Technical Objects Between Categorisation and Learning: An exploratory case study in French middle school

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Abstract
In this article we present exploratory research carried out in order to understand how students (from 12 to 14 years old) relate to technical objects. It uses technical objects that are part of everyday life and mediated reality. A questionnaire was administered to 57 students in French classes. The questionnaire was composed of three parts: 1) the detection of technical characteristics of objects; 2) the ability to create relationships between objects; and 3) the direct use of technical objects and personal interest in sciences and technology. The results show the complexity of the relationship with technical objects and the need for an educational mediated intervention of design and technology education.

Key words
artefact, technical object, categorisation, learning, technological education.

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The Mediation of Technical artefacts
Oral and written language, texts, musical and scientific instruments are all example of artefacts. This concept, in fact, encompasses several kinds of objects. They are produced by human beings and serve as mediation between the subject and the environment (Vygotsky, 1978). Several authors have stressed the social and cultural dimension of artefacts, particularly developed in the framework of the activity theory (Engeström, Miettinen & Punamaki, 1999; Leontiev, 1975).

French research has particularly focused on the concept of a technical object (Andreucci & Ginestié, 2002; Cazenobe, 1987; Mauss, 1936; Sigault, 1990). We can find different definitions that help to understand the specificity of this concept. An object is characterised as "technical" from the moment it brings a technique. In other words, a technical object brings an action that is traditionally effective and with considerable (physical) effect (Haudricourt, 1988; Mauss, 1936; Séris, 1994; Sigault, 1990). Specifically, Rabardel defines technical objects as "anything that has undergone a transformation of human origin (...), which is ready to be used, developed in order to be part of finalised activities[1]" (1995: 59). In fact, according to Ginestié (2011), the material nature of the object integrates a human intention of manufacture: it explicitly carries the goal for which it was designed. In other words, the technical object becomes a necessary mediator in the relationship with reality (Akrich, 1987). Understanding the characteristics of technical objects becomes necessary for a more conscious relationship with the world around us. The wide range of applications, such as biotechnology, medical implants, and genetics innovations highlights the increasingly complex and hybrid development of high-technology. Such a context brings out the importance of establishing processes of sense-making and problem solving based on technical knowledge to allow people to take more informed choices about energy, climate issues, use of resources, etc.

In this paper we will focus specifically on technical artefacts and technological literacy. Indeed, as suggested by Ineke and de Vries (2012), understanding the nature of technical artefacts is a relevant part of technological literacy. The specificity of technical artefacts has long suffered from a lack of attention and reflection. In particular, the research has shown a limited interest in technical objects and on the cognitive implications derived by their social use (Andreucci, 1990, 2003, 2007; Andreucci & Roux, 1992). Considering this perspective, the purpose of this article is to understand the relationship experienced by students in the middle of technological literacy education at school. This relationship is influenced both by a cognitive dimension and by the learning process. To understand this process, we present below a brief review of studies about the categorisation of artefacts and specifically the French perspective on Technical objects. Then, we present the structure and the results of the survey conducted in a middle school in France. In our opinion this type of research has the potential to contribute to the debate around Technological curriculum and design of objects and their impact on social and work environments.

Categorisation of Technical objects
Knowledge is directly acquired through interaction with the world and concepts are understood as a distributed and flexible pattern of neural activation that recalls specific situations (Barsalou, 1999; Lakoff & Johnson, 1999). According to current literature, primary organization of our knowledge is not stable and abstract, hierarchical, or

[1] Original citation: « toute chose ayant subi une transformation, d'origine humaine (...), susceptible d'un usage, élaborée pour s'inscrire dans des activités finalisées

taxonomic, but is thematic and located, flexible and linked to contexts and situations (Borghi, 2002), with a central role of social dimensions. Indeed, there are multiple ways to build categories and everyday reasoning is fluid and dynamic, providing a qualitative activation of information (Reyna & Brainerd, 1995). Access to a given type of knowledge organisation is strongly mediated by the contexts, experience and purpose of our actions (Barsalou, 1987; Borghi, 2002; Smith, 1995). As suggested by Solomon, Medin and Lynch (1999), categorisation is only one conceptual function among several and concepts serve multiple functions which interact with cognitive structures and mental processes. Smith (2005) argues for a dynamic systems approach to cognition: the continual coupling of cognition to the idiosyncrasies of the here and now makes cognition relevant and provides the mechanism for developmental change.

