How do the Interactive White Board and the Radio Frequency IDentification and tracking system work? Exploration of pupils' spontaneous knowledge and didactical proposals for Technology Education

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Abstract
This paper reports two exploratory surveys focused on the pupils' spontaneous knowledge about the functioning of technological systems. The qualitative and quantitative data analyse highlights their general unawareness, their reasoning from the material components, their lack of vocabulary to explain how the RFID Pass or the Interactive White Board work. The questionnaires and interviews reveal available cognitive supports in order to develop pupils' understanding. The paper suggests didactical and pedagogical orientations for designing school activities.

1. Introduction

Since its genesis in the 1960s modernity, Technology Education has been legitimated by one of its purposes concerning young pupils' appropriation of their contemporary technical world. Ortega y Gasset (1945) underlined the necessary relationships between school contents and the environment of daily life in a cultural perspective. Léontiev (1972) or Vygostky (1970) in a more psychological point of view argued also the human need of appropriation the new artefacts in order to integrate the progress of thought. But Technology Education such as a basic and general education is confronted at present with two main issues linked. The first issue concerns the necessary understanding of new artefacts or systems with digital technologies. The second issue refers to pupils' possibilities to identify these systems and technologies. This paper contributes to the exploration of pupils' ideas regarding two systems: the Interactive white board and the RFID Automatic identification (used for the checking and tracking in public transports).

2. Research questions and theoretical frame

2.1. Objects, artefacts and systems

Mitcham (1992) or Frederik, Sonneveld and de Vries (2011) note that "Artefacts are probably our most obvious everyday encounter with technology". They underline also their broad spectrum and their different kinds (object, machine, tool, device, mechanism or system) described by the main authors. De Vries (2005, p. 14) also discusses with a same philosophical and epistemological point of view, the meanings of "natural objects, instruments, tools and artefacts" and defines "artefacts" as the generic term. He insists on the function that establishes the relationship between users and designers and then underlines the risks of confusion between applied sciences and technology knowledge.

Within proposals for technological literacy, one characteristics of a technologically literate person is: "understands basic engineering concepts and terms, such as systems, constraints, and trade-offs" (NAE & NCR, 2002; Pearson, 2007). As a result of the evolution, the artefacts are mainly technical systems and are generally intelligent systems. Their main change concerns their integration within information systems with WIFI, WRAP, RFID... technologies. Numerous technical systems work with the same principles: the devices (material objects) only are one terminal, for example a Smartphone or a point-of-sale terminal.

2.2. Technology literacy and artefacts' understanding

A technologically literate person is able to understand these technical systems by distinguishing the material components, their functions and by picturing connected and distant computers with information systems.

The "spontaneous knowledge or naïve ideas" are defined by Lautrey (2008) such as beliefs, notions or concepts learned by children from their experience in daily life and without school teaching. The request of international scholar papers during the last ten years results only in a few researches about pupils' spontaneous knowledge. Svensson and Ingerman (2010) propose five ways for understanding systems: using objects, the function of objects, objects as part of a process, objects as components in one system, objects embedded in systems. The authors suggest three levels: "1) the level of the objects themselves – objects as objects; 2) the micro level inside objects – objects with components as systems; and 3) the macro level outside objects – objects as part of systems, together with human and society" (p. 273).

These researches underline the systems description by pupils. One other research identifies children's initial knowledge (Andreucci & Ginestié, 2002; Ara, Nararajan & Chunawala, 2009). Menger (2010) shows that young pupils use subjective explanations based on experience, objective explanations based on materials or logical explanations with links between motion and functions of the different pieces. This perspective is close to the distinction suggested by Piaget and Garcia (1983) between the "intraobjectal" description (centred on perceptible characters and founded on empirical abstraction) and the "interobjectal" analysis (based on reflexive abstraction) that initiate a "transobjectal" understanding (based on isolation of structures).

2.3. Issues

With this theoretical frame, we suppose that middle-school pupils looking at current technological systems only identify the material or visible pieces without establishing relationships with the other components. This main "intraobjectal" point of view doesn't enable them to explain how these systems work nor the relationships between components that transfer invisible information.

3. Methodology

In this perspective, our main interest was the choice of two different familiar systems: the control system used in Parisian urban transports (Navigo-Pass, figure 1) and the Interactive white board used in classrooms (IWB, figure 2). These two systems are familiar for pupils. Nevertheless they are different in their use, structure and capture, treatment and transmission of information. This choice is founded on the fact that, even though these systems are both software dependent, they have unique and contrasting characteristics. Our hypothesis is that these opposite characteristics will induce distinct levels of understanding of the objects' functioning. The Navigo pass'e appearance as a simple plastic card hides its internal components. This characteristic prevents the user from thinking in intraobjectal terms. By contrast, the IWB was chosen because its components (projector, computer and board) are clearly apparent, thereby enabling components-evidence based thinking.

