A Critique of Technology Education for All in a Social and Cultural Environment

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Abstract As in many countries, technology education (TE) has been introduced into general education in France, where it was introduced in 1985. The initial curriculum expressed a real will to position it in a social science perspective in terms of the relationship humans have with their technical environment on the one hand and, on the other hand, how this technical environment organises social relations between human beings. Thirty years later, it is clear that this orientation has largely failed and that the teaching of technology today is far removed from the original intention as regards both elementary and secondary education. The purpose of this article is not to trace the history of the last 30 years but to understand why such ambition has failed, through a critical study of choices as well as lack of engagements of educational authorities.

The critique is epistemological in terms of the TE curricula as well as its integration in the school structure. Critique is also sociocultural, including understanding of the world in which humans are living and developing. It is ultimately educational whenever societies organise schools for the transmission and development of knowledge, including the interrelations between school subjects and the efficiency of the teaching-learning process.

Keywords Technical object • Individuation • Socialisation • Education

1 About Epistemology

The connection that we maintain with the environment, particularly the technical environment, enables us to establish relationships with the things that make it up. Understanding these relationships inspires many fields of research in social sciences. The designers of the first curriculum saw this teaching as one that would allow youth to build significant understanding of their world. They adopted a particular focus on applying socio-constructivist approaches and systemic

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interactions. They departed drastically from the previous manual and technical education and with technology as an application of science.

Translating this epistemological ambition into curriculum was the main difficulty encountered by the designers. Translating this ambition into school tasks is not easy, specifically in terms of the acquisition of knowledge and development of competences. In this section, we discuss how humans organise their relationships with the technological world they design, produce and use and how this epistemological approach influences the technology education (TE) curricula.

1.1 From Thing to Object

Education aims to organise the perceptible environment, from the most familiar to the farthest, into an intelligible world. This movement is based on the qualification of undefined things that occupy this environment into objects with which humans can know, act and think. To study this complex process, we refer to the theory of systems and the understanding of complex organisations (De Rosnay 1975; Ellul 2004; Le Moigne 1984; Le Moigne and Morin 2001; Morin 1991, 1992, 1994, 1995).

Understanding our environment depends on the objectification of the things that make it up and the networks of complex interrelations between different things. As Simondon theorises, human activity is largely designed to establish relations with these things, and the nature of the relations defines the nature of the objects we build (Simondon 1989a). This human activity becomes more complex with the increase in the complexity of organisations that help humans to act in their environment by rearranging or modifying it. In this sense, the mode of existence of technical objects, i.e. the production by a human of a relationship with one thing, is a manifestation of our attention to the social organisations by which and for which these objects exist. For now, we will look a little further at this process of creating technical objects understood as the objects produced by humans for a specific need.

A priori, understanding one's environment involves establishing relationships with the different things that inhabit it; the object exists when a subject is building a relationship with it; the nature of the object depends on the nature of the subject-object relationship. Technical objects are mediators of our relationship with the world. There is an inbuilt simultaneity in this relationship between the world of undefined things and the symbolic representations we develop to read and build objects that we handle, design, produce, modify, etc. (Simondon 2004). For example, a chair has existence only when a subject considers it in its environment, either because he uses it, or he wants to make one, or he wants to describe it. In all cases, the relationship he establishes will define a different object with which he will act differently—use, manufacture, describe, etc.—within its environment.

The undefined thing becomes an object when a subject establishes a relationship with it. This relationship represents above all a meaning that will guide the actions of individuals. Thus, the same thing can be at the origin of different objects depending on the nature of the relationship.

1.2 Object as Point of View

Each relationship established with the undefined thing presumes different points of view adopted by the subject. Each point of view defines the nature of each relationship and accordingly the nature of the object. The multiplication of point of view increases the ability to understand an undefined thing in its complexity and therefore in its entirety. Thus, a single point of view reduces the relationship to a cause-effect approach and reduces the construction of the object to a very particular case. This particularism is usually enough to explain a localised phenomenon. Going from explanation to understanding broadens from this localism by expanding the network of subject-object relations, on the one hand, and, on the other hand, by including this network in an organisation of interrelations (Simondon 2005). The diversification of point of view allows one to move from an explanatory mode to an understanding mode. The objectification of things that make up our environment is a process based on the subjectivity of the subject that establishes a special relationship in order to build a specific object. This definition of the subject-object relationship constitutes a major contribution to constructivism: humans are a 'machine' to build relationships that make possible the existence of objects (Simondon 1989b). This mode of existence of objects involves complex mental operations, such as categorisation, prioritisation, enlargement, deepening, development, stabilisation and transfer. Simultaneously, the individual learns to act on and with his/her environment and becomes aware of his/her ability to act.