To understand the classification of artefacts, a first step to consider is the distinction between living beings and non-living things. In fact, many studies have been done on the ability of children to make a distinction between living beings and non-living things (Inagaki & Hatano, 1996; Kalish, 1998). The essential natural concepts are the internal and genetic properties that are not altered by superficial changes; for artefacts, the perceptual properties are essential (Gelman & Wellman, 1991; Medin & Ortony, 1989). In addition, the research of Kalénine, Garnier, Bouisson and Bonthoux (2007) shows that the search for common functions generates progress in the categorisation of artefacts but not in the categorisation of natural objects. Also, as noted by Brandone and Gelman (2009), children and adults produce more commonly generic noun phrases (e.g., birds fly) about animals than artefacts. Furthermore, Rhodes and Gelman (2009) demonstrate that young children, like adults, view animal categories as natural groupings, but artefact categories as more conventionalised.

In relation to the artefact categorisation, Malt and Sloman (2007) suggest that the elements for the categorisation are: physical features, current function, original function intended by the creator, category membership intended by the creator and features having a particular causal status with respect to other features. Specifically about artefacts, Puebla and Chaigneau (2014) conclude that when participants received complete information, they based their categorisation on individual properties and did not show evidence of using inference to categorise. In contrast, when the state of some property was not observed, participants gave evidence of using available information to infer the state of the unobserved property, which increased the value of the available information for categorisation.

The research for this paper focussed on the specific field of cognition about the categorisation of technical objects. In French literature, specific research has been conducted to understand the relationship between objects and organisation of technical knowledge of students. This interest arises from the need to know more about the technical domain (Séris, 1994). In this way it is possible to put order in the diversity around us and build relationships with other objects, starting from relationships and knowledge already acquired. Among the different studies, Andreucci and Ginestié (2002) show that pupils (aged 12 to 15) provide limited meaning to the concept of a technical object. The diversity of objects they categorised under the concept of technical object decreased with age: indeed, pupils tend to exclude from technical objects many artefacts like food products, clothes, and buildings. These results were confirmed by Lasson (2007).
We present below our pilot study that was carried out in order to understand how students relate to technical objects from their environment.

Study

Objective

The purpose of this exploratory study was to trace the relationship of students (aged 12-14 years old) with technical objects that are part of everyday life, such as in school, with family or with peers and mediated reality from textbooks, from schooling or media. In this way we wanted to explore three aspects related to: 1) General understanding of technical characteristics of objects; 2) Ability to make relationships between objects; and, 3) Personal and direct use of technical objects.

Participants

The participants were 57 students aged between 12-14 years of age drawn from two different classes in two different schools. Technology education in France is compulsory for all the pupils from 3 to 15 years of age. Specifically, at elementary level (3-11 years) scientific and technological education is associated with guiding the children in the discovery of the world in which they live. Later, for 12-15 year old students, technology education becomes a full school subject, oriented to convey the existence of technical objects and the social organisations that produce and use them.

Methodology

To develop this research it was decided to use a questionnaire with mainly closed questions. The questionnaire is a method designed to collect information on the variables under investigation. Usually the categorisation of objects is carried out in small workshops with a limited number of subjects or directly face-to-face

Item	Not an object	%	Item	An object	%
1	Salad	90	1	Bike	90
2	Volcano	88	2	Scarf	86
3	Tulip	84	3	Sheet of paper	74
4	Boiled egg	76	4	Train	54
5	Nuclear power plant	70			
6	Milk cow	70			
7	Jam	66			
8	Plane tree leaf	66			
9	Home	58			
10	Submarine	58			
11	Bird's nest	50			
12	Uranium	49			

Table 1. Items classed as Not an object or Object

between the subject and the researcher. In this research, it was decided to use the questionnaire as a pilot for future extensive research.

The short version of the questionnaire is reported in the Appendix. (The original version administered to the students was in French). In line with our research objectives, the questionnaire was composed in three sections and 18 questions, organised as follows:

- Part I: detection of technical characteristics of objects (five questions);
- Part II: ability to create relationships between objects (ten questions);
- Part III: direct use of technical objects and personal interest in the technical and scientific (three questions).

The specific questions for each part have been developed in a process of tuning between research interests, the literature on artefacts and adaptation to the generic didactic objectives of the curriculum of the French Technological Education in middle school. To improve the understanding of the students, it was decided to use images, which allow the reader to gain more immediate understanding and did not penalise students who had not fully mastered reading skills. The images were selected on a criterion of representativeness, which would make the main elements visible. Where possible the images selected come from French textbooks of Technological Education. All the items in each question were presented in alphabetical order. The questionnaires were administered manually to students in classes in a paper version, directly by the teacher after school activities.

Considering the length of the questionnaire, it was administered in two sessions of about 20 minutes each.

After the data collection, we have proceeded to the analysis of the data, with a qualitative analysis of the responses due to the limited number of participants. The percentage is given as an illustration of the type of response rather than a generalisable result.

Results

The results are organised in three sections, following the structure of the questionnaire above described.

Part I: Detection of technical characteristics

In this first section we asked the participants to identify and assign technical characteristics to a list of items that included technical objects but also animated and natural entities.