Figure 1: Navigo Pass

Figure 2: Interactive White Board

Two explorations have been driven with two different Parisian groups during 2010 and 2011. The first survey centred on RFID is based on 368 junior high school pupils (year 9 -10). The second survey centred on IWB concerns 253 pupils (year 7 to 10). Each survey is completed by exploration of adults' ideas: 32 tertiary students and future teachers (RFID) and 23 teachers (IWB). The collection of pupils' or students' and teachers' explanations has been implemented in a first time by questionnaire. In a second time interviews have been organised with couples of pupils (survey 1) and with each teacher (survey 2).

4. First Survey

After different tests, the questionnaire is laid out on one page A4 only is structured with a short introduction and two questions (figure 3).

> SURVEY: How does the Navigo Pass works?
> You use a Navigo Pass in urban transports. It's very practical and enables you to gain time.

I. Please write With your own words how you think the Navigo Pass works. You may use drawing for explanation.

II. Please indicate if other objects work as the same according to you.

The corpus of answers for each question has been read first and then studied in order to identify the key-expressions i.e. words or ideas-phrases, (cf. Henry & Moscovici, 1968). The quantitative analysis indicated the main pupils' spontaneous knowledge (Table 1; no responds or users' opinions: 17 %). As pupils mentioned several ideas, the cumulative percentage is upper than 100 %.

Smart	Magnetic	Detection	Information	Code	Infrared	Signal
31 %	19 %	17 %	8 %	7 %	4 %	3 %
Validity	Waves	Contact	Radar	Sound	Electromagnetic field	Scanner
3 %	3 %	2 %	2 %	2 %	2 %	1 %

Table 1: Key pupils' spontaneous knowledge

This first distinction enables to define three relevant categories (Table 2).

Categories	Key-words	Examples
Object	Smart, radar, scanner…	It's an electronic smart system
Principle	Magnetic, infrared, wave, contact…	It's the card that does waves with the machine and it opens the gate
Function	Information, validity, detector	We enter if the card is valid.

Table 2: Categories of the content analysis of answers

Unsurprisingly the analysis highlights that the great majority of pupils don't know how the Navigo-Pass works. Only one pupil knew the RFID system and explained it. The general idea (1/3 pupils) is that Navigo-Pass is a smart card which working under the influence of a magnetic field. The data transfer is rarely mentioned. This spontaneous knowledge is underlined within the second answers. Pupils noted that other similar objects were: badges or card-pass (50 %), payment card (12 %), phone card (4 %).

These results were consistent with the concepts and ideas expressed by the interviewees. Indeed, we also found that the questioning enables pupils' discussion that allows they to progress in their conceptualisation and to abandon their spontaneous ideas. They discover progressively that the issue is the remote control. Then they imagine different principles but don't have any elements in order to argument a hypothesis of theirs. The two following extracts were chosen as an example:

Q: How do you think Navigo-Pass works?
Johanna's answer: But, technologically?
Jean's answer: Bah, it's the card which does waves with the machine and it opens the gate.
Johanna's answer: It's magnetic, isn't it?
Jean's answer: Yes, that's what I mean; I didn't mean waves. It's something that bustles when we are near the barrier; that deactivates something.

Q: Why do you think about magnetism?
Johanna's answer: I don't know. It's because we don't press a button. It's not necessary to touch the thing.
Jean's answer: The fact that attracts, that is at distance.
Johanna's answer: Then, it allows going faster.

Q: Do you think if we slide a magnet upon the device it can activate the mechanism?
Jean's answer: If it has the same properties, Yes!

Q: What properties? What is special within the transport card?
Johanna's answer: But, inside the card there is a chip or something like that? Inside a magnet there is no chip, thus it doesn't work. Otherwise everybody could through!

The interviews reveal that the pupils' understanding is mainly limited by the lack of knowledge. They don't know this technology and they can't invent it of course! Nevertheless it seems that there is not any epistemological obstacle for its description and discovering as a specific remote control. Based on the didactical orientation of Giordan & Pellaud (2008) who suggest that learning is in fact moving from an initial conception not very effective to a conception more adapted to the new situation, there are three didactical proposals: 1) implementing school activities based on the comparative analysis of different cards (magnetic cards, smart cards, RFID cards); 2) explaining the induced current in order to understand electric energy of the card without battery; 3) developing documentary surveys of the different technologies. The interviews show that the best pedagogical approach would be to encourage pupils' spontaneous explanations in order to enable them to identify the different issues: the remote control, the automatic device, the role of the card components and the data capture, their transmission and treatment. This last point would allow to understand the tracking that is never identified and nor imagined by pupils. In addition, the questionnaires and the interviews reveal pupils' greatest difficulty: their lack of vocabulary and concepts in order to describe precisely or analyse systems or artefacts and thus move from intra-objectal level to interobjectal level.