The different points of view always contextualise the object thus constructed. This process of objectification derived from individual subjectivity allows us to specify the object in its environment and thus the subject characterises this environment. Neither the object nor the subject is isolated from its environment; the system so formed treats equally subject-object interrelationships, object-environment interrelationships and subject-environment interrelationships. For Simondon (1964), this process concerns the object just as much as the subject. It is constituted as an individual acting on and with its environment, which Simondon defines as individuation. Acting, explaining and understanding organise the relationship between a human being and his/her environment.

In line with the fact that the nature of the relationships determines different registers of human activities, the register of techniques defines the technical attribute of a class of objects (Andreucci and Ginestié 2002). An object is technical when it carries within itself a technique, that is to say, it proves it can achieve a predetermined goal (Séris 1994). More simply, techniques can be defined as effective traditional acts (Haudricourt 1988; Mauss 1936, 1948), highlighting the fact that there is no technique without transmission and, so without tradition, and no technique without significant material effect (Sigault 1990). The technical nature of the object implies its recognition as a human construction without any ambiguity about its mode of existence as a response to a human need (Simondon 2014). However, this external definition is no longer operative (Cazenobe 1987) when the materiality, causality and finality criteria cease to be supportive of each other or when we refuse to detach the human background from the material object in which it is embedded (Akrich 1987). This is the case, i.e. for the most familiar objects humans use, like a bicycle, pencil, mobile phone, computer, car, chair, etc.

In France, TE, in its first principles, aimed at articulation between action and understanding. TE was designed to provide for pupils the key for understanding their technical environment, i.e. recognising human activity in and with this environment, understanding the purpose and the organisation and ultimately building their own individual relationship with the world of technical objects (Deforge 1993). The curriculum considered the objects manufactured as products of human organisations and from four privileged points of view:

1. As a user, pupils identify the functions of use (which purpose for which need) and the functions of esteem (why a user would buy this object and not another one that responded to the same use).
2. As a family of objects, pupils recognise the purpose of this family and why and how one particular object is different of the other.
3. As a trader, pupils investigate the distribution of the product and the economic dimension of trade and sale.
4. As a manufacturer, pupils study the fabrication of the object with a special attention to its design by transforming all the functions identified at the three previous stages in technical functions and integrated solutions.

By specifying these points of view, the first French curriculum gives opportunity to pupils to elaborate a wide understanding of the mode of existence of technical objects, supported by the use of formal languages and skills. According to this approach, TE might enlarge understanding of the technological character of the manufactured object; but what are the effects of this teaching on the pupils' understanding? This is explored in the following subsection.

1.3 How Pupils Deal with the Concept of Technical Object

As we said, we could think that TE produces an extension of the concept of technical object. The results of a study conducted in the early 2000s (Andreucci and Ginestié 2002) show the limited understanding that pupils have of the concept of technical objects. It also shows that the extension given to this concept is becoming increasingly narrow in school. However, pupils seem to be able to tell the difference between animal and human fabrications. Furthermore, the nature of the material—natural or synthetic—used to achieve the object is not enough to recognise it as a technical object; the biological reference seems to retain the primacy of the technical character even if it concerns an explicit artificialism (e.g. a plastic flower). Pupils seem relatively aware that the notion of human production relates to the technical nature of the criteria.

The same study shows that pupils between 11 and 15 years old have a tendency to reduce the span of this concept during their schooling; they 'naturalise' objects more easily at the end of middle school than at the beginning. This trend does not apply to the category of the best representations, which remains stable over time; in this category, two objects, computers and video games, reinforce their status. Some objects (flute, artificial lake, wiring diagram, boiler, ruler, handsaw, photography, slingshot, handmade pull, pen, etc.) see their status deteriorate significantly to reach the category of poor or very poor representations. The ordinary technical objects, whose use does not justify specific school learning, become poor representation of the concept, while objects that require intellectual investment become good representations. This result is quite surprising when we consider this fundamental concept: a technical object exists because it is designed and manufactured to meet the need of users. These processes of 'naturalisation' or 'instrumentation' illustrate the instrumental genesis by which a tool becomes an instrument (Rabardel 1995).

In another study (Ginestié 2002), we observe that teachers massively focus their school organisation on design-manufacturing and they widely provide pupils with instructions to follow. They reduce the situations of problem-solving. In fact, the technical nature of the objects does not result from school tasks of design-manufacturing. This choice shows, on the one hand, the epistemological limitations of these founding principles and, on the other hand, the limitation of approaches like 'learning by doing'. The question of the activities' purpose becomes central.

1.4 From Gesture to Word

The link between the action and the meaning of the action is just as essential as the subject-object relationship. The French translation of *understand* is *comprendre*, which means *take with*. This clearly fits into the register of actions on and with the environment: humans act knowingly. This awareness of the action simultaneously creates the foundation of the skilfulness (the action) and the meaning of the gesture (the understanding of action). This simultaneity is a key element of individuation; it fits in a constructivist perspective and understanding appears as a very high level of learning (Simondon 1989b). Establishing relationships with the environment involves close articulation between the way to do something and the purpose (why do it and, above all, why do it in this way). Simondon agrees with anthropologists that action is always aimed towards a goal—of which the subject is aware or not—and requires organisation to be realised. The development of understanding involves knowledge acquisition.

