Pupils' “representations” of ICT. A preliminary study in six European countries

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Abstract

A co-ordinated empirical European work (Project REPRESENTATION, MM 1045) has been led in six countries, with the aim of getting an insight of pupils’representations regarding ICT. A common protocol was defined. According to it, the pupils of one classroom in each country (fourth and fifth graders) were asked to draw a computer, to label its parts and to write short texts about computer uses. Representations are at the same time rather similar (children tend to focus on the external parts of computers) and rather contrasted. representations seems to be much affected by the task proposed to pupils. the school context, the use of a computer at home and in school and, probably, the gender.

1. Context

The European Project REPRESENTATION (MM 1045) has been launched in 1998 in order to develop knowledge about pupils' representations regarding Information and Communication Technologies (ICT). It considers 10-12 years old pupils in Denmark, France, Greece, the Netherlands, Spain, the United Kingdom. We shall present here some results of the first year of this project, making use mainly of a deliverable we were responsible of (see http :// hermes. iacm. forth. gr for more information about the project).

One of the main initial tasks was to establish an initial conceptual model of children's representations. We decided to select contrasted cases, the granularity of observation being the school, with a focus on particular classes where teachers have been associated to researchers, following a scheme of action research.

The empirical work was done in the spring of 1999. We made the choice of relying on a combination of drawings, text writing and interviews as a research tool. This choice could in effect lead to rich data and allow for rich interpretations. The canvas for getting data was the following.

Each pupil of the chosen class was asked to draw on a sheet of paper a computer and to produce a legend giving the name of the different parts. Then, each pupil produced a short text (naturally in his mother tongue) on the theme "*What is for me the usefulness of a computer*".

On the basis of this first production, six pupils were to be selected in each class and interviewed. Their selection intended at trying to represent the different pupil profiles as seen in the classroom. In a second time, the class was asked to produce a short collective work about what computers might bring in the future, under the supervision of the teachers. The process was realised by the way of the teacher’s choice.

This scheme was globally respected. However, in accordance with the principles of action research, ecological validity made it necessary to adapt the tasks to the particular practice of each school and teacher. Two partners deviated from the initial framework. Depending on the class habits, interviews could not take place in Greece, and were replaced by a class discussion. The UK contribution to the data collection adopted a different protocol. This special protocol, relying on a spider-mapping task, has been set up in order to obtain richer data. Spider-mapping or indeed any type of linked drawings are a means to depict related or unrelated thoughts and produce something more concrete from which the initial ideas can be developed, or the methods of linkage considered.

2. Results about pupils’ ICT representations

We’ll first present preliminary remarks about the different methods that have been used to capture children’s representations. Then findings will be classified under three headings : ICT objects, ICT functions or uses, ICT users.

2.1. Preliminary remarks

The collection of data seems to have posed no major problem, the pupils being willing to discuss the topics and to express themselves.

The data collected in six countries constitute a rich material that could be submitted to many in-depth analyses. So far, only an exploratory analysis was performed. Indeed, the aim of this phase of project REPRESENTATION was only to establish an initial image of pupils' representations of ICT

The following section tries to highlight how the differently methodological approaches have contributed to the initial picture of pupils’ICT representation that will be presented afterward.

2.1.1. Drawings

The drawings give very interesting clues as regards the ICT representation of the pupils. Although roughly similar as regards aesthetic features, they show considerable variations in their components. This leads one to think that the differences in drawing abilities cannot be the sole explanatory factor. Relating this variations to the data obtained

during the interviews, whenever possible, gave a good insight upon what pupils know or not, consider as important or as unimportant, use or do not use. Drawings are very efficient at giving insight upon the representation of hardware. Through the very simple index of number of computer parts depicted, this representation happen to be either very complete in children often confronted with computers (particularly at school), or very poor for some of the least exposed ones. Besides, drawings confirm some of the hypotheses that could be formulated concerning the use of ICT. For example, any physical device such as wiring is not relevant and thus may be neglected. What come at the first plan are the parts that are subject to children's activities.

2.1.2. Texts

The texts collected (that have all been written in the children's mother tongue) show considerable variations from one country to the others, but are relatively homogeneous within each school. For instance, in France they are rather short, and generally poor as well from the content point of view as from the vocabulary used. There are very few adjectives and a very limited range of verbs and nouns. At the opposite, the English pupils produced texts that were rather long and rich. (The shortcoming of the language production approach in order to inquire representations in children are once again illustrated). Particularly, writing has proved to be difficult for the children of lowest school achievement. It is nevertheless important to note that the poverty of the vocabulary is also reflected in the drawings and in the interviews. On the other hand, some pupils appear to have very strong technical knowledge, and the associated vocabulary. These differences in the extent to which pupils are able to label objects are no doubt influential for learning, at least about ICT themselves.