5. Second Survey

The exploratory survey is driven with the same procedure. The questionnaire consists of four questions.

SURVEY: How does the IWB work?
A new technology called Interactive White Board is currently introduced in classrooms.

I. According to you what are the necessary devices in the IWB.

II. Please write in your own words how you think it works. You may use drawings for explanation.

III. The WIB is a numerical and interactive board.
– Why is it a numerical board according to you?
– Why is it an interactive board according to you?

IV. Please, indicate if other objects work as the same according to you.

The first question identifies the components (table 3). Surprisingly, numerous pupils forget one or several main components. Only 1/5 pupil mention energy. The internet connection or the software is very rarely mentioned. There is a little difference between year 7 or year 10 pupils. The first component named by the youngest is the video projector while the oldest named the computer first.

Component	Video Projector	Computer	Pointer	Board; Screen	Electricity	Remote control	Internet	Software
%	78	73	63	28	20	8	2	1

Table 3: The components of IWB (n = 251)

The data concerning "how it works" have been analysed with word identification or ideas-phrases. The answers may be classified as four categories according to their meaning:

– The category "connected" focuses on the relationships between the components;
– The category "command by computer" underlines the core component:
– The category "elements" indicates a few components unrelated to one another:
– The category "button" is based on the actions only:

The answers don't explain the functioning but give a partial description of the system only. The youngest pupils' answers are less complete than those of the oldest pupils. The answers focus mainly on the material aspects without analysis of the data transmission and without interaction from board to computer.

The word "numeric" is unknown (only 1/3 pupils answer) and is interpreted in three ways: connexion with a computer, tactile commands, pictures.

The word "interactive" is also unknown. The pupils' answers link it with tactile actions without indicating inputs. Only a few answers (n < 10) associate it to computer or playing action. These spontaneous ideas are close to the information of similar items (question 4). There are either different objects with tactile interface (phones, digital tablets...) or objects of world pictures or world games (TV, video, camera..., game console) or more simply computers.

The questions of the interviews surprised the teachers, even the two technology teachers. Among the 23 teachers, only six of them mentioned the software and its importance. One of the teachers explained that the communication between the electronic pen and the board was established by a "radio signal". Generally users don't question the technological system. But they speak easily of its "interactivity" with a pedagogical point of view only.

Major findings of the second survey show the unawareness of the IWB system and the lack of interrogation of teachers. The IWB is used at school without explanation of the technological and information system. When they are asked pupils or teachers according to their own experience analyse the set by the organisation of its components and visible relationships between them. Then it is only an "intra objectal" analysis founded on the actions of use. One important fact is that pupils' answers show certain sensitivity. When they try to explain the functions they underline the relationships between two components. This partial conception may be a support in teaching-learning and in progressing in the understanding of technological systems.

6. Conclusion

These two surveys of questionnaires and semi-structured interviews are only centred on how these complex objects work and how they are made.

– The qualitative and quantitative data analysis reveals the following:
– The prime identification of each artefact is perceived as an object itself or as a compo-

nent of one set; the RFID Card is seen as a smart card or magnetic card and the Interactive White Board is identified as a computer and video projector;
- This spontaneous approach is both perceptive and material; the immaterial components of the software or the information flows are not mentioned, but appear in interviews only;
- There is no great difference between pupils according to their age or grade in school;
- The scientific and technological vocabulary is poor; pupils don't have the words to describe or explain the artefacts or systems.

But, one of the results shows also the lack of interrogation of pupils. They are surprised by the questions. Use appears more important than the understanding of the functioning of these familiar artefacts. It seems that teachers do not stimulate their curiosity and let them be in the attitude of user or customer. It's a great issue for the development of technological literacy.

Nevertheless pupils' discourses highlight different useful elements in design and implementation of new activities: the necessary consideration of their spontaneous knowledge and confusions, level of their partial approach, possibilities of their extension in a socio-constructive approach. These results enable researchers or policy makers to discuss the contents of Technology Education, their updating according to the contemporary world and the school opportunities in developing young pupils' technology awareness. The future of Technology Education is linked to the ambition of enabling pupils to build concepts and models in order to read and understand the complex technology systems that they mechanically use. Perhaps it would be necessary to establish a relationship between formal and informal technology education and thus define a new curriculum for basic school with some kind of popularization like Demers and Llull (1982) have already suggested it.

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