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ORIGINAL PAPER

Viewpoints of higher education teachers about technologies

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Abstract In the context of recent debates on technological literacy, a renewed research effort has focused on the nature of technologies.
The aim of this work, which considers 'epistemological knowledge' as viewpoints which spring into gear in a given situation, is to use questionnaires and interviews to identify the opinions of teachers in a training institute for master technicians in Tunisia on technologies. The objective was to try and define how these teachers perceive the relations between sciences, technologies and societies and how social and cultural aspects affect their discourse on technologies.
The results of the questionnaires and the analysis of their discourses indicate that teachers essentially perceive technology as an applied science for which the ultimate purpose is progress and consumption. The relations identified by teachers between technologies, sciences and societies, reveal dichotomies between science and technology both with respect to the status teachers attribute to knowledge and to their views on its teaching.

Keywords Epistemology · Nature of technologies · Science · Society · Technology

Introduction

Although we now live in technological societies some authors have shown that students do not know how technological knowledge is constructed and the way in which it is related to scientific knowledge and social evolution (Gigling, Garnier, &

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Marinacci, 2000). Technologies, which are mainly perceived as applied science, nevertheless have potential for social transformation that schools can no longer ignore. How can young people be trained to come to terms with a more and more complex environment, in other words the unstable, continually changing and unpredictable environment we live in today?

For Postman (1992), American society is like a ''technopoly'' in which the citizens are expected to accept the proclamations of experts in very specialised fields, which only the most highly trained people can understand, without asking any question. A useful technological literacy for citizens today would enable them to take part in discussions and critically evaluate current research. For O'Neil and Polman (2004), one way of helping citizens to participate in debates with specialists is to develop their understanding of research methods, techniques and data analyses and of the crucial importance of controversy in scientific practice. This would be more useful to the general public than trying to convey too much knowledge which would quickly be forgotten.

With young people now living in a world that Fourez (2002) has referred to as ''techno-nature'', it is difficult to precisely describe the ultimate objective of technology education. Educational programmes may have different goals for which training programmes are subsequently developed to achieve them. This might involve focussing on the development of students' technical culture, their epistemological training and teaching them concepts or having them undertake projects, discover or simulate the way in which companies operate, and thus prepare them to be future professionals, researchers, engineers, technicians. They should also be taught to be future citizens so that they help organise their world and get involved in social and political action. Given such a wide range of orientations there is no doubt that this will lead to controversial teaching proposals (Bybee, 2003). For instance, Williams (2000) has stated that there is probably more international agreement among technology educators about the activity of technology than about the content of technology. The suggestion of technological literacy programmes for all, has also led to a debate with some people seeing therein the possibility of ''reconciling'' students and citizens with science and technologies (ITEA, 2000/2002), while others consider that under this new banner there is simply an old project for imposing Western hegemony on the world (Carter, 2005; Legendre, 2004).

This initiative in favour of training and literacy has lead researchers in technology education in several countries, to focus on the impact of recent reforms (Meade & Dugger, 2005). These have raised research issues and contributed to renew the questions of educators in many countries with respect to the teaching and learning not only of knowledge *in* technologies but also of knowledge *about* technologies.

In Tunisia, as in many countries, the recent educational reforms have emphasized the development of a technological culture for all, future technicians and citizens. The Institutes for training specialised technicians[1] are a recent innovation in higher education. Their mission is to train specialised technicians to meet a social need for training and employment in industry and services. This innovation in the educational system has lead to the creation of a new teachers' community. Some teachers are engineers, others were trained in physics. In this context, their viewpoints on technologies may be diverse. In this study, the perceptions of the nature of technologies of teachers in the new institutions for training specialised technicians were documented.

[1] Instituts Supérieurs des Etudes Technologiques (ISET).

The ''nature of technologies'' and the perceptions of teachers - of technology and technologies as teaching disciplines - have been research objects for several years (Davies & Rogers, 2000; Jarvis & Rennie, 1996; Jones, 1997; McRobbie, Ginns & Stein, 2000; Mittell & Penny, 1997). Many discussions have tried to determine the epistemological contours of technology education and this still seems to be a crucial issue in the light of the recent reforms. The emphasis placed on scientific and technological literacy training in several countries appears to have re-posed questions asked by the STS movement and to question once again the importance attributed to technologies in these reforms and epistemological viewpoints on the nature of technologies. For Dugger (1988), before one can define a technological discipline it is necessary to first consider the nature of technologies. For Locatis (1988), it is important to investigate the relationships between science and technologies, to raise the issue of values and technologies and to take into account the social dimension of technologies. In line with the STS approach, this involves considering that while science and technologies are different, they interact with each other and with the society which allows them to emerge. They evolve and are transformed while transforming society and *vice versa*. Now, as Layton (1988) has emphasized, the T in the STS approaches often involves treating technologies as applications of science. Moreover, in the light of the recent reforms, the need for the professional development of technology teachers has been underlined (Bybee & Loucks-Horsley, 2000; Daugherty, 2003). For Dugger (2001), the professional development of teachers requires the integration of knowledge of technology.

Considering technologies as applications of science or as an autonomous field which produces knowledge are two different epistemological viewpoints, both of which appear to be important elements as they may influence the implementation of reforms in class. Therefore it is important to study the perceptions of teachers, of technologies as a field of knowledge and subject matter for teaching.

Considering that the Institutes for training specialised technicians (ISET)[2] are a recent innovation in the Tunisian educational system, with a new teachers' community initially trained in science or engineering, our research aims to identify the viewpoints of teachers teaching electrical engineering in these new higher education technology institutions.