2.1.3. Spider maps

Spider maps obtained in the UK school must be analysed in the light of the particular protocol used. They show that drawings of this kind capture a wide variety of ICT related activities. They also demonstrate the diversity of both ICT and computers in a world wide setting. For instance many show world wide communication and interaction between business and social functionality. At the lowest level, games predominate. Spider maps nevertheless hardly captured procedural representations.

2.1.4. Interviews

The interviews, as defined in the framework, have provided complementary data upon drawings interpretation. They sometimes allowed enriching our comprehension of the drawing (see below for the French case). For example, they proved that some missing components (as wires) although not having been represented, were known. This usually did not invalidate the interpretation of drawings but rather suggested that only components that are functionally important for pupils are inserted in the depiction. Interviews also permitted to undergo the language difficulties pupils were faced with when writing the text. However, it appeared that the procedural component (mention of actions that may be performed within the ICT domain, or explication of how systems function) is very underrepresented in what has been extracted using the defined grid for the interviews.

2.1.5. Collective work

Collective works, as it was conceived in the initial methodological canvas, was aimed at better exploring the imaginative part of the representational space. Whenever they were performed, they demonstrated a strong involvement of children regarding ICT, with again a very positive and confident attitude toward computers.

They also revealed important gaps in children knowledge of computer technology, since some classes described as imaginary some devices that already exist. The imagined devices were often attributed human characteristics. In this context, altogether, the collective works have particularly highlighted how important children find it to develop a language-based mode of interaction with computers. Denmark and Netherlands contributions are very exemplary here. It is worth notifying that the interaction that pupils wish is usually an asymmetric one, where computers are expected to respond to their request in spite of having any initiative.

The sequel of this text presents some preliminary findings that emerge from the analysis of data. This analysis has been performed according to a three dimensional frame considering ICT objects, ICT functions, and ICT actors.

2.2. ICT objects

By ICT object, it will be meant here any piece of hardware or software. The hardware is quite easily broken down into components, from the whole system to each of its part, or even to the microcircuits and electronic components (although the later level certainly is not relevant here). As regards software, such an analysis is harder, and the granularity of the analysis itself is problematic. In this preliminary work, only the level of applications and files has been considered. It must however be kept in mind that software components (command, windows, controls, etc) would be worth investigating.

On the whole, French pupils mentioned very few objects pertaining to the word of computers, on both hardware and software sides. The poverty of ICT objects present in the representational space emerges from all data gathered (language based methods, or picture based ones as well). Procedures, programs are hardly mentioned, and when they are, the vocabulary is not the appropriate one. The actions

that may be performed with the objects are in very limited set, and are often described with an approximate wording. Even games that seem to have a first plan role in children representation of ICT are very few to be mentioned in French data. At the opposite, English and Netherlanders are able to mention many possible uses of ICT, and brands or program names are very current.

Whereas discrete uses (e.g. playing music) are represented in spider map data, they do not often appear in other countries (neither in the texts nor in the drawings of computer systems) except when imagination is called for, i.e. in the collective work.

On the whole, pupils seem to have perceived both hardware and software as reliable. There is indeed almost no dysfunction mentioned, with only some references to the millennium bug.

2.2.1. Hardware

The concept of hard disk is almost absent in the data collected in France (see also below, the storage function). The CPU does not have a central role in the machine, and is not always represented (and never named appropriately). It is used only to insert floppies and CD-ROMs. The component that is considered to "think" is the screen (e.g. annex : Rachid), and this can be seen in the fact that the few represented cables converge to it. The concept of "computer "seems to include only the parts that the children regularly interact with : screen-keyboard-mouse (e.g. annex, Hakima). Danishs drawings and interviews give the same impression. The size of the screen is sometimes a little exaggerated (for example as regards the size of the keyboard) whereas that of the CPU tends to be diminished. This confirms their relative importance.

Among all the countries, three categories of keyboards (non-exclusive) were found in the drawings : the grid-like ones, the ones that depict particular keys, and the one representing the numeric pad. It appears that when characters are represented on the keys, they are almost always rearranged according to the alphabetic scheme, more usual for children. These large differences between drawings might uncover differing modes of interaction with the computer, and this idea might be further investigated.