1. Is it an object or not an object?

In the first question we asked the participant to identify if the item, at various levels of familiarity, is or is not an object. The results show that for the majority of students there is a consensus of over 50% on the collocation of the items for the category Not an object or Object. In Table 1we present the items ranked in order of High to Low % for each category.

From this result, we see a gradation in the attribution of category object and not an object: 1) for some items, the students are almost unanimous in their collocation, for example Salad and Bike reach 90% of agreement in their collocation; 2) for some items the consensus is

Item	Not living	%	Item	Living	%	Item	Virtual	%
1	Wig	98	1	Flu virus	90	1	Avatar	96
2	Snowman	94	2	Coral	90	2	Cartoon	92
3	Frozen fish	84	3	Bacterium	84			
4	Talking doll	74	4	Hair	62			
5	Robot	64						
6	Nails	48						
7	Smileys	46						

Table 2: Items classed as Living, Not living or Virtual

intermediate, for example the train is placed as an object for 54%, for 34% as not an object and for 12% they don't know; 3) finally for other items there is more dispersion in the consensus. For example, Uranium finds a less clear collocation indicated by 49% as not an object; 15% an Object, and for the last 36% they do not know.

From this first initial investigation, we can see that the classification becomes more uncertain for objects less tied to the prototype of their category or more distant from common experience. Also, if we consider technical object as anything that has undergone a transformation of human origin (Rabardel, 1995), these first results show that students have a narrow view of the concept of object. The usual technical artefacts such as a Bicycle, a Scarf and a Sheet of paper are undoubtedly considered as objects by the clear majority of students (respectively 90%, 86% and 74%), without giving rise to a full consensus. So far we cannot doubt that the students know that these entities are human fabrications whose mode of existence is tied to the function to which they must respond. We can also see that within the same class of technical artefacts such as means of transport, some human fabrications are more difficult than others to be considered as objects. So the Bike seems to be a better representative of the concept of object than are Submarines (58%) or Trains (54%). These entities could not be directly manipulated, due to their large size, which could explain this result. Thus, it is likely that the mere mention of a train as "small and electric" place it in the toy category, facilitating its membership as an object.

Similarly, within the category of buildings, we observe that a Nuclear power plant, due probably to its highly technological nature, is easier to consider as an object (70%) than a House (50%). But, in the same way, the fact that the buildings cannot be handled, transported or empowered for direct action, makes these objects a poor representation of the concept of object. Meanwhile, the biological entities, like a Salad, a Tulip, an Egg, a Plane tree leaf, are not seen as objects by a majority of students, respectively 90%; 84%; 74%; and 66 %.

In the case of the egg that explanation would be a bit less relevant, considering that we are talking of "hard-boiled egg". Indeed, 10-12 years old students, for example, tend to refuse the status of living thing to a cut flower or a dead rabbit in the situation of a dichotomous classification like "living" or "non-living" (Bardel & Triquet, 1998). However, the same study also shows that when the possibility to categorise these things as "dead" is given, this is the option favoured by students. It seems, as well, that at least from this specific age the ontological status of being alive is preserved to the biological beings, for which it is considered an invariant of an existential nature. In contrast, technical artefacts cease apparently to be considered as such when their functionality vocation is compromised: indeed, a broken vase is no longer a vase.

It will be useful to take into consideration comparable data from the point of view of the same level of categorisation about the natural and artificial objects categorisation. Despite the assumed belonging of the entities to two distinct categories, the living and the non-living, it is interesting to see how children are able to find analogies and similarities between entities under both worlds.

2. Living, Not living or Virtual?

In this second task, we present a list of names corresponding to a living entity, not living or virtual and we ask to which category they belong. In Table 2 we present the items ranked in order of High to Low % for each category.

Given the learning, started usually from the primary school, about the classification of living entity, we find that most students know that virus, coral, bacteria are part of the living world. However, we note that membership of the living organic attributes such as Hair or Nails are much less evident. The first is considered by 62% to be living

Item	Manufactured	%	Item	Natural	%
1	Bleach	92	1	Rainwater	96
2	Glass	90	2	Corn	90
3	Carton	88	3	Honey	90
4	Cement	86	4	Butter	80
5	Plastic	82	5	Wool	74
6	Rubber	68	6	Petroleum	74
7	Steel	70	7	Sugar	64
8	GMO maize	70	8	Gasoil	56
9	Polyester	68			
10	Iron	52			

Table 3. Distinction between Natural and Manufactured

and by 30% non-living; vice versa the Nail is considered by 48% to be living and by 36% a non-living thing. This is probably due to the fact that school learning gives less reference to these entities.

