 2003) in explaining the aim of experiment. The teacher helped students while they undertook the experiment. The students were given a study guide for the experiment that included questions, purposes, and details of the practical relating to the reactions of carbon dioxide. When the students finished their practical work, the teacher provided questions about the experiment they had carried out. During the experimental work, the students were active in carrying out the practical work and discussing it with each other. The teacher asked questions about the experiment at the end of the practical, so directing students to think about what they had done and seen, rather than directly telling them information about the reactions.

Over the sample of lessons the nature of teaching fell short of the constructivist ideal.

However, extensive use of textbooks was only seen in three of the observations. Moreover, a range of other activities were seen (in the number of observed lesson indicated), including:

- student discussions (4)
- student practical work (4)
- teacher demonstrations (3)
- graph-drawing (2)
- concept mapping (2)
- open-ended inquiry (1)
- peer instruction (1)
- role play (1)
- internet based quiz (1)

In school S3, a chemistry lesson was observed and the students were active during this lesson. During a demonstration, the teacher discussed the concept of density. When she warmed a mixture with a hair dryer, colored liquid became buoyant and a convection current was set up, and the teacher referred to the density difference. A student did not understand what was meant by density and asked the teacher, who explained the concept using a role playing technique. She chose 7 students who represented particles and were positioned around the room. When she brought near hair dryer to them, students walked away from each other and two students stayed in that region. Therefore, she tried to explain the density concept by using role-play.

In school S4, the chemistry teacher started the lesson by presenting questions about the topic. Then, he gave students graph paper to plot graphs. He then worked individually with students who did not understand what they should do. Also, he walked around between the students and formatively assessed their graphs. He collected graphs that were drawn correctly, and he gave feedback to students who drew the graph incorrectly. He also gave them copies of the correct graph. After that he asked some questions about their results, such as “what about precision?” “What is your conclusion if you look at your results?” After students had offered answers to his questions, he explained the expected conclusions and then he ended by checking that everyone was “happy”.

Teacher questions were observed in all the lessons. In three cases the questions seemed primarily concerned with checking students had heard and remembered what they had been told, whilst in three lessons the questions seemed designed primarily to check student understanding. For instance, the science teacher observed in school S2 used the internet at the end of the lesson, in order to present a quiz. There were 20 multiple choice items about the subject. These questions were answered one by one by students. If students gave a wrong answer to a question, the class discussed that question again. A mixture of question types was observed in the other lessons. However, during the observations there was minimal evidence of teachers explicitly seeking to elicit students’ own ideas and so to identify alternative conceptions that might influence further learning.

In school S1, a teacher had previously given homework regarding radiation and living organisms. Students were asked to compose a concept map about this topic. The teacher had assessed their homework before and he gave back it them during the lesson. He gave feedback regarding their concept maps and he asked them to revise their homework. In Turkey, teachers would not set homework to produce a concept map since few teachers know about concept mapping. Such approaches are often considered to be a waste of students’ time by both students and teachers in Turkey.

DISCUSSION

A small sample of science lessons in England was observed. These lessons were generally 'progressive' compared with the traditional lessons that make up common practice in Turkey. The posters, maps, and pictures regarding science on the walls of the teaching laboratory are very good for students because students can look at this material at any time. In Turkey, there are no posters, maps, and pictures about science in the classrooms. A periodic table may be in the science laboratory, but teachers do not very often use laboratories because there is considered to be too little time for this. Also, students are not motivated to undertake laboratory work, which does not seem related to the multiple choice items they must answer in order to enter university.

Using technology or media can be very important for supporting teachers in making work interesting and relevant to students. Students do not use any media in the secondary school in Turkey. Teachers in schools and colleges observed in England generally used the computer very effectively in their teaching. However, this would not be the case for Turkish teachers.

Teachers observed in England generally worked in more informal settings, and used a range of teaching approaches, so that students were commonly involved in activities (other than just listening and taking down notes from the board or textbook). Activities such as role-play (Dorion, 2007), group discussions (Taber, 2007), and concept-mapping (Taber, 1994) contrast with students sitting in orderly rank and file listening to a teacher who is presenting the knowledge to be acquired. Despite the informal set up in some classrooms, the physical layout of others did not seem conducive to 'constructivist' teaching, perhaps due to the same rooms having to double as teaching laboratories as well as being used for other forms of learning activity.

During the observations there was minimal evidence of teachers explicitly seeking to elicit students' own ideas and so to identify alternative conceptions that might influence further learning. The lack of apparent explicit focus on students' own ideas is worthy of comment, as the elicitation of students' conceptions to inform teaching is at the core of constructivist approaches to teaching (Taber, 2003), and of the pedagogic guidance issued to teachers by the UK government (Key Stage 3 National Strategy, 2002b). However, it was observed that English teachers commonly undertook formative assessment of student work during lessons, giving them an opportunity to diagnose student thinking and potential alternative conceptions.

CONCLUSION

The present study is based on a modest sample of science teaching observed in a range of English schools. Although it would be inappropriate to generalise in any quantitative sense from the sample to the broader school population, the overall picture of English science teaching that was drawn from the observations seems consistent with the image presented elsewhere (QCA, n.d.-a, n.d.-b).

Compared with traditional teaching practice in Turkey, much of the teaching seen in England would be considered progressive, and more in line with the constructivist approach that the Turkish authorities are trying to introduce. We can suggest several reasons for this. Teachers in England are well supported compared with their colleagues in Turkey. Smaller class sizes, regular teaching in laboratories, availability of diverse teaching materials, technician support, availability of reference and display material, and teaching rooms well equipped with both scientific and ICT equipment, all contribute to the conditions that allow science teachers to incorporate more 'progressive' approaches into their teaching repertoires. However, even with constructivist ideas being widely 'taken-for-granted' and strong levels of resource in terms of books, IT, laboratories, apparatus and chemicals, and technicians, the teaching observed in this study often fell short of a

constructivist ideal. At one level this may reflect how the most effective pedagogy may not always 'look' progressive to the observer visiting the class (Millar, 1989; Mortimer & Scott, 2003). Constructivist teaching can take many forms (Taber, 2009: 298-313), and may often involve shifts between what seems progressive and what may on the surface appear quite traditional.

Despite these provisos, it does seem clear that - even in a well-resourced context where teachers are generally open to constructivist messages - teachers may often fall back upon elements of traditional, didactic teaching. The folk-psychology model of teaching – as transferring knowledge from the expert to the pupil – acts as a common alternative conception of the learning process which is itself very tenacious (Taber, 2009: 126-128). Teacher education needs to challenge this notion, through both pre-service training and continuing profession development.

This consideration of the English context, where constructivist ideas are widely taken for granted, and teachers are well resourced, suggests that even under conditions favourable for reform, teaching retains strong features of traditional approaches intended to bring about non-viable knowledge transfer (rather than knowledge construction). This suggests that to bring about the shifts in science teaching desired in Turkey, the authorities will surely need to invest significantly to provide teachers with suitable conditions for reforming their teaching – both through professional development and in terms of teaching and learning facilities.

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