The nature of technologies

A discussion of epistemology will enable us to identify debates on the nature of technologies, the relationships between technologies, science and societies, the interactions between problems in technical fields and those in arts, science and philosophy. It will soon become apparent that the issue is highly controversial. For instance the technology education approach assumes that technology should first be defined and the question of making a separate subject arises (De Vries, 1996; Herschbach, 1995).

For some authors, ''technology'' and ''applied science'' are considered to be equivalent (Bunge, 1966). For Galbraith (1979) ''technology means the systematic application of scientific or other organized knowledge to practical tasks''. Note in passing that there is an idea of it being ''descendant'' of science due to the systematic application of previous knowledge, the end purpose of which is to solve problems.

[2] Instituts Supérieurs des Etudes Technologiques.

Consequently technologies would be in debt to science and would not produce knowledge but would only apply knowledge developed elsewhere.

On the contrary, for other authors technologies cannot be reduced to applied sciences and develop knowledge within their own specific frames of reference for the fulfilment of their own specific projects. Heidegger (1977) underlined for instance that technology is not neutral and fulfils its own ends to control nature (Das Gestell). Technology predates science by millennia and in this view, science can be considered as a specialized form of technology. In order to take this independence of the innovative process with respect to scientific knowledge into account, Dosi (1982) suggested considering the ''*technological paradigm*''. According to this approach, technologies should be considered to be a science independent of other scientific disciplines. The philosophy of technology has also shown that technological knowledge is different from scientific knowledge and that technology cannot be described as ''applied science'' (Dasgupta, 1996; Mitcham, 1994; Ropohl, 1997). The idea that ''scientific discoveries'' are followed by technical applications does not resist when confronted to an analysis of research practices (Collindgridge, 1989; Dosi et al., 2005) or an historical analysis (De Vries, 2005; Staudenmaier, 1984).

Different types of technological knowledge have been distinguished. For instance, Dosi (1982) has defined technology as a set of practical and theoretical knowledge, of know-how, of methods, of procedures, of experience of success and failure and of physical materials and equipment. Staudenmaier (1984) has suggested considering that technological knowledge is developed from four types of knowledge: scientific knowledge, problematic data, technological theories or theories of engineering and practical skills. For Ropohl (1997) the different types of technological knowledge involved technological laws, functional rules, structural rules, technical know-how and socio-technical understanding. De Vries (2003) has proposed categories of technological knowledge that relate to current philosophical views on the nature of artifacts from an action theory point of view : physical nature knowledge, functional nature knowledge, means-end knowledge, action knowledge. We can thus consider technologies to be a way in which particular knowledge is developed within specific theoretical and methodological frameworks. We agree with Ginestié (2003), who said that ''t*echnology is an autonomous science, distinct from other sciences*''.

Consequently, different viewpoints on the relationships between science and technologies can be identified: on the one hand, a tradition according to which technologies are applications of science, and on the other, a view that technologies are independent of science. The way this latter belief is expressed nevertheless depends on the authors (technologies develop and are partly based on scientific knowledge or technologies are an independent scientific field with its own principles).

Gardner (1994) identified four viewpoints on the relationships between science and technologies. An ''applicationist'' viewpoint according to which science constitutes the origin for technological developments and technologies are thus considered as applications of sciences; a ''demarcationist'' viewpoint according to which science and technologies are considered to be independent fields of knowledge; a ''materialistic'' viewpoint according to which technologies provide tools which enable science to develop; an ''interactionist'' viewpoint according to which science and technologies are mingled to such an extent that they form a ''seamless web''.

De Vries (1996) has then called for a new paradigm in technology education to go beyond the ''technology is applied science'' paradigm. Taking a similar approach, Layton (1993) claimed that it is not necessarily true that scientific knowledge involves the development of technological know-how.

We then question the image of technologies conveyed at school, in other words the explicit and implicit elements provided in teaching by means of which students are able to develop ideas of what technology is and how it relates to science.

Various studies of what English-speaking researchers refer to as the ‘‘nature of science’’ have suggested that individuals can develop a set of ideas on the nature of science and express different viewpoints in different contexts rather than having a permanent epistemological profile which is used in all situations (Driver et al., 1996; Ryder, Leach, & Driver, 1999). There is therefore no sense in speaking of conceptions of students or teachers of the nature of science separately from the context in which this knowledge intervenes (Leach & Lewis, 2002). In this respect, Larochelle and Désautels (1987) developed the idea of ‘‘epistemology in action’’. Likewise, Collins et al. (2001) used the term ‘‘ideas-about-science’’ to refer to a collection of ideas that teachers and students may have or develop when dealing with images of science and scientists in different cultural contexts and on the basis of different implicit and explicit messages from formal education.

In this context, our study deals with the ‘‘epistemological knowledge’’ of teachers in higher education while considering this term as a practical shortcut to mean knowledge of technologies as practice, of the nature and the status of scientific and technological knowledge, that individuals use in different situations.

Some studies have shown that primary school teachers had naive opinions of the nature of technologies (McRobbie, Ginns, & Stein, 2000) and conveyed a positive view of technologists (Guerra-Ramos, Leach, & Ryder, 2003). They refer to them frequently as inventors or developers of machines and devices.