Instead Avatar for 96% of all students is considering as Virtual. Cartoons are also categorised as virtual objects by 92% of students. Smileys and Robot are, however, placed most within the category of non-living (respectively 46% and 64%) and then to the virtual (4% and 34%). Through the television, movie, Internet and video games or software that makes possible the creation of artificial characters, the virtual and augmented realities are now parts of the culture of students. Robots due to their concrete materiality are regarded by student as real concrete objects but not belonging to the world of the living, despite the fact that they are animated.

In general, we can see how it is not always possible to delineate the membership with definite borders, although the category Living, Not living or Virtual are related to an essential feature in the understanding of an entity. It must be determined in a later work if this result arises because the physical organs or attributes of living beings, like the leaves on trees, the petals for the flowers, and hair for animals, are more difficult to categorise for students.

3. Is it natural or manufactured?
This third question investigates a further feature of a set of items in relation to their natural or manufactured nature. In Table 3 the items ranked in order of High to Low % for the two categories are reported.

Overall, it appears that students have good knowledge of the natural or manufactured substances and materials categorised. The elements that are more uncertain in this specific selection are Gasoil and Iron, considering also that for Gasoil 20% of students do not know the answer. But, in general it reaches a consensus greater than 50% for all items presented. It may be noted, however, that among the natural substances, some of them, like Rain water, Wheat, and Honey seem easier to consider instead of others, like Wool, Oil, and Sugar. This could be due to the fact that the natural character of the substances is less obvious when it comes to materials that are presented to us usually as processed products, like wool sweater, refined oil, granulated sugar. Again, therefore, this result should be investigated in our next work.

4. To store, Transform, Distribute or Ineffective?
In the following question we wanted to investigate if a certain number of items were perceived as objects that store, transform, distribute or are without relation to energy. In physics, energy is an abstract theoretical concept, with the fundamental property that it is conserved. As demonstrated by several studies (Beynon, 1990; Lee & Liu, 2010; Lemeignan & Weil-Barais, 1992) energy is a concept discontinuous from life-world experiences: the children's conception "constructed from everyday experiences are different from scientifically accepted ideas and are very resistant despite formal teaching[2]" (Megalakaki, 2009, p. 14).

Item	Stores	%	Item	Distributes	%	Item	Transforms	%
1	Heat	55	1	Bulb	56	1	Electrical sander	40
2	Gas	40	2	Oil	47			
3	Wood	38	3	Food	43			
4	Solar Panels	38	4	Thermal Power	36			
5	Batteries	37	5	Coal	33			
6	Manure	33						

Table 4. Stores, Transforms, Distributes or Ineffective item

[2] Original citation : « Ces conceptions, construites à partir des expériences quotidiennes sont différentes des idées scientifiquement acceptées et sont très résistantes malgré l'enseignement formel ».

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In Table 4, we present the overall overview of the results for each items and respective higher frequency for each category selected.

The results show that there is not a clear-cut position of students in allocating each element in a category. The highest value is in fact Bulb with 56% who say that it distributes the energy and 31% of the students say that it transforms the energy. Less consent is for the item Coal for which 33% of the students say that it distributes the energy.

The results that emerge are generally distributed, demonstrating the difficulty of the students to determine a clear understanding of the relationship of each of the elements proposed with energy. In general, we consider that the teaching of energy is an essential topic, essential in relationship with technical objects, proposed for teaching science through Science-Technology-Society (STS) (Aikenhead, 1994).

5. Known and Unknown Items
In this question we presented a list of objects at various levels of familiarity such as objects of common, new and old use. Below in Table 5 there is a summary of the frequency from the total sample.

N.	Name	Frequency
1	Electric car (new)	96%
2	Typewriter (old)	96%
3	USB stick (current)	96%
4	PC (old)	94%
5	Phone (old)	96%
6	Digital wristwatch (new)	96%
7	Electronic cigarette (current)	94%
8	Bluetooth headset (current)	94%
9	Balance	90%
10	Iron (old)	88%
11	Record player (old)	86%
12	Ball of yarn (old)	86%
13	Mechanical coffee grinder (old)	76%
14	Music mill (old)	74%
15	Drone (new)	54%
16	Camera (old)	46%
17	Mechanical mixer (old)	42%
18	Mechanical food chopper (old)	28%

Table 5. Known and unknown items

From this analysis we can see that most of the objects are known by the students with a total frequency of more than 50%. Interestingly, even the newest modern, but not common items such as digital wristwatch have already entered into the common knowledge of new teenagers. Items less known in our specific sample of students were the camera, the mechanical mixer and mechanical food chopper: these items do not fit in everyday life today and do not have a typical form in the corresponding modern objects whose current shape is digital or electrical. We can consider how these obsolete items, now considered antiques and no longer direct utensils known by the students, were very popular less than half a century ago and they continue to be sold in common flea or specialist markets. This result could be explained by the very little space that the history of technical objects occupies in the French curriculum of technological education.