Although in Greece the school had no computer at the time the data were collected, and the pupils had rarely a computer at home, CPUs are represented very often. In Netherlands data, the CPU also appears often, but computers were available to children sight during the drawing task ; it does not seem that they perceive its central role better than in the others schools. One of the drawings of computer systems is particularly informative about how the UK pupils investigated here are more knowledgeable about computing : a pupil drew the circuitry inside the CPU. Although it is an imaginary one (the pupil is aware of that) this proves how rich her representation is.

As regards what allows one to connect to another computer, there is almost no trace of awareness in the data collected, except in the spider-mapping task (see below). Modems are out of the representational space of pupils, but this might be in part because of the fact that computers drawn are mostly those that can be found at school. The cables that could represent a LAN also never appeared, but this is in no way surprising since wires that are even more visible are neglected. Although the PC's are often networked, the pupils do not see the device for connecting to the Intranet or to the Internet.

Mice are the most often connected (either to the keyboard, to the screen, or to the CPU). The depiction of the cable might be related to the fact that the mouse is a small object that would be hard to identify without the cable property. Another interpretation is that the mouse cable (and particularly its length) places a limitation on what can be done with the mouse itself.

Printers are sometimes represented in the drawings.

As regards multimedia facilities, there are again many differences among the schools. Whereas loudspeakers and CD-ROMs as well are scarcely drawn in France, they are very often represented in the data from other countries. Here, it might be considered that sound and CD-ROMs are often associated (in the interviews) with games. A relation between the importance of game in the pupil representational space and the depiction of multimedia components seems plausible.

Most UK pupils drew computers with "multimedia" capabilities, as is shown by the presence of microphones, loudspeakers, CD-ROMs etc. Other peripherals were also included, notably digital cameras and scanners, and were shown as being connected to the main computer.

The microphone that is present in one Danish drawing and in one Netherlander drawing never appears in French drawings. Its scarcity in the spontaneous expression of the representations of the pupils contrasts with their willingness to have computers interacting with them through language. But it is true that this equipment is not everywhere present and may be rarely used.

2.2.2. Software

In French data, elements revealing Operating Systems appear in only two drawings. Apart from this, games and educational software (although they represent only the software used in their school) are often depicted or talked about. For French pupils, the vocabulary related to software that is used is very poor, revealing little conceptual knowledge in this area. However, the class investigated has a low level (and was quite well chosen, since it brings very interesting insight on the deficiency of ICT representation in poor socio-economic environment), with many pupils having difficulties even simply with the French language. The analysis of the data show the importance of owning a computer at home

(or knowing someone who does…). In the social milieu investigated here, the environment cannot provide the children with complementary knowledge about computer. As a result, they only consider the software they are confronted with at school.

As regards United Kingdom, the analysis of spider maps shows that any types of software application are represented, chiefly generic types - word-processing, drawing etc. Some of these are labelled with text, others are identifiable from the drawings ; the pupils have drawn the screens and nodes (links) carefully so applications can be identified by logo or typical graphical representation for that software or in some cases the operating system also. Some students have concentrated on specialised environments (e.g. computer games), thus showing a detailed knowledge of this area.

In between these two extremes, the pupils from other countries have diverse knowledge of computer programs. Drawing and writing tools are very often present in the data, naturally after the games that occupy an important place in children ICT representation.

2.3. ICT functions and uses

In our approach of ICT representations, it also appeared interesting to describe what functions of ICT are used and/or perceived by pupils. Four functions have been considered : learning, looking for information, playing, and communicating.

Indeed, these functions are not independent. For instance playing has a social role that results in communicating, but it can also lead children to acquiring new knowledge. Consequently playing may have a learning function. Conversely, learning with certain tools may be entertaining, as was pointed by many children during their interview or within their text. Looking for information can aim at finding help for learning as well as for playing. Thus the different functions have been explored independently only for theoretical concerns.

2.3.1. Playing

Games appear to be an essential component within the representational space of many pupils. Some pupils do not mention games in their text ; unfortunately, none of them were interviewed (in the French data). It could be further inquired whether the absence of this reference to games relates to the experience children have with ICT. Naturally, other children place game in first position (within the text content, or during the interview).

The social function of playing games (i.e. playing together, exchanging games software or game devices) is rarely revealed in the data.

Interestingly, Greek data appear to give a secondary importance to games. On the contrary, among the UK pupils games also showed up with considerable significance. Pupils most often identified specific games and referred to them by name, indeed this specificity was so marked that it was possible to sometimes identify what brand of computer the pupil had at home through the software which had been “bundled” with the computer itself. This marked awareness of game and program specific knowledge suggests that many pupils' representations of computers are intimately tied to their personal experiences and usage.