Other studies on the viewpoints of secondary school teachers and university teachers showed that technologies are mainly perceived as applied science. For Bungum (2005), the remarks of the secondary school teachers are often rooted in their pedagogical context. In the survey of Lewis (1992), while on the whole all teachers considered that technology was an applied science, university teachers were the biggest group to hold that viewpoint. Overwhelmingly, the teachers emphasized the practical aspect of technologies. Those with doctoral degrees were more numerous in considering that teaching of technologies should take into account the social, political, moral and economic dimensions of technologies.

In order to document the epistemological knowledge of university teachers in an institute for training specialised technicians in Tunisia, we focussed on the following research questions:

What are the viewpoints on technologies of teachers in a training institute for specialised technicians? How do they perceive the relationships between sciences, technologies and societies? How do social and cultural aspects intervene in their discourse?

Methodology

Data collection tools

Different methodologies have been used to explore the epistemological viewpoints of teachers over the last 30 years. Some use written tests and questionnaires, while others concern observations in the classroom, others again use interviews, and finally some use both classroom observations and interviews. The questionnaires have been criticized for not being able to take into account that teachers' ideas are elements which are rooted in a particular context and evolve over time (Koulaidis & Ogborn, 1989). These viewpoints are in particular partly developed by teachers according to their own teaching practice (Nott & Wellington, 1996).

In order to determine the epistemological viewpoints of teachers on technologies, we used questionnaires and interviews. Aware of the limitations of questionnaires, we used them in order to collect a significant amount of data, constructed according to methodological choices designed to limit the known difficulties inherent in this type of tool.

We drew up the questionnaire on the basis of the available literature while taking into account the following points:

1. Assuming that the epistemological viewpoints of teachers are elements constructed in relation to contexts, we asked them contextualized questions to identify to which elements the people replying were referring (Leach, 1996).
2. As for the VOSTS questionnaire (Aikenhead, Ryan, & Fleming, 1989), we expressed the viewpoints of people who are not specialised in the scientific language of philosophers by using "everyday" language.
3. We chose a form which would make it possible to "translate *the actual variety of points of view* [...] *rather than to reduce them to a simple dichotomy*" (Larochelle & Désautels, 1996).

Teachers had to indicate their agreement or disagreement with each statement on a 5-point Likert scale. The themes dealt with in the questionnaire concern the nature of technologies, their relationships to sciences, the relationships between technologies and society, technological culture and technology teaching.

During semi-structured interviews, these points were discussed in more detail with teachers. The questions were inspired by Fourez (1994).

Participants and context

We sent the questionnaire to more than one hundred teachers of electrical engineering at ISET, but only eighteen people replied (four women and fourteen men). Most have a science oriented *baccalauréat* (French school-leaving certificate), a master's degree and a DEA (post-graduate degree - or master's degree) in electrical engineering. Three of them had tenure (since they had successfully passed the national entrance exam for the recruitment of teachers called *aggregation* in French) and two had doctors' degrees in electrical engineering.

The teachers questioned had from one to ten years of experience. Furthermore, three technology teachers accepted to be interviewed (we refer to them as F, G and H). All had initial university training and had at least a Master of Science degree, as do most teachers in the ISETs. The interviews lasted about half an hour each, were audio-taped and were fully transcribed.

Data analysis

For the questionnaires, we identified the teachers using codes E1–E18. We classified the answers into four groups corresponding to the following questions:

What are the epistemological viewpoints of teachers on technologies, the nature of technological knowledge, their objectives, their final purpose, how do they define technological approaches? (Questions 1, 2, 3, 5, 6, 10, see appendix).

How do teachers characterise the relationships between science and technologies? (Questions 7, 8, 9).

How do teachers characterise the relationships between technologies and societies? How do they conceive a technological culture? (Questions 4, 11).

What are the viewpoints of teachers on the teaching of technologies? (Questions 12, 13, 14, 15).

We shall now describe all of the results obtained by the questionnaire and in order to make things easier for readers we shall provide a few examples of teachers writing.

When analysing the interviews using the transcripts, we considered that it would be more relevant to analyse the whole conversation than to analyse each question. We thus analysed the contents of the discourse of teachers interviewed in order to determine their viewpoints on the nature of technologies, relationships between science, technologies and society and on technological culture and the teaching of technology.

Results

Questionnaires

The epistemological viewpoints of teachers on technologies

Most of the teachers acknowledged that technology was a specific field but that it was nevertheless ‘‘descendant’’ of science. They rejected the idea of the autonomous development of technologies, in other words they rejected the ‘‘demarcationist’’ viewpoint (Gardner, 1994).

The first question dealt with the establishment of technologies. The statements 1 and 2 may be grouped together as a position in which technologies are considered to be a particular production model based on their own *rationale* and controlling the way in which they are developed (Larochelle, Désautels, & Pépin, 1994). In one case, this recognition of the distinctive nature of technological production may be said to be *strong* in a sense that technology would clearly be autonomous or even completely autonomous (statement 1). In another case, this recognition was *weak* and non-exclusive to the extent that the speaker recognised that technology was a specific field but claimed that its progress also depended on scientific breakthroughs (statement 2).

Thirteen teachers disagreed with the first statement, in other words the idea that technological knowledge is autonomous, which is its strongest possible meaning when referring to the distinct nature of production of technologies.

Teachers’ opinions were mostly in favour of a ‘‘weak’’ recognition of the specific progress of technologies, with this progress being at least partly due to scientific production. The same teachers agreed or completely agreed with the last statement which stipulated that technologies were due to scientific work. Thus, while the teachers considered that the progress of technologies was ‘‘partly’’ autonomous, they also claimed that the technologies followed scientific knowledge.