At the end of this first section of the questionnaire, we considered the technical reality that surrounds us, noted that it is not always possible to understand it directly for itself and human work reinforces this opacity (Martinand, 1996). This difficulty in reading technical Objects increases if we consider technologically advanced objects despite the fact that they control more and more of our reality. An example is the actual revolution of the "Internet of Things": it is the interconnection of uniquely identifiable embedded computing devices within the existing Internet infrastructure, offering advanced connectivity of devices, systems, and services. Objects and technology are always more related, as suggested by terms like “pervasive computing” and “embedded networked computing” or “disruptive technology”. As such, they refer to devices and technological solutions that are interconnected, that extend and create a different understanding of our environment. Indeed, Barlex, Givens and Steeg (2013) propose the introduction of “disruptive technology” as an aspect of technology into the technology curriculum to help learners to engage in future-thinking and new affordances that the technology introduces.

Part II: the Ability to create Relationships between Objects
For this section of the questionnaire, we started from the consideration that “Categorisation of real world objects is a fundamental adaptive behaviour that allows man to reduce the complexity of the physical and social environment by organising it” (Bideaud and Houdé, 1989, p.88)”. The process of thematic categorisation that applies to group items on the basis of a common empirical meaning, e.g. the farm, the station, the circus, the forest,

N.	Group of images	Combination with the high occurrence	%
1	Dragonflies, vulture, helicopter, airplane, hang-glider and windmill	Helicopter, airplane, hang-glider	26
2	Corkscrew, swing, nutcracker, elbow articulation, scissors, wheelbarrow	Corkscrew, nutcracker, scissors	40
3	Sun, thermal power, food products, nuclear power plant, hydraulic power, firewood	Hydraulic power, thermal power plant, nuclear power plant	53
4	Mobile phone, radio device, X-ray image, bat, microwave oven, satellite transmission	Mobile phone, radio devise, satellite transmission	39
5	Sheep, silk worms, cotton field, flax field, automatic power loom, cashmere scarf	Sheep, cotton field, silkworms	14
6	Plastic container, metal canned food, paper bag, glass bottles, carton packaging, cream jars	Plastic container, metal canned food, glass bottles	18
7	Block of butter, cheese, jar of jam, cow, bottle of milk, slice of bread	Butter, cheese, milk	39
8	Flashlight, bedside lamp, flashlight, streetlight, gas-discharge lamp, candle	Flashlight, bedside lamp, hand lamp, streetlight, gas-discharge lamp, candle	21
9	Electrical sander, washing machine, flat iron, vacuum cleaner, electric stove, electric drill	Washing machine, iron, vacuum cleaner	20
10	Wasp's nest, teepee, igloo, straw hut, termite mound, nest of weaver birds	Teepee, igloo, straw house	51

Table 6. Classification of different items

actually allows students to group a wide variety of entities such as for the farm: a tractor, barn, haystack, pig. The construction of these thematic categories precedes that of taxonomic classes based on the recognition of common properties to their members. For example, for the birds we have the properties of flying, having wings, having feathers, a beak; for the clothes we use them to dress, and they are made of fabric. Therefore, we attribute an indefinite name for the generalisation of the category, like "it's a bird; it's clothes". However, the ability that children have to mix these two types of categorisations to find a relationship between natural and artificial objects remains more complex.

In this second part, we examine the classification of different items and examine the possible relationships between them, considering that knowledge is organised in naive consistent theories (Carey, 1985, 1991; Keil, 1992). In addition, studies on the conceptual development show that the acquisitions are dependent on the field (Wellman & Gelman, 1998). In each task six images were presented, which included a representative picture and a tag with its name. In the results we present only the most frequent combination proposed by the students. The rest of the combinations have lower frequencies and are therefore not reported. In Table 6 there is a summary of the groups of images proposed with the respective combination with high occurrence.

The following section provides details of each combination proposed:

1) Use of air for movement: in the first example, we presented images linked together by the use of the air for movement, Dragonflies, Vulture, Helicopter, Aircraft, Hang-glider and Windmill. The combination most frequently experienced was the one that put together the aircraft (26%), excluding the two items related to the animal kingdom and the Windmill. So, the objects made for the specific purpose of flight or affiliated to the class of transportation were put together. No student has suggested the combination of all six images on the basis of a common aerodynamic principle.

2) The principle of the lever: the second task required students to identify a grouping of a set of six items, Corkscrew, Swing, Nutcracker, Elbow articulation, Scissors, Wheelbarrow, connected to each other in a generic way by the lever principle. In this case, the choice that prevailed was related to the context of everyday life. Indeed all the items can be found in a context like the kitchen. Only 4% of the students have linked all images together, showing that they had identified a relationship between them. No

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answer was provided by 9% of students. Considering the total number of students that have suggested a group excluding the elbow (53%), this demonstrates the difficulty in relating natural and artificial objects or to group technical artefacts that have very different functions.