For anthropologists, knowledge is a social construction that conditions the development of an individual; he/she constructs his/her own knowledge to enable him/her to act in and with the social group to which he/she belongs. This individual enlarges his/her capacity to act on and with his/her environment by enlarging the field of knowledge (understanding more things) and by deepening some of them (understanding better and better). Objects, relationships, descriptions, representations and symbols all lead to organising and stating human exchanges with the world of things. The development of understanding is a dynamic process with acute consciousness of the action. There is no real hard evidence of the need to develop high-level language to develop techniques but the two always go together (Leroi-Gourhan 1989). Humans simultaneously manufacture tools and symbols (Latour 1991; Rashed 1997). It is the final orientation of their activities that gives meaning to the practice that organises a praxeology indicating ways of acting (Castoriadis 1999). The elements of social diffusion ensue from these ways of acting collected in the praxeology, and this makes the transmission active because it has been enriched with new ways experienced by others (Séris 1994).

The development of technologies and the evolution of tools and objects are systematically accompanied by a development of language (Leroi-Gourhan 1973). Acting evolves with the modes of symbolic representations that describe it (Castoriadis 1975). The completion of an activity refers to the objects produced by humans, to objects that result from activity and which give rise to symbolic elaborations (Latour 1992). An object does not exist at the fleeting immediate time of its use, but it is registered in a more global scheme of meanings, specifically in the register of the potentialities which organise human activity (Wallon 1979). In fact, this dynamic generates another temporality and a new generic order that superpose the temporality and the natural order (Althusser 1994). The established relationship, which simultaneously generates objects and activities on and with these objects, causes a change in the status of the object that becomes a tool as soon as it is registered in this relationship. Tool and word have empirical existence immediately doubled by a universality; they are tool or word as concrete instances of this tool and this word (Leroi-Gourhan 1992). The process of individuation gives the reality and the appearance of control by the individual user but also the appearance and the reality of the control of tool and word over the individual for whom they pre-exist and that could not be without them (Althusser 1986).

This semiotic mediation broadens the subject-object relationship; the object becomes a socially shared tool, carrier of a tradition of uses and meanings that simultaneously determine the manner of use and the aim of such use.

1.5 Languages as Structuration of Codes and Symbols

The codes and the symbols that describe the objects-tools and define their possible fields of action with and on these tools are organised in specific languages according to a grammar, a syntax and a semiology. Languages symbolically organise this double arrangement of procedural schemes (how to do it) and semiotic schemes (why do it in this way). Language, as symbols organisation, makes sense of the continuity from the thing to the object, then to the tool, by making intelligible relationships. The structure of languages, whether for thinking or communicating, is formal: language puts into words that which represents the abstract tools in a meaningful way for oneself (understanding) or for others (communication). The formalisation of the description of the expected outcome also requires a clear description of how to achieve it. The achievement of the task as intended involves formalisation inevitably accompanied by a rationalisation of the arrangement of the means to implement it. Some of the emerging technical characteristics can be attributed to languages. This is the first formalisation of a prescription from the very specific perspective of the expected outcome.

It is also a normalisation as soon as one invites the dialogue partners to adopt a single perspective. Using a set of rules and descriptions of symbolic significance stems from the construction of meaning when it is concerned with the relationship between the signifier and signified. The development of techniques goes together with the development of technical languages. At the same time, the number of languages increases and extends their universality. For example, standardisation efforts have largely left the workshop to extend standards (i.e. AFNOR, CEE, ISO, etc.). The formalisation, description, precision and standardisation of relationships are of course a matter of abstract codes and symbols that make the objects more real when the subject knows about the languages used.

The mediating role played by technical languages has been widely studied in many works (Bessot and Vérillon 1992; Rabardel and Weill-Fassina 1987; Weill-Barais 1997; Weill-Fassina and Rabardel 1985). Indeed, in these approaches, technical languages appear as structuring factors of human action at the same time as they allow us to structure their thoughts. The aim is to reflect on a particular view of an action process. The logical formalisation activity is related to the language because, on the one hand, it autonomously produces statements and, on the other hand, these logical statements can themselves be heteronomous with other statements (Wittgenstein 1961). The technical languages are tools for the formalisation process of concrete achievements. A design drawing says nothing about the designer, let alone the workers responsible for carrying out the design. On the other hand, it allows their actions, the material they handle, how they manipulate it and the result to be codified. There is an extraction of individual praxis of a praxeology that tends to depersonalise this description in order to generalise to the same class of problems regardless of the actors. This process of depersonalisation and contextualisation induces the level of description of generality of a language. This level determines the language's extent to a more or less large community who shares the same meaning unequivocally.