2.3.2. Looking for information

This function is at the first plan in Netherlands and UK data, whereas it is almost absent in the French one. Gathering information on Internet is very important to Netherlanders either for compensating lacks of knowledge ("when the teacher does not know") or for satisfying personal hobbies (fan clubs). Many UK pupils knew about the Internet and could broadly describe what it is for. Few presented data that suggested they had "hands-on" experience of using the Internet, either at school or at home, but many expressed a desire to use the Internet. On the contrary, Greek data do not reveal such an importance to information retrieval (on the web) in the context of school learning. But this is possibly due to Greek teachers traditionally providing pupils with the whole information needed to learn.

2.3.3. Communicating

Here we refer to communicating through ICT, and not face to face communication about ICT. This could also be interesting to investigate, but the data collected according to our framework does not give many evidence of this).

French and Catalan pupils do not often refer to this communicative function of ICT and then it is the writing tools that are evoked more than the on-line ones. Interestingly, the few French children that write or talk about Internet it as a means of communicating and not as a means to search information, or to entertain. The mailing and dialogue functions of Internet are privileged. As already mentioned, the social aspect of games (having fun with other children, exchanging games, moving to others’place) is rare in pupils. UK pupils also refer to the communicative functions and many had grasped the idea of using computers to send information (e-mail) between remote sites.

2.3.4. Learning

In all the schools investigated this function is in a good place in the texts, probably reflecting the context in which data was collected, and children attempts to meet the researcher expectations. But it must be noted that the references to school context are rather frequent in the drawings of children having no computer at home. [The drawings of the Catalan pupils are very significant in this respect].

Many French pupils draw a screen that displays the educational software they are confronted with at school, but it is no doubt related to the fact that they do not experience ICT in other contexts. French pupils perceive the computer as a helping device for schoolwork.

At the opposite, Greek children have no experience at all in learning with computers (except one of them). Yet, they place the learning function at a good rank both in their text and in the collective discussion. However the essential meaning of learning seems to be rather different from the one intended by French : learning is more of getting new information, whereas French pupils meant more practising already acquired knowledge.

The French pupils investigated here seem to have developed a representation of the computer as a means of being taught rather than as a means to actively learn with. The computer trains them, providing them with exercises.

2.4. ICT users

The question addressed here is whether pupils gave any evidence of having an implicit definition of ICT users.

Pupils hardly ever represented themselves in their drawing and consequently, it is difficult to have an insight of the way they represent themselves as ICT users. However, in the rare case where they represent themselves, they often appear relatively small compared to the computer. Other studies (cf. Levin & Barry, 1997) have interpreted this size disproportion as revealing a feeling of lack of power as regards technologies. It is however worthy noting that this feeling is nevertheless associated with a positive attitude that appears in the smiling faces represented.

From the few data collected, no other users especially appear to be highly associated with ICT. Pupils sometimes only evoke their parents using computers within their workplace. It could be interesting to investigate whether some professions are systematically associated with the use of computers, or with the use of certain kind of software.

In relation with the social function described before, it could be wondered whether there is a sense of an Internet community at least in some pupils ? Indeed ICT appear to be a mean to join groups (see for instance the communication with fan clubs in French, Danish, or Greek data). It seems however that the feeling of pertaining to such groups cannot be asserted from the rare evidence of groups in the data.

The data collected are not sufficient to reveal if pupils have any representation of differences within the computing world (for instance the opposition Mac/PC). There are a few makes that appeared in some children data, but it seems that these occurrences were not related to any particular variable.

3. Discussion

Within the frame of this exploratory phase, it must be first remarked that the data obtained are highly contextual and that differences between schools may be partially explained by this fact.

Thus, the school investigated in France is in a particularly difficult area. This can explain that representations of ICT be rather poor in French data. Low language competencies (related to this difficult context) make it hard to explore the representations apart from using drawing interpretations. In this school, most pupils do not have computers at home, and remarkably, some pupils qualify as computer what would expected to be classified as games. School ICT activity has a particularly strong impact on these children's representation since they have almost no other experience of ICT. Here, the specificity of the French school appears in the representation of computers helping schoolwork. Materials and programs are almost unknown : the essential part often is not represented, and even the vocabulary misses to describe one's own actions with computers. Internet is not particularly present (contrary to Greece for example).

Greek data corroborate what has been said about hardware objects in the representational space of French pupils. Children from less favoured social classes have incomplete representations of what constitutes a computer. The Greek case also confirms that school practice affect the representation of the functions of ICT. Learning with computer was difficult to represent for these particular children since they had not experienced it. Contrary to French children, most Greek children included multimedia accessories in their drawing, giving them the status of a necessary part of computers.