We assumed that this ''weak'' recognition was due to them considering technologies as resulting from scientific work and of recognising that only ''afterwards'' could they make progress by themselves based on their own production and on scientific production. Moreover, technological development was perceived as being devoid of social practice and constraints. The use, for example, of digital technologies is a sign of progress and evolution, with digital technologies being described as better and resolving some problems inherent in analog technologies.

For example, four teachers answered that digital technology was more efficient than analog technology. For E4, analog systems always ''*lost some information*'', for E15, digital technology was simpler, ''*digital technology has now become the norm, due to the complexity of analog technology on one hand and to the ease with which it has been possible to implement digital technology on the other*''. For E8, digital signals have a higher quality: ''*the need is for a correct signal, based on all or nothing algorithms*''. As indicated by teacher E3, the performances recognised for digital technology appear to be due to a technical evolution: ''*it was first made possible through research into ways of transforming analog signals into digital signals (to find efficient codes) and then to technological evolutions which made it possible to use those codes, in other words to create components which would execute the codes*''.

Moreover, technology is perceived as involving the manipulation of technical objects and the correct use of more and more efficient procedures. Teachers referred to current media events (robots on Mars), fashionable objects being marketed and advertised (cell phones, portable computers) and teaching disciplines (telecommunications, electronics).

The technological approach is only science plus applications which are implemented and sometimes considered to be ''knowledge''. The teachers believe that this involves solving practical problems, serving industry and developing economic growth. Teachers also believe that technological progress leads to social progress and agree with the statements ''improve the quality of life'' and ''lead to social progress''. Furthermore, we noted that teachers opinions differed and that some were not sure that the end purpose of technology was to produce knowledge and develop a representation of the world.

For most teachers, technologies are not neutral as they are affected by interests, values and personal motivations of researchers.

Thus, for some of them, technological knowledge may progress according to the resources available to researchers (''*if you have money, you can go to the moon*'' (E6), ''*nowadays research cost a lot of money*'' (E1)) and the aims that they have set for themselves (one may ''*[create] the best and the worst*'' (E7), according to ''*the goal of technological knowledge*'' (E11)). One teacher indicated that the researchers' motivations were of fundamental importance: ''*the interests, values and personal motivation of researchers make them determined to achieve their objectives*'' *(E3)*. Researchers are also affected by financers as indicated by teacher E1, ''*researchers live in societies, work in groups and are paid by organisations (public and private) hence technological knowledge is influenced by researchers as well as by their partners*''.

For others on the other hand, the knowledge produced is neutral, just as researchers; only ''applications'' are then considered to be either ''positive'' or ''negative''. Consequently knowledge and ''applications'' appear to be separate. This might mean that science and technology are a-ideological and a-ethical, while only their applications are affected by different interests and values.

Moreover, most teachers consider that technological knowledge is influenced by those who finance research and determine research policy guidelines.

E2 indicates for example: "*research trends are determined by political authorities since they are the ones who control and monitor research programmes (I am talking about third-world countries)*". Likewise for E8, "*research performed by the USA army reflects that politics affects both the field of research and its aims*". E10 was fairly critical of research choices made by certain countries: "*India, like other countries, decided to undertake research to make the atomic bomb instead of trying to solve problems of epidemics and viral disease*". Likewise E11 referred to a sensitive area: "*some technical knowledge such as weaponry, remains under the control of government politicians*".

Furthermore, teachers consider that activities which involve the use of a technical object (such as a doctor whose treatment involves using "devices", a child who is photographing a landscape, an electrician repairing an installation, craft production of pottery, a nurse taking an X-ray or the production of electricity) are to be considered to be technological undertakings. We believe this reveals a dichotomy between knowledge and technical tools related to a conception of technologies as practical applications of scientific knowledge, in other words based on a separation into "practice and theory". Technology then appears to be fairly straightforward, being mainly limited to the technical object rather than a specific undertaking to further knowledge.

Relationships between science and technology

For most of the teachers, science creates theories and technologies implement them. Teacher E18's justification for this, clearly illustrates this opinion "*... technology is the application or implementation of what science provides as a theory*".

Most of the teachers also believe that science and technology are related, on the one hand by technological applications developed following scientific work and on the other by tools provided to science by technology. Note, for instance, the justifications of a few teachers. For teacher E2: "t*echnology is a technique which uses scientific knowledge to put things into practice*". For another teacher for example, the production of an electronic component: "*is an application of the science of semiconductors...*" (E15). For teacher E18, "t*echnology is the application or putting into practice of scientific theory*"; this is also indicated by teacher E3: "*...since it mainly consists in confirming, in implementing scientific concepts and applying them to different fields*".

One question concerned the differences or similarities between science and technology. Most teachers answered that science and technology are "different" and we again realised that these teachers appear to believe that technologies use theories produced by science and that they are direct applications of scientific concepts. Thus, science and technologies may be characterised as "different" if we believe that the former (science) "produces" theoretical knowledge and that the latter (technologies) "apply" the same knowledge. The "applicationist" viewpoint (Gardner, 1994) concerning the relationship between science and technologies is then predominant.

Relationships between technologies and societies, technological culture

Most teachers agree that technologies and societies influence each other. For most teachers our current societies are based on the development of technologies, while the change in life style and increasing needs of our societies leads to a greater need for scientific and technological progress.