Our ability to produce symbols and to communicate with and through them makes our system of values very unstable. For example, reference to *natural languages* appears to facilitate the understanding of a very artificial environment and accredits the idea that the natural order predominates artificial orders. This inversion of signs is in flagrant contradiction with the development of human social organisations, based on the domination of the natural order by the growing of techniques and languages that allow description, transmission, development and so on. This *naturalisation* of a language by its mastery is closer to the process of *naturalisation* of technical objects we observed.

The semiotic development supported by TE tends to naturalise the relationship to the object and consequently the object itself. This same process is at work when a user loans intentionality to the object he/she uses.

Fundamentally, for a large number of actors in France, TE is not closely linked to the role of specialised languages and teaching these languages because building relationships with the technical environment appears as a premature specialisation. For these promotors of ‘learning by doing’, technical languages are too conceptual, abstract and theoretical. In fact, they promote a procedural approach to achieve tasks based on skilfulness and techniques, and they don’t engage with a semiotic approach based on meaningful elaboration. This choice, in contradiction with Simondon’s individuation theory, reinforces the differences between sciences, as the place where pupils think, and technology, as the place where they apply and make, i.e. pupils study the electricity circuit principle in sciences and they apply it in technology by building an electric torch. This approach does not provide a real understanding of what an electric torch is; Ohm’s law doesn’t explain this. The French curriculum emphasises the development of scientific knowledge through an experimental approach; at the same time, TE aims at mastering professional skilfulness and meanings on the social division of labour, widely based on manufacture organisation (workshop, methods office, design office, etc.) and skill levels (from worker to engineer). This reference to the ‘real’ industrial world is widely present. The evolution of TE curricula, also including an introduction to science and technology in primary schools over the past 30 years, swings between these two approaches. If the relationships that an ordinary person has with the world of objects he/she manipulates and uses daily are widely present in the curricula, this approach do not find legitimacy in the teaching practices. All the constituent principles of different curricula include this educational dimension of future citizens but without any consequence in teaching plans. Should this education focus on life lessons in which a technical object is studied from every angle? Should pupils study the mode of existence of this object through tools and successive transformations and the social organisations in which this object exists? The answer is not simple and the reality is probably even more complex.

1.6 From Tool to Instrument

The semiotic networks, supported by specific languages, allow a potential action to be assigned to each object created by a relationship and given the status of a tool. The action is part of a project with a goal that can be explicit or not and is organised in the activity of the subject. The tool thus defines a potential action that organises the activity field by setting a field of possibilities. The status of a tool is not an intrinsic characteristic; its recognition as such is based on familiarity, social utility and potentialities. An object could be recognised as a tool by one person and not by another; i.e. a chair is easily recognised for a large part of humanity as the tool to sit in and not for those sitting Indian style on the ground.

Recognition of tools is an ordinary educational situation. A teacher knows the usefulness, the social significance and the potential of the tools he/she introduces in his/her teaching; he/she purposes tasks to organise the discovery of these tools by pupils, and, in fact, he/she expects that pupils recognise the situation as a possible domain of use of these tools to act with and to develop new knowledge. Tools allow a pupil to improve his/her performance, increase the quality of the solution and aim at greater satisfaction. The link between procedural schemes such as *instrumentation* (how to do it) and semiotic schemes such as *instrumentalisation* (why to do it in this way) defines an artefact that simultaneously includes the action, the meaning of this action and the values that guide the whole. This artefact becomes an instrument that supports the subject's activity to reach his/her goal. Therefore, the mastery of the activity is characterised by knowledge and defined as the organised power of action.

The activity is the motor of learning: it defines the organisation of actions produced by a subject to achieve a task. This logic of organisation characterises the strategy for fulfilling the task completion. This strategy is planned and structured a priori. The procedural and semiotic schemes are highly automated with increasing expertise, thanks to the acquired experience. Expertise includes the forecasting and planning that guides the activity through the execution of actions (which actions, in which arrangement, when and for which expected result) in a permanent appreciation of the difference between planned strategy and results. From this perspective, understanding becomes an instrumented activity as instrumental genesis. This complex mental process characterises expertise; ultimately, the gesture performed, the task carried out, seems very simple, independently of their real complexity. The appropriation of the technique by the individual explains the close link with invention and a creative act.

This irreducible dimension of originality at work in all human activity, even in the most automated skilfulness, guarantees the possibility of renewed questioning about the meaning of this gesture, of this technique and of this work. At the end of his documentary, the director Henri-Georges Clouzot tells the painter Picasso of his wish to see him create a masterpiece in 30 min. The painter replies: *No*, *not in thirty minutes*, *Mr. Clouzot, but in seventy-five years and thirty minutes* (Clouzot 1956). He implies that the originality of the object lies not only in the implementation of the technical gesture but in the meaning given to it through the experience gained in a long reflexive journey which in turn changes and determines the technical gesture.