On the other hand, The UK pupils come from a school paying high attention to ICT and have an experience of it. They seem to be aware of the importance of computers in everyday life. Spider maps demonstrate a high variety and show an awareness of connection between computers. There was a high contrast between those having personal computers, mentioning more often software.

Furthermore, some computers were in sight of the pupils during the session in several, but not all, schools. Although the text assignment was rather specified in the research design, some preparatory activities took place in some of the schools whereas the assignment was only presented as such in others. As a result, some schools appeared to have more knowledgeable children. For example, whereas the NL pupils seem to be very comparable to the UK ones as regards their knowledge about network functions and about hardware, they did not demonstrate the same awareness of the importance of computer in everyday life. Interpreting this difference would however be risky, since the tasks used were not quite the same. The methodology used in UK might have brought to light some elements of the children's representations that would not have emerged otherwise.

Despite a lack of methodological homogeneity, having collected several forms of evidence upon

representations has given us information about the european situation. Analysing drawings and texts has confirmed that representations are at the time rather similar (e.g. children focusing on the external parts of computers) and rather contrasted with respect to the activities led in the classrooms. What appears from ICT representations seems to be much affected by the task proposed to pupils. The representations themselves are influenced by the school context, the use of a computer at home and in school and, probably, the gender.

4. Perspectives

The data we collected are just a first snapshot. They did not give access to fine-grained ICT objects ; the reality of children as ICT users hardly appears. Although the representational space that emerged from the spider mapping activity is quite complete about ICT objects and functions, even this method also gave little insight about ICT use and failed to capture procedural representations. This may be partially attributed to limitations inherent to the protocol we used. Therefore, a complementary research action was led by interviews in one of the school in the French network, in order to test whether other interview scheme could give more information about procedural representation, and notably on the way computers or e-mail works. Interviews focused on the description of what happen when they send or receive e-mails.

The results emerging from the transcription of these interviews provide some interesting hints. The description of email is closely related to the real use pupils have at home or in the classroom. For example, some pupils only mention the possibility to write to students of another class. The students are unable to provide explanations about the way information is sent to another place. Some of them can evoke some notions, *network*, *site*, *connection*, *and subscription*… without really being aware of their meaning. For example, one says that a network is like a "battery full of energy".

Concerning the task of sending an e-mail, pupils can only mention the different actions they have to do according to the software they use. Much confusion can be remarked between the notions of e-mail, Internet, web site, and so on. No one has a clear understanding of the relationships between these notions. For example, one pupil says : "…the e-mail, that is the address, Internet these are sites, these are information". For another one :" the mail, one receives messages that somebody sends to us and Internet one sees everything".

These findings reinforce the idea that students' representations are highly contextual and depend upon what has happened in the classrooms. They also depend upon what is requested of them. It is improbable that drawings and text might bring dramatic new elements.

This is why the second part of the REPRESENTATION project was planned to conduct further investigation using concept mapping (cf. McAleese, 1994). This way to assess representation could provide richer data. Using computer based concept mapping (CBCM) tools seem to be a promising way to capture pupils' representations. However, the CBCM tools available need to be adapted to children, particularly as regards the complexity of interface and language facilities (see Baron, Bruillard &Dansac, 1999). Such an adaptation constitute the second objective of the REPRESENTATION project.

Aknowledgements

We want to thank our European partners for their inputs, as well as Don Passey (university of Lancaster) and Jean-François Rouet (CNRS-LACO, France) for their pertinent reviews of our work. A special mention is due to Michelle Harrari for her help.

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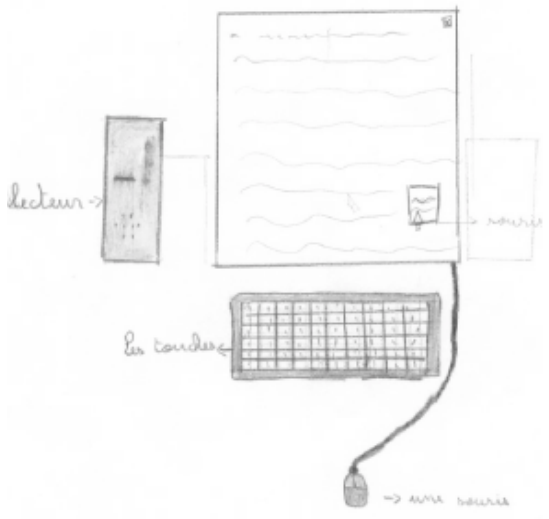
Annex: examples of drawings

Hakima

Hakima is a 9 years old French girl living in a city near Paris. She has one brother (17) and one sister (14). She has no particular hobby, except may be drawing. She has a super Nintendo that she uses for car racing games. She