The most widespread justification is that current society is based on "*the development of technologies*" (E15). In this context, the change of life style and the increasing needs of our societies mean that there is a greater need for scientific and technological progress. Thus, for teacher E5, " *modern society is a consumer society, consequently technology provides the products which it needs*". Thus the relationships between technologies and societies appear to fall into the socio-economic domain.

Two teachers found a link between technological and social development, with the society progressing due to technologies: "*indeed, technological progress leads to social progress and development*" (E16) and "*society, civilisation and modern life ... are the fruit of scientific and technological progress...*" (E10). Once again, we find the idea of progress in justifications given by teachers, with technological progress leading to social progress as indicated by the following remark: "t*echnology responds to social problems for the purpose of improving living conditions or satisfying peoples expectations*" (E4).

Cultural and social spheres are related to technologies by needs which may differ from one society to another and from one era to another. These needs are apparently the consumption of technological objects. Thus we find that these teachers' perception of society is somewhat vague as the social changes caused by technologies appear to be limited to commercial exchanges and social stakeholders appear simply to be consumers.

A positivist viewpoint of technological developments as leading to social progress and well being for people appears to be held by many of the teachers interviewed.

Most of the teachers believe that technological culture is characterised mainly by correct use and exploitation of technological products. A right choice of technical object, mastery of a technical process, a practice of "*do it yourself*" and experience, appears to enable the development of a technological culture.

Thus for E15: "*in order to characterise this technological culture it is necessary to know how to choose a technological product (to known how to determine its characteristics and its operating mode)*". For E3: "*one may speak of technological culture, which is mainly characterised for instance by knowledge and understanding of processes which are used every day*", which is also expressed by E7: "*yes, it is perhaps the fact of knowing how to live in a technological world (mastering and using technological equipment and technological processes)*". Teacher E2 suggests that "*citizens should be encouraged to adopt this culture in order to popularise technological devices*".

For teacher E8: "*for handymen, we refer to technological culture, as this is an everyday example which validates the idea*" and offers as examples "*to adjust an electrical plug or replace a bulb, you need a technological culture*". For E6, "*scientific culture helps to set up a technological culture*", which again brings us back to the idea of technologies being due to science.

The teaching of technologies

For some teachers, as teaching of science and technology requires the same scientific knowledge, they are thus "similar". For others, this teaching is "different" because the technologies are only "applications" of scientific knowledge. In both cases, teachers justifications indicate that the teaching of science concerns theories and the teaching of technologies concerns the practical applications of these theories. Here again we find the dichotomy noted in relation to the links between science and technologies.

The social objectives of the teaching of technologies do not appear to lead to structured teachers expressions. Their discourse was not developed and focussed on improvement of living conditions. Here for example is the viewpoint of teacher E3: "*make society evolve and improve the level of life*". Other teachers have used the terms "*modernise life*", "*make life easier*". This brings us back to a positivist vision of technologies which would lead to social progress and human well-being.

The pedagogical objectives of technology teaching are focused on training students in the correct use of products (choose a technical product and use it properly).

For instance, for teacher E15, this involves "*knowing how to choose a technological product, setting it up and knowing how to modify it*", for teacher E17 it involves: "*knowing how to use technological equipment, knowing how to apply technological processes, choosing the most suitable technology*". For teacher E17, a question is also "*how to use technology*" and for E5 "*how to take advantage of technologies*".

When understanding is the goal, it concerns scientific concepts and their applications.

Thus, for E3, it involves "*understanding scientific concepts*" and how "t*o apply them in practical cases*". For teacher E10, it involves training a student who knows how to "*use knowledge and the know-how*". Finally for teacher E16, the point is to "*get interested in science and also keep up to date with technological progress*".

Teachers believe that the teaching which is done is focused on scientific knowledge. We can interpret this by considering that teachers acknowledge that the teaching done is not focused on technological register.

Teacher E3 considers for example that students "*are capable of understanding and using knowledge and scientific concepts*". Two others believe that "*they do not have enough practical experience*" (E8) that they "*do not have enough practical experience and too much theory*" (E10). Teacher E18 believes that this teaching leads to train students who have "*enough scientific knowledge*". Two teachers, expressed more critical viewpoints, considering that this teaching trains "*students who perhaps know how to apply knowledge but are very far from being creative*" (E1). In the same line of thought, teacher E15 believes that this teaching, as it is practised today, "*cannot meet the needs of society*" and he adds "*it tends to form uncreative and unmotivated students*".

Three teachers believe that this teaching trains "*students to be passive and does not encourage them to think*" (E5), that we are "*always training students whose knowledge is outdated by technology*" (E10) and that at the level of "*ISETs, we tend to train unemployed people and mediocre students certified ISO 9002*" (E14).

Thus for some, teaching does not meet the requirements for training students to think or for meeting social or economic needs.

It also appears that the announced goal of training students how to correctly use products does not correspond with the practices referred to in higher technological education in which the emphasis is placed on teaching scientific theories. Does this mean that training in the correct use of technologies is being left to primary or secondary education or to other institutions (family, society, companies)? In the latter case, the development of a technological culture based on doing it yourself and on experience and the correct use of technological products would then be done outside of school institutions.

Interviews

The teachers interviewed considered technologies as applications of science (''... *technology and applied science go hand in hand*'' for teacher F). Their purpose does not seem to produce knowledge. They are mainly practical in nature, unlike scientific knowledge which is theoretical, ''*consisting of theories, theorems and laws to be applied*'' (G). Technology aims to ''*applications, practical issues*'' and science does not try to find solutions but to investigate ''*abstract*'' questions for teacher H.