1.7 Understanding Through Expert/Novice Activity

The set of interactions between the task to be carried out, knowledge available and activity deployed to achieve it defines the learning situation. A new task produces new knowledge if the subject cannot achieve it with his/her existing knowledge. Spontaneously, the subject tries to address the task with what he/she knows; the willpower to achieve this task implies a conflict. This inability to produce a socially satisfactory solution creates an imbalance, and the subject seeks ways to produce a solution, searching in his/her social environment for new and available tools. He/she develops new relations with new things and tools for the social group in which he/she lives. At the same time, he/she develops procedural and semiotic schemes;

he/she builds a new instrument for acting, that is to say, an operational instrument for achieving this new task. This new instrument has produced a new structure of his/her knowledge that integrates these new schemes and, in the end, a new knowledge—new knowledge that allows him/her, on the one hand, to enlarge the ability to act on and with his/her environment and, on the other hand, to extend his/her understanding of his/her world (Cheneval-Armand and Ginestié 2009). Learning is the result of a new problem that arises for the subject, far from the reproduction of gestures acquired by mimicry in a linear logic; it is a logic of adaptation of the gesture to the situation.

Many authors (Béguin 2007; Bonnardel 2009; Borgmann 2001; Chevalier et al. 2009; Christiaans and Venselaar 2005; Coles and Norman 2005; Darses 2009; Dorst and Cross 2001; Engeström 2000; Fortus et al. 2005; Kroes 2002; Lebahar 2007; Liu 1998; Mathews and Swainston 1992; Tricot et al. 2006) deepen the analysis and understanding of the activity of experts in situations of problem-solving. They focus on the initial description of the problem as the most important part of the activity, allowing an expert to establish the orientation's base of his activity by organising the planning of actions in time. The solution is the consequence of this initial description and the choices made at this moment. Three phases divide the initial description of the problem: (1) a basic description of the problem, (2) a theoretical description of the problem and (3) an exploratory analysis of the problem to ensure some qualitative properties of the solution. This initial description is difficult to analyse. It is a mental activity, which does not leave particular traces. The routines used by experts are familiar, with a high level of automation. The initial description organises an orientation base of activity; an expert progresses step by step, following this orientation, collecting information that confirms or not the effectiveness of each action, anticipating the results and continuing with the same plan (or modifying it).

In contrast, novices make a partial initial description; they discover a small number of constraints, mostly explicit constraints. They adopt a strategy of immediate transformation of the constraints, one by one, into local solutions without integration in a comprehensive solution. They have a poor idea of the expected result and progress by trial and error. The general solution is a collection of local solutions that are more or less complete (Amigues and Ginestié 1991).

A teacher has to organise the conditions of initial description. Classes are organised as workshops with a large autonomy devoted to groups of two or three pupils. They have at their disposal a description of the job to be done, a technical dossier and the tools and resources to do the job. In many cases, there is a detailed description of the order of actions to execute. By this description, the teacher shortcuts the initial description of the task, indicating the orientation base and the planning of actions. Guided in the task's achievement, pupils perform the task with a good rate of success and obtain a solution which conforms to the expectations. But, because they are centred on a procedural resolution of the task, without 'real' problems to solve, they just enact procedural schemes and they have a very poor construction of semiotic schemes. Finally, they perform the task with a low level of understanding and learning. In this perspective, TE appears to be a subject without any great interest (Ginestié 2008b).

The initial curriculum aims at helping pupils to understand the world of objects produced by humans and to be aware of their ability to use them for acting with and in their environment, but epistemological reflection was not sufficiently deep to give a sufficient ambition to TE. Pedagogical guidance, coupled to few 'real' problem-solving situations, reduces the impact on pupils' learning.

2 About the Sociocultural Inscription of Technology

By focusing on the relationship with the world of technical objects, TE gives prominence to the pupils' individuation. Their sociocultural dimension remains largely implicit. Development of technologies suggests a discourse on technique within a sociocultural tradition where innovations meet specific social pressures. TE, in the first curriculum, claims to understand a technical object within the social organisations for and through which it exists and aims at understanding this not only in terms of structural aspects of technical objects but also as social facts. It is not enough to answer the question 'how does it work?'; we should also ask 'why does this object exist?' and 'why does it exist in this shape?'.

2.1 Object as Social Artefact

The construction of a discourse on technique enlightens human and social sciences such as history, anthropology, ethnology, sociology, economics and ergonomics (Perrin 1988; Sigault 1985; Spengler 1969). Consider Simondon's theses on the promotion of awareness of the meaning of technical objects in their social reality (Simondon 1989a). Objects contain a human reality in order to fight against any blindness towards technology, whether in terms of technophobia or an unconditional acceptance of progress. Awareness of the existence of technical objects is consubstantial to consciousness of the existence of the subject as an individual and as member of a particular social group: *tell me what objects you are using (and how you use them) and I tell you who you are*. If the technical objects appear in a special human context, conversely, the human is also part of a technical universe that existed previously, governing and changing his/her future. Lecourt (1997) illustrates this double game of influence through evolutions of the digital world. Based on the banalisation of these technologies (computers, notepads, smartphones, etc.), this world becomes unattainable for the one who ignored this, not because he lacked a service he has today, but because his future is profoundly modified, whether it involves his objective relationship with time and also all its emotional relationships with others. Techniques are not external to humans; they are derived from life and integrate and set out its standards (Lecourt 1997, 2009). In other words, there is a positive mutual inclusion of human life in the world of technique. This does not exclude appropriation by the user of the object but generates invention and creativity; the sociocultural dimension exists through the tools that human groups use, share, develop and create.

We just underline the power to act that the instrument gives to each human and, by evidence, the role of TE as the way to access to tools that characterise the social group in which the young live. In this sense, the transmission of tools is the process of conservation, including intergenerational, of their achievements; it is also a process of development and expansion as these sharing tools are based on the sum of the knowledge constructed by each individual who composes the group. Conservation is a process of withdrawing into oneself, into one's social group, whereas development is a process of opening up to others.

2.2 Dialectic Socialisation-Individuation

In French, the term knowledge has two significations:

- *Savoir* mainly refers to the individual's potential for acting; it describes the knowledge, the know-how and the values brought by the person. It defines the individual's understanding and represents his/her potential of actions (consciousness within the individual of what it is possible to do because he/she knows).
- *Connaissance*, which mainly refers to the social institution, defines the social heritage and represents a potential of knowledge (awareness of the individual that, in his/her environment, there is a social group who knows).

The acquisition of *savoir* by an individual thus allows him/her access to *connaissance*. The awakening to this double level of consciousness, self-awareness and consciousness of the other, is a strong element of learning process, based on the individuation and socialisation of the person. Knowledge is structured through this dialectic tool-instrument in which *connaissance* is linked to the tool, whereas *savoir* is linked to the instrument. Procedural schemes are easily identifiable; semiotic schemes fall within this interpenetration between the meaning that each gives to a thing and the meaning commonly assigned to this thing by the social community. This interpenetration induces the nature of the relationship by simultaneous combination of both the processes of:

- Socialisation, by using a car, a knife, a chair, an idea, etc.; the individual marks his/her belonging to this community that produces and uses such objects.
- Individuation, by marking his/her familiarity of these objects he/she uses as my car, my knife, my chair, my place, my job, my idea, etc. (Lebahar 1994).

Such dialectic testifies to the complexity of these relationships and aims to open up many other essential debates out of this paper. In sum, the broad sharing of the same objects, the same categorisations of these objects and the same tool-instrument potentialities defines the homogeneity of a social group. Languages, whether general or very specialised, are the semiotic instruments that allow members of a group to share their uses, their potential and their mode of production or evolution. The logic of conservation aims to preserve the homogeneity of the group by standardising these exchanges, codifying and developing them.

Expression like ‘good usage or practice’ valorises the individual praxis in the light of social praxis shared by the group. Doing as others do while proclaiming one’s own personality is an ongoing internal dialogue that generates socio-cognitive conflict, i.e. a tension between the desire to conform to the group and the desire to mark one’s difference. Far from reproducing a gesture identically, humans transform and modify the gesture unpredictably. The example of the above-mentioned smartphone, as trivial as it is, reveals that its use is not the same for everyone. Depending on the person, it can become a *negation of its existence*, for those who are de facto ignored (partially or entirely) by the user, or as a means *to expand the spectrum of feelings and reasoning*, an instrument for work or for socialising (Schwartz and Durrive 2009). The group becomes heterogeneous through its openness to other individuals, even if it is only to ensure the intergenerational transmission necessary for its own conservation.

From a systemic point of view, phases of instability and stability alternate. This alternation allows stable states, as an unstable equilibrium position, to be found after destabilisation phases generating evolutions. The slightest disruption—i.e. the affirmation of a new point of view, new idea, new method, more rational, more cost-efficient, more effective, etc.—will undermine the internal organisation. Therefore, the group will reorganise itself to find a new unstable equilibrium position, thus initiating a new stable phase. This process is a permanent dialogue between tools that constitute the heritage of the group and the instruments brought by the individuals. The incoming of new *savoir* brought by an individual unsettles the organisation of the *connaissances* of the group and vice versa. The stakes of knowledge are always stakes of power. Evidently, it is easier to promote instruction based on access to *connaissances* than education based on elaboration of *savoirs*.