3) Energy: in this case, the six selected pictures were related with the concept of energy: Sun, Thermal power, Food products, Nuclear power plant, Hydraulic power, Firewood. In this case, the most frequent choice was the putting together of the three plants manufactured by humans to produce energy, excluding the natural elements. No answer was provided by 9% of the students while only 5% made the connection between all images.

4) Waves: here we identified images linked together by the generic principle of waves and radiation: Mobile phone, Radio device, X-ray image, Bat, Microwave oven, Satellite transmission.

The highest frequency of grouping was linked explicitly with the transmission waves. In fact, they are all equipped with antenna in the representation provided. We do not know if this grouping is based on the transmission function of the information or the presence of the common physical attribute. In this case, only 2% found a link between all the elements and 85% of the students made a group excluding the bat, the only animal provided in the group. It is not clear if this is due to the lack of knowledge on the specificity of the bat or just because it is an animal unlike the other objects provided.

5) Handicraft: in this case, we provided images related to textile production: Sheep, Silk worms, Cotton field, Flax field, Automatic power loom, Cashmere scarf. In this grouping we find the highest dispersion of combinations: 26 for a total of 50 students. There is not a clear dominant category. In fact the highest (only 14%) comprised the first three images, the Sheep, cotton field, silkworms. However, this was a high percentage of students in respect to other combinations in this task (11%) who found a link between all the items, probably because the natural and artificial items have a clear common feature namely textile production.

6) Objects from recycling: the objects gathered here were all technical artefacts. It included packages made from different materials: Plastic container, Metal canned food, Paper bag, Glass bottles, Carton packaging, Cream jars. It can be considered that they all belong to the category of containers or garbage. There isn't a clear prevalence of a dominant category. In this case, 16% of students found a link between all images.

7) Dairy production: in this case six objects related to dairy production were presented: a block of butter, a cheese, a jar of jam, a cow, a bottle of milk, a slice of bread. It was thought that a number of students here would tend to associate butter, jam and bread achieving a thematic class like 'breakfast'. But no student proposed this specific composition. On the contrary, we observed that the grouping of the three most common objects is the one that corresponds to the three dairy products (butter, cheese, milk). The grouping that appeared most relevant was not the one that corresponded to the process of categorisation according to the event schemas and scripts proposed by some authors (Mandler, 1984; Nelson, 1988; Schank & Abelson, 1977). Rather than grouping together foods which are usually eaten but have no link between them from the point of view of their composition, it seemed more appropriate for students to group products that have the same origin. Moreover, 56% of students excluded the cow from their combinations group which reflected the difficulty in associating entities belonging to different orders (living and non-living) even when, as here, the industrial products give their existence to the biological entity.

8) Lamps: in this specific case, it was decided not to include the object names to avoid suggesting the explicit semantic combinations. The six pictures presented were: an electric light, a bedside lamp, a flashlight, a streetlight, a gas-discharge lamp, a candle. In this case, 21% of students found a link between all the objects. 61% of students ruled out the candle from the grouping, considering it non-electric and less complex than the other items.

9) Electronic items: in this case, we presented six images of everyday technical artefacts related to domestic appliances and more precisely to the household: an electrical sander, a washing machine, an iron, a vacuum cleaner, an electric stove and an electric drill. The most frequent combination of three objects is for washing machine, iron and vacuum cleaner. 50% of students made a link between all objects linked by their domestic use and not as a result of their electrical functioning. Presumably because for the students these objects are necessarily electric devices and they don't know the precedent mechanical version, for example, manual grinder, hand drill, brooms.

10) Home and shelters: here the six pictures concerned the following objects: a wasp's nest, a teepee, an igloo, a straw hut, a termite mound, a nest of weaver birds. If we consider that only the human made objects are technical artefacts, students could combine the three human

Item	> 2hours use	%	Item	Motivation in learning Technological subject	%	Item	Interest	%
1	Smartphone	36	1	Discovery of reality	65	1	Technology	40

Table 7. Use of technology and interests

habitats in opposition to the natural and animals' habitats. But if students do not take into account the innate or acquired technical behaviour accompanying the manufacturing of objects, they have tended to group them all because they all have the same social function. We observe here that the majority of students (51%) considered that only human habitats have a common feature and that only 21% combined all the items. So, it seems that a common property of the social function is not sufficient to gather animals and made objects.

From this second part of the questionnaire, we see that the students show certain flexibility in the categorisation of data, considering that they do not use the same systematic indices to perform their grouping. In general, a functional and contextual categorisation is more activated by the students. We can consider the activation of different logics: empirical generalisation (classification), through observation or identifying superficial features, and theoretical generalisation (identification) through experimentation and transformation, of the genetic origins of phenomena that may be quite different.