The final objective of technologies is to solve problems and to develop new products. This involves finding ''*more and more suitable techniques to meet the need of the factory*'' (F). For teacher G, technologies and techniques appear to be synonymous. Taken in its narrower sense, technology thus appears to be a practice of techniques, with technique being conceived as a neutral ''*tool*''. For teacher H, technology is the source of ''*technical progress*'' and ultimately the well-being of individuals, as it continually creates new, ''*more evolved*'' techniques. This in itself is a productive capability and growth factor for the economy and a source of progress for society. Technological evolution thus allows for the ''*evolution*'' of society. For this teacher, technologies bring progress and modernisation and thus well-being. Furthermore, he considers that technological developments are necessarily the result of scientific research but are also influenced by socio-economic aspects (the need to market new products or to miniaturise products for instance).

''*I think that the digitisation of technologies was motivated in particular by the need for mobile instruments which means that for all of our applications for general use, for computers, diaries, our small GSM, telephones etc, we have small applications which you can fit in the palm of a hand, but which have become indispensable for daily life with the result that everybody tries to acquire them. Given that they are continually evolving we have less and less space to store them, so we try to make them smaller and smaller and digitisation, the switch over to self-controlling technology, has become unavoidable*''.

The relationships between technologies and societies are expressed with various levels of complexity. However, all teachers consider that technologies have a socio-economical impact on individuals and societies. Teacher F describes technologies as having a social impact on the behaviour of individuals.

''[...] *For me ... it can only be advantageous thus ... thus it makes life easier thus ... take the example of portable devices thus ... they make communication between people easier*''.

Technologies, which are imposed by political choice for teacher G, become available for consumption and appear to be designed to rapidly ''*modernise*'' society by aligning it with technical evolutions. Technologies thus have a socio-economic impact to the extent that they affect the behaviour of individual consumers. Links between technologies and society thus appear to concern social "modernisation" and the impact of the use of technologies on individuals. G in particular referred to opening up to the outside world and facilitating exchanges through Internet and gave examples based on his own personal experience of Internet.

"*technologies have a socio-economic impact, on the one hand social, and on the other economic ... because new technologies, yes, obviously they facilitate ... exchanges*, ... *industry, commerce, but they are mainly communication means, now, you can communicate in time .. in real time if you want to, particularly to make exchanges easier*".

H sees a link between technologies and societies to the extent that technologies influence social constructions (he uses the example of Japan as a society shaped by technologies). In considering that societies are also in some way products of technologies, he believes that the more that technologies are developed, the more "*advanced*" or the more "*evolved*" are the societies, thus again referring to the idea of progress. This led him to rank societies according to their technological development and to say ironically that Tunisia is a society of "*primates*". He then also described hierarchy within societies and referred to the fact that one of the consequences of digital technology is the emergence of a "*digital divide*" which increases social inequalities. An "*elite will master the technology*" and "*there is another segment of the population which will be left out or even stigmatised as a passive user, these are people who only use the technologies*[...]". Moreover, H considers that technological knowledge is not neutral but changes individual behaviour and social relationships.

"*Not neutral under any circumstances. They modify our behaviour, they modify our relationships, for instance when you begin to realise that you are visiting your parents less since you have your portable, you can count the number of times you visit them, in other words instead of going to see someone, the instinct is to phone now or to write a message, so often we forget what people sound like when they call you back and unless their number is in the directory on your telephone (and their name pops up on the screen) you will have trouble remembering the sound of their voice whereas if you go back only ten years, you were able to recognise your friends and your parents when you heard the first "hello" on the telephone, so we may conclude that is has changed everything*".

When the question of technological culture is raised, social, historical and cultural influences on technology elaboration are estimated differently by the teachers : from no influence to a strong and value-laden influence. It appears that in G's remarks, technology is likened to an exogenous productive capacity, disconnected from social and cultural foundations.

H described a technological culture which enables consumers to rationalise their daily purchases and to analyse commercial offers in order to get the "*best*" consumption. He gave the example of a rational purchase of household appliances or computers on the basis of critical analysis which the purchaser has to make of the technological components and needs (technological culture of citizen) and the subsequent limiting of individual freedoms following recent developments in security technologies and video surveillance systems (technological culture of citizens on individual and collective levels).

"*In the technology world, I think that the only way to regulate technology is to take an ethical stand because if we leave it like that, it will destroy everything. You can see for instance what is happening in Great-Britain where everyone is being watched. All people are being watched, you are being filmed from the moment you leave your house until you reach your office. Now this is a considerable technological break-through from the security point of view, so you look outside and say ah! Nothing will escape us now ...* [...] *yes, this technology will simply wipe its feet on my personal freedom. From the moment it does limit my personal freedom I think that we should regulate it*".

In comments on scientific and technology teaching, we find a distinction being made between theoretical approaches and practical applications. Note the low expectations of F of what students should learn.

"*... for the theoretical side if you want ... if you want to make a difference between a lesson in technology and a lesson ... in science for instance ... for the technology lesson ... you first try to present ... the technology used, its characteristics ... the means that it has to implement ... to achieve this technology and we thus try ... to implement thus ... this phenomenon thus ... we have to use ... give examples on instruments, devices, automation which is available in the markets ... what you can find on the market so you have to give practical examples ... on the other hand, for a scientific lesson ... you give, of course you can find applications but ... abstract applications ... which are not directly related to ... society if you want ... there aren't any therefore if you want, there aren't any immediate spin-offs ... future exploitation of ... a physical law or ... a theoretical law*".