2.3 Understanding as Complex Social Activity

Understanding, in the sense built here, is a decisive issue in education and an ambition in 1985 for the TE curriculum. School is responsible for giving meaning to social actions of pupils in their social community, and TE should help them to develop relationships with their environment, which is highly technologised. This idea is not new. For Dewey, technique and innovation offer a better understanding of our environment that science alone cannot make intelligible (Dewey 1916). Educated citizens are aware of the essential terms of their environment. Sharing the democratic control of development in our societies involves educating pupils in the social logic of the technological world. Knowledge sharing is performed in order to share power.

Technology, taking effect in the heart of human activities, breaks barriers that previously separated people; it expands human relationships. It creates the interdependence of interests on a wide scale. It brings with it the belief that mastery of nature for the benefit of humanity is possible and leads humans to look at the future and not the past. Now they look at the future with the firm belief that well-used intelligence can free us from the evils formerly thought inevitable. It is no longer a dream that devastating epidemics can be overcome; it is realistic to expect to overcome poverty. Technology has familiarised us with the idea of development in the gradual and constant improvement of the fate of the human community (Dewey 1916). This way of thinking at the beginning of the last century was present in the ambition of the first TE curriculum; 30 years later, this hymn to the glory of progress has been widely questioned. Without engaging in philosophical or political debate on the values of progress and its consequences, we can see that these 30 years have shown the social role played by teachers and schools faced with social evolution (globalisation of the economy, impact of technological developments on the natural environment, increasing social inequality, etc.). These debates have affected particularly the community of technology's teachers regarding the meaning of their teaching and its relevance. The curriculum has been progressively expurgated of all these points of debates. It has given gradually priority to the realisation of procedural tasks (by guidance of actions) to the detriment of the construction of social meanings.

The development of the guidance of action is not a simple pedagogical convenience; it is also a way to eliminate any significant alternative to the construction of critical sense by pupils. Faced with non-problematic tasks, guided in achieving them with a low autonomy of action, pupils repeat storylines written by the teacher that they perform without great motivation. At the end, they express little interest in TE and a disaffection with this teaching. Several studies conducted during this period show this (Ginestié 2002, 2005, 2008a, c).

3 Education for Developing Socialisation Through Individuation

If we want human communities to continue to improve, it is necessary for education to give young people the intellectual means of invention and innovation (Howes 2008). This formulation sounds like a slogan: education is the way to develop humanity. By linking the fate of human communities with the development of intellectual means, Howes makes explicit the relationship between *connaissance* and *savoir* and between socialisation and individuation. TE is a way to awaken youth to collective knowledge to empower them to invention and innovation, i.e. to carry on in turn the progress of knowledge. For school entry, knowledge is organised and grouped into fields that integrate progression, what needs to be studied and the order in which it is studied, concepts and procedures for the use of these concepts. School subjects are social constructions supposedly representative of the social knowledge they organise, but there is not a direct link between both.

The reconstruction of fields exclusively for teaching is fragile because they do not derive from social references but were organised for teaching. The references have no particular role in the definition of knowledge for school purposes (Cheneval-Armand and Ginestié 2009). Based on a traditional academic dividing, school subjects no longer meet the modern challenges of teaching, education and training (Johsua and Dupin 2003). The logics of structuration of school knowledge have tended to give themselves a coherence of progression that is all their own. The disaffection linked to low social enhancement of technological studies adds to the lack of interest related to the organisation of the teachings mentioned previously.

The role of the teacher, specifically for TE, extensively evolves with the changes of traditional school organisations. The meaning of a school for all changes the balance between instruction and education under the pressure of the acceleration and globalisation of sources of knowledge, through the digital networks. This dynamic promotes a comprehensive approach to the social, economic, cultural and technical environment of the pupils. The school can no longer play the almost exclusive role of transmitting knowledge; the mastery of knowledge slips gradually and resolutely towards the control of access to knowledge resources.

If we follow the thesis of Simondon, learning is the construction of relationships that will allow the pupil to act with instruments he/she constructs (Rabardel and Béguin 2005). This thesis is quite relevant to the evolution of school organisations, on the one hand, and, on the other hand, the logic of learning of individuals. The teaching-learning process is the result of the confrontation of the three separate logics: of the curriculum, of the teacher and of the pupil. Referring to the theories of activity, the school situation is characterised by the task entrusted by the teacher to the pupils but it is not a guarantee of the engagement of pupils to complete the task.