We recall here the study of Luria and Yudovich (1971) on the classification tasks consisting in the assembly of objects such as a tree, a saw, and an axe. Generically, in Western culture, a saw and an axe belong to the category of tools, and the tree to the category of plants. In Uzbekistan with illiterate participants all items are posted in the same category (one needs a saw and an axe to cut a tree), considering the systemic functional connection between them. As noted by Sannino (2010), in this case it used a formal logical or empirical generalisation however, if one aims at genetic or theoretical generalisation, one has to identify a basic functional connection, also called a "germ cell", between the phenomena:

> Categorisation of problematic phenomena within empirical generalisation might be useful for a while as an intermediate analytical step, but that is not enough if the subjects aim at changing their practices. Subjects have to look for generating mechanisms behind the problematic phenomena they refer to. This mode of generalisation has very different potential because it brings subjects to think dialectically about their practices, to establish connections with many other phenomena that initially remained in shade because they looked different, to explain this systemic constellation of problematic phenomena, and to construct new solutions (p. 587).

In the science curriculum, classification of living beings refers to a widely known, prior and scientifically established knowledge. In contrast, technology education often focuses on specific objects without worrying about the generality of knowledge taught. Technology education should not be on restrictive knowledge that is applicable only to a small number of specific artefacts. Learning should be generalised and transferred in a relevant way to gain some cultural value.

Part III: Use of technology and personal perception
In this section, we have developed three questions related to different aspects: 1) the time that students spend using some technological object related to the school and house contexts for formal and informal learning; 2) the importance of learning a technology subject; 3) generic students' interest in scientific and technological subjects. Table 7 provides a summary of the main results for the three questions.

Regarding the first question it appears that the use of the smartphone is the most common (more than two hours per day for 36% of students and at least one hour for 27% of them) followed by the use of the internet (2 hours by day for 23% of subjects and between 30 minutes and one hour for 50% of them. From the second question, the awareness of the importance of science literacy as an opportunity for the discovery of reality (65%) was the majority choice. The link between the study of technological objects and future professional choices remains relatively low (26% of answers). From this, it appears that student do not realise the importance of technical and scientific training for their professional future. Finally, we asked the students to indicate their interest in scientific and technological disciplines. The analysis shows that the most interesting for them was thus ranked: 1) greatest interest was in technology; 2) average interest was for physics and chemistry; biology, geology and astronomy; 3) lowest interest, computer science. From this third session, we can see the strong contrast that emerges between the great use of technology and the lower interest for computer science: paradoxically, the new technological object with which they spend more time during the day constitutes the subject least interesting in formal learning. Probably, the computer science is for them an area to explore directly and practically, making more valuable use of the formal learning provided by the school.

Discussion

This paper takes into consideration the technical object by the subjective experience of students between 12 and 14 years. This first study is exploratory in purpose. The results concern a limited population of students and need to be tested with a larger sample. The results indicated that the relation of subject with technical object is complex, considering the complexity of our environment.

From Part I we observe that the concept of object itself has a restrictive meaning for 12-14 years old children. This result goes against the very generic definition that many authors give to the artefact concept. Apparently, big, static and not directly manipulable artefacts are not easily considered as objects. We find also that living entities are also bad representations of the concept of object. It appears that it is not enough that a biological entity is transformed by man for it to be seen as an object. So, a fortiori, we can think that biological beings from industrial production are difficult to assimilate as technical objects. These first results show however that the natural character of some substances (wool, oil, sugar) is less obvious when it comes to materials that are presented to us usually as manufactured products. In Part II we can also see many difficulties for children in finding common points between natural and artificial objects even when the industrial products give their existence to the biological entities. Grouping technical artefacts is also non obvious when they refer to different social functions despite having the same physical and operative principle. Students show certain flexibility in the categorisation of objects in the sense that they do not use the same systematic indices to perform their grouping. However generally, they fail to find epistemic analogies for group objects that also have many different properties. Part III reveals the low interest students have for design and technology education and the moderate one for scientific education.

In general, the pilot survey brings us back to the importance of handling and knowledge of the technical objects from "inside", allowing a practical familiarisation through experimentation, observation and manipulation. Considering this perspective, our survey is intended to clarify the current discussion on the redefinition and reorganisation of the common core acquisitions for 12 to 14 years old pupils (Lebeaume, 2011). The French national program called the "The common base of knowledge" promoted an updating of technological curriculum, in continuity between college and high school, and with a stronger contextualised approach. The trend is to use different methods of analysis, design and implementation, allow the children to plan own work, searching multiple solutions to the same process.

For a more general theoretical perspective we can consider that the nature of artefacts is basically embedded in dualism (Kroes & Meijers, 2006; Vaccari, 2013). As pointed out in English but also in French literature (Akrich, 1987; Cazenobe, 1987; Haudricourt, 1988; Inheldher & Cellerier, 1992; Simondon, 1958) technical artefacts as such are "mixed" in the sense that they combine scientific properties, physical, chemical, geometrical, that characterise the material objects in the margins of the specific social nature of properties related to their intent, their design, their production, their use and, also, their way of deterioration and recycling - generating significant problems in our consumerist societies.