For G, the objectives of teaching technology involve teaching how to use technologies ("*preparing a world ... a population ... to ... master ... at least ... to know how to use ... the new technologies ... for the social good*") and training qualified specialised technicians "*who are able to work in industry and who can thus be productive*".

He claims that at the present time, technology teaching trains people "[...] *who are not very qualified*" and that in technology teaching "[...] *in spite of efforts which had been made, in spite of ...what you may hear ...we are not very efficient*". H finds it difficult to talk about the ultimate objectives of technologies and the social objectives for training students in the use of technologies. We find that his answers reflect current viewpoints on the issue and might call them "positivistic conventional wisdom". H finds that technologies are there to make life easier and to provide jobs and prosperity even though during the interview he criticised the wide-ranging effects of technologies on the social and human levels. Furthermore he considers that we should make a critical and ethical appraisal of technologies. This seems to indicate that while H has thought about the relationships between technologies and society, he has not thought very much about the ultimate objectives of technologies.

For H, teaching of technologies should aim "t*o assimilate new technologies ... that's all...*" [...] "*get to know new technologies available on the market*". This "assimilation culture" appears to us to focus on "technological objects". H is very disgruntled about student training: "*we are not training people in the full sense of the word ' training' ...* [...] *no, we are not doing that, we are doing any old thing.*"

Students are being taught to learn how to resolve problems rather than to learn how to think, to relate to their environment, to develop knowledge of technologies and to use technologies. It also seems to mean that this teaching does not aim to develop autonomous subjects but rote behaviour.

''*It doesn't train ... It only trains technocrats, apart from some experiments in a few engineering schools ... but if you take the education dispensed in technology degrees or the education dispensed in institutes for training specialised technicians, it is simply technocratic teaching based on procedures in which students are taught how to do this, how to do that. How to find a solution to such and such problem, how to solve such an ambiguity, but we are not really dealing with technological culture and you will find that even the best student in the class does not know anything about technological innovations available on the market even if he is the best student in the class*''.

For him it is the system which is responsible and he sees himself as an actor in the system. According to H the problem arises due to evaluation based on knowledge instead of promoting training in a technological culture. He thus sees evaluation as a central element in teaching and learning approaches.

''*It is the system's fault, because we are like that. Because we decided to reward only knowledge and not a technological culture*, [...] *We are busy training very basic technocrats, hence people will have degrees but not know how to speak, they don't know how to express their needs, they don't know how to write reports ... when they write them, they are very poorly written, they have practically no culture ... and in their curriculum nothing is planned to provide them with culture, nothing ...*''.

Conclusion

We have tried to document the epistemological viewpoints of technology teachers in an Institute of higher technological education and of course the results cannot be generalised to the whole population of teachers of technology in Tunisia. The study, based on questionnaires and analysis of teachers' discourses indicates that technology is mainly perceived in an ''applicationist'' way (Gardner, 1994). Teachers draw a dichotomy between theory and practice or between abstract and concrete considering science as dealing with the establishment of laws and models and technologies being a practical application of scientific theories. For some teachers, technologies do not aim to develop knowledge, which disqualifies them from being considered as sciences. Other teachers define technologies as applied sciences. Thus, they acknowledge that technologies produce knowledge but that it is due to science with technologies using scientific knowledge and practical skills.

Teachers consider that technological development is influenced by other than strictly technical criteria and in particular socio-economic elements and political choices. For these teachers the ultimate goal of technologies is progress and consumption.

With respect to relationships between science, technologies and society, the teachers questioned consider that technologies are by-products of science and influence individuals and societies. For some, technologies have socio-economic consequences to the extent that they incite individuals to consume. Others add that some people suffer this pressure to consume whereas others appear to analyse it, and for a teacher, this leads to contribute that societies are divided into different groups.

With respect to the teaching of technologies, teachers' comments reveal the dichotomy between theory and practice expressed in relation to technology and science as areas of knowledge.

As emphasised by Bungum (2005), the remarks of teachers of technologies during interviews on relationships between science and technologies are often developed by referring to their pedagogical practice. Their explanatory remarks are thus based on a breakdown between disciplines and the corresponding hierarchies when considering differences between science and technologies. For secondary school teachers it is probably true that it is mainly during their studies, when teaching and also through media discourse and social representations that they develop a viewpoint on the nature of technologies. For teachers in higher education that we interviewed, they have dealt with technology research and have themselves contributed to develop knowledge within a community of technologist-researchers. We supposed that considering their diverse initial training and professional experience before teaching in the recent Institutes for training specialised technicians, their viewpoints on technologies may also be diverse. But it would appear that their viewpoints did not become more complex at that time and that they are similar to those of teachers in secondary education. This questions the ways by which epistemological viewpoints are formed in different educational institutions while direct teaching on epistemology is absent in the curriculum.

We should however specify that this study enabled us to investigate teachers' perceptions of technologies as expressed when responding to questionnaires and during interviews and that it is impossible to generalise on the basis of a limited number of case studies. Thus, our results do not give any indication of the predominance of similar viewpoints among the whole population of technology teachers in the ISETs.