It is not enough merely to give a problem to a pupil and ask him/her to solve it. The teacher must play a decisive role in pupils' efforts to become involved in the task as well as to supervise their activity. The different modes of interactions put in place by the teacher characterise the different kinds of teaching-learning processes. They determine whether or not devolution of the problem occurs and whether or not pupils make progress during its accomplishment. This process is one of the key elements in constructing knowledge and pupils' cognitive progress, notably through discursive episodes. The teacher plays the role of facilitator in building knowledge aims (Roux 2003a, b, c; Trognon et al. 2006). The task must exemplify the importance of the knowledge targeted by teaching. The obstacles must be salient and the learning environment must allow for overcoming them. The task must allow supervision of the pupils' learning activity. Pupils must do things they have never done before; the problem must be original, and the pupils must identify obstacles they need to overcome in order to find the solution within the constraints incorporated in the problem. The pupils use the task-oriented environment; they choose the available resources (or the means of accessing them). In order to overcome each obstacle, pupils plan a chronology of their actions and structure their activity by defining and by anticipating the use of available resources aims (Rabardel 1995; Vérillon and

Andreucci 2006). Such task organisation goes beyond the procedural descriptions usually detailed in the traditional guided learning (Verillon and Rabardel 1995). In fact, the problematic dimensions of a situation must be recognised as such by the pupil. The teacher cannot claim that this task is a problem to solve for him.

The teacher can impose on the pupil the achievement of the task as school duty, but not to solve the problem. It is not easy to design and build tasks, which make the obstacles salient, which make resources available and which organise the conditions to maintain their activity. This supposes the dynamic management of interactions between teacher, pupils and knowledge, which is not in the tradition of French schools; the teacher is tempted, through these interactions, to lead pupils to the solution by imposing his/her own logic.

4 Some Conclusions

How should we understand the current situation of TE in France? The curriculum was designed on a particularly relevant epistemological foundation; numerous researches have widely accompanied its establishment and its evolution for 30 years, and, at the end, we observe the disaffection of pupils and the lack of learning. The answer to such a question is not black and white; however, it is very significant in terms of the evolution of the French educational system during the same period. Many surveys (such as OECD's PISA) show that the gap between the educational attainment of young people is increasing and these differences add to the social inequality. A very old elitist tradition, reinforced by the strong logic of academic subjects, contradicts the democratic principles of free education for every child, whatever his/her social origins, for ensuring equal opportunities.

From the early years of primary education, school performances are the baseline of pupils' assessment, and the school subjects' hierarchy accentuates the place of abstraction and encyclopaedism. In this genesis of education in France, the main way of study is general education. When a pupil fails, he is *oriented* in a technological or vocational course, to reach a professional diploma; the diploma level determines the level of the intended job and therefore the level of social integration of the young graduate. This system was efficient to help France to move from a rural society to an industrial economy, but it has resisted neither mass education nor the economic and social evolution; for 40 years, education policies have tried to make the education system come closer to the needs of contemporary society.

The introduction of TE for all, and we can appreciate the magnitude of the ambition of its designers, was an answer to this evolution. Based on the understanding of the environment, it was also a break with the established hierarchy of school subjects; technology was no longer where pupils made things but the place where they understood why. By articulation of action and reflection in problem-solving situations, it proposed to develop original educational project-based approaches.

This chapter raises some critical issues that allow understanding of the failures and successes of the implementation of such education. Two major lines of action emerge from this educational policy. The first axis concerns the curricula relating to TE but also to other academic disciplines such as mathematics, science, French, history, arts, etc. Curricula should foster broader articulation of individuation and socialisation and be less prescriptive about how to teach and more open on issues of knowledge that make sense socially and culturally.

The second axis concerns the evolution and the increase in skills of teachers, constantly evolving, oscillating between formal academicism and professionalisation. Training should allow future teachers to acquire knowledge and develop the skills necessary to implement changes in curricula, to design and develop educational situations that give each pupil the opportunity to be constructed (individuation) within the framework of social, economic and cultural society of the twenty-first century (socialisation). This second axis means that teaching is a profession that is learned. Teacher education supposes to give meaning to this job; it is not a sum of encyclopaedic knowledge and skilfulness.

In 2013, a big reform opens up these projects explicitly of recasting schools. It aims at a profound change in curricular structures, including emphasising the interdisciplinary, rethinking the academicism of the learned knowledge and paving the way for educational practices that promote a project-based approach and problem-solving. It inscribes teacher training within a university vocational education at master's level. To support these axes, it anticipates the development and structuring of research in education. The goal is explicit: education seeks to educate citizens who can think for themselves, extrapolating from 'I possess therefore I am' to 'I think therefore I am'. The philosophy of the Enlightenment continues to inspire French educational policy!

Beyond this critique of the French curriculum, this chapter brings a contribution to a more general approach of technology education as a tool for critiquing other curricula. The dialectic individuation-socialisation is another way to think of the place of TE as essential part of modern education for all. It highlights the importance of better understanding the teaching-learning process, including through teacher-pupil and pupil-pupil interactions and the effectiveness of organisations implemented. As we have seen, the place and the role of TE in our modern education systems involve many different approaches to be considered and implemented. The construction of this theoretical framework involves references to philosophy, anthropology, sociology, psychology and ergonomics but also the engineering sciences and the sciences in general. Thus posed, this framework is revealed to be a great tool to analyse the actual activity of pupils and teachers and so to query the real curricula. This perspective opens some opportunities for international investigations.

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