The intervention of technological education should help to change and improve the "meeting" of students with the technical objects by inserting it in a context ascribed to the production, to the world of work and the technical process. This investigation leads us to consider how to organise the meeting with technical objects and how to incorporate them into a process of sense making. The way artefacts are presented in education should be such that pupils learn to recognize characteristics of the artefacts that are not specific to one particular artefact, but that relate to the nature of all technical artefacts. For example, the understanding of the concept of "volume" has always been by several approaches (like, physical, psychologists). But, in regard to technical artefacts, it is not the volume but the "bulkiness" that makes sense in terms of the practical activity like the storage of artefacts. Consequently, as a result of many technical properties (telescopic, foldable, deflatable, nested objects) children construct the idea of space being taken up by material entities as a one-dimensional variable and unstable size and quantity before as a three-dimensional quantity and physical and geometric invariant.

Technical Objects Between Categorisation and Learning: An exploratory case study in French middle school

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Technology education can contribute to a better understanding and give an informed access to the high-tech environment in which we live. It prepares each person to deal with the technical world (Flick, 1992). At school the students develop a technical point of view of the objects (Lebeaume, 2000) and the school students increase their familiarisation with technical objects (Ginestié, 2006; 2011). Technological literacy can reveal the genesis of technical objects, in relation to the production, distribution of industrial practices and contemporary technology. In particular, we can consider that conceptualizing of technical artefacts should be an objective in our teaching of technology education. Indeed, according to Kuutti (1996) each object of design became a crystallisation of the experience about the mediated relationship between humans and the world. This relationship is not fixed but constantly changing with its history. It therefore requires more knowledge that one single person can possess (Fischer, 2000) for a complex design. Focusing on conceptualisation in technological education can help students to contribute to further development of technology and to acquire the knowledge, habits and skills necessary to participate actively in social activities (Martinand, 2002). In a complementary way, it is interesting to reconstruct the understanding of teachers on some specificity of technology education, as in the study of Hallström and Klasander (2013) about pre-service technology teacher understanding of technological systems, starting from the consideration of the difficulties of pupils to complex aspects of the system structure.

Finally, we can consider that the object becomes more embedded in the mediated relationship with the surrounding reality, starting from the consideration that we are dealing also with a "body techniques" (Mauss, 1936). Indeed, as questioned by the anthropologist Bateson (1972), the boundaries between the social (human) and material (object) are overlapped, as expressed in the metaphor of a blind man with a stick: "Where does the blind man's self begin? At the tip of the stick? At the handle of the stick? Or at some point halfway up the stick?" (p.318). In this perspective, both social and material components, internal and external to the subject, make it impossible to draw a boundary line between the mind and the context. In fact, as argued by Clark (2001) "much of what matters about human intelligence is hidden not in the brain, nor in the technology, but in the complex and iterated interactions and collaborations between the two. The study of these interaction spaces is not easy, and depends both on new multidisciplinary alliances and new forms of modelling and analysis" (p.154).

Conclusion

This first study is exploratory in purpose. The results concern a limited population of students and need to be tested with a larger sample. About the research, we found different difficulties. Firstly, the questionnaire seemed long and complex to students, perceiving it as an additional cognitive load. Sometimes there has been the difficulty of the students to understand the delivery of the questions. These aspects will be considered for future improvement of the questionnaire. Also, aspects to consider for improvement of the study are:

- To add questions on social variables and the cultural context of belonging;
- In Part I, detection of technical characteristics of objects, the ability to discern biological, mineral and artificial belonging and to retrace the typology of artefact will be added. Furthermore, there will also be a focus on technological systems content.
- In Part II, the ability to create relationships between objects, the combinations will be proposed in the questions (based on the pilot test results) in limited numbers to avoid dispersion and a set of criteria to justify the choice made will be provided.
- In Part III, direct use of technical objects and personal interest in the scientific subjects, the level of familiarity in the use of different objects will be investigated.

The follow up of the research will consist of a survey with students from 11 to 15 years old. It aims to shed light on how children apprehend some aspects of their current material environment according to their age, gender, socio-cultural environment to which they belong, and urban or rural area where they reside. The questionnaire will be developed for this purpose in two versions, one for the younger children (11-12 ages) and the second, a full version for the older students (13-15 ages). It will be in an electronic format and completed online with the software Sphinx (http://www.sphinxsurvey.com/). The online version allows us to deal with an extensive number of participants and facilitates an initial automatic data analysis. Also, the use of images and the use of only closed questions will save time and facilitate its online completion by students.

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