Nevertheless, since the technology teachers of the ISETs have a basic university training in science disciplines, complemented by two years of preparation for a specialised master's degree, we think it is possible to identify training possibilities for this work. We therefore believe that it is necessary to include a section on epistemology in the curricula for training technology teachers. By dealing with epistemological issues in science and technologies, teachers would be offered the possibility to complexify their viewpoints on technologies in order to distinguish them from applied sciences. We also think it is important to propose a larger vision of issues that may be raised by the relationships of technologies to science and society and to bring into question the whole training curriculum for a specialised technician.

The recent implementation in 2006 of a training programme for all higher education teachers in Tunisia offers a way to explore these issues. In future work, evolution of teachers views on the nature of technology can be analysed.

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Appendix: Questionnaire about the nature of technologies (translation from French)

Question 1: How are technologies established?

	I totally agree	I agree	I don't know	I disagree	I totally disagree
1. Technology advances mainly on its own. It doesn't necessarily need scientific discoveries.	☐	☐	☐	☐	☐
2. Technology advances by relying equally on both scientific discoveries and technology's own body of knowledge.	☐	☐	☐	☐	☐
3 Both scientists and technologists depend on the same body of knowledge, because science and technology are so similar.	☐	☐	☐	☐	☐
4. Technology builds on scientific studies.	☐	☐	☐	☐	☐

None of these choices fits my basic viewpoint. My viewpoint is :

Question 2 : Present in a few lines a technology that you consider interesting or remarkable :

Question 3 : According to you, why digital technologies have been developed ?

Question 4 : What are the relationships between technologies and societies ?
Do you agree with the following statements ?

1. Technology and society influence one another : technology shapes and is shaped by our actual society.

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

2. Technology is embedded in a historical, political, cultural and social specific context; consequently, technological knowledge differs according to the aim, time and location.

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

3. Technology and society cannot be separated.

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

Question 5 : Is technological knowledge neutral ?

1. Technological knowledge is influenced by the interests, values and personal motives of the researchers :

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

2. Technological knowledge is influenced by funding agencies :

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

3. Technological knowledge is influenced by research policy :

☐ I totally agree ☐ I agree ☐ I don't know ☐ I disagree ☐ I totally disagree

Justify your viewpoint :

Question 6 : What are technologies for ?

	I totally agree	I agree	I don't know	I disagree	I totally disagree
1. producing knowledge	☐	☐	☐	☐	☐
2. understanding the world around us	☐	☐	☐	☐	☐
3. designing and manufacturing new things	☐	☐	☐	☐	☐
4. inventing new processes	☐	☐	☐	☐	☐
5 solving practical problems	☐	☐	☐	☐	☐
6. organising society	☐	☐	☐	☐	☐
7. inventing tomorrow's world	☐	☐	☐	☐	☐
8. improving life conditions	☐	☐	☐	☐	☐
9. increasing economical growth	☐	☐	☐	☐	☐
10. serving industry	☐	☐	☐	☐	☐
11. finding solutions to the problems that face society	☐	☐	☐	☐	☐
12. leading to social progress	☐	☐	☐	☐	☐
13. favouring consumption	☐	☐	☐	☐	☐

None of these statements fits my basic viewpoint. My viewpoint is :

Question 7 : What are the relationships between science and technology ?

	I totally agree	I agree	I don't know	I disagree	I totally disagree
1. Technology gives new tools to help science going further.	☐	☐	☐	☐	☐
2. Science is aimed to produce theories and technology leads to practical applications.	☐	☐	☐	☐	☐
3. Science and technology are so closely related to each other that they cannot be separated.	☐	☐	☐	☐	☐
4. Technology is the science of techniques.	☐	☐	☐	☐	☐
5. Science is aimed to phenomena understanding and technology to problem solving.	☐	☐	☐	☐	☐

None of these statements fits my basic viewpoint. My viewpoint is :

Question 8 : Is technology an application of science ?
☐ Yes ☐ No ☐ I don't know
Justify your viewpoint :

Question 9 : Are science and technology

different ?
☐ Yes ☐ No ☐ I don't know
similar ?
☐ Yes ☐ No ☐ I don't know
Please give an example :

Question 10 : According to you, can the following activities be characterised as technological ?

- A doctor elaborating a treatment ?

☐ Yes ☐ No ☐ I don't know
Justify your viewpoint :

- A child taking a photograph ?

☐ Yes ☐ No ☐ I don't know
Justify your viewpoint :

- An electrician mending an installation ?

☐ Yes ☐ No ☐ I don't know
Justify your viewpoint :

- Craft manufacturing of potteries (Nabeul) ?

☐ Yes ☐ No ☐ I don't know
Justify your viewpoint :

- A nurse taking a radiography ?

☐ Yes ☐ No ☐ I don't know

Justify your viewpoint :

- Electricity production in a thermal plant ?

□ Yes □ No □ I don't know

Justify your viewpoint :

- A child drawing ?

□ Yes □ No □ I don't know

Justify your viewpoint :

- A shoe-repairer mending shoes ?

□ Yes □ No □ I don't know

Justify your viewpoint :

- The manufacturing of nuclear fuel ?

□ Yes □ No □ I don't know

Justify your viewpoint :

Question 11 :
The terms « scientific culture » are sometimes used. Is there a technological culture ? If Yes, how to characterise it ?

Question 12 : Are science teaching and technology teaching
different ?

□ Yes □ No □ I don't know

similar ?

□ Yes □ No □ I don't know

Justify your viewpoint :

Question 13 : According to you, what are the pedagogical objectives of technology teaching ?

Question 14 : According to you, what are the social objectives of technology teaching **?**

Question 15 : What do you think of students training in your technology teaching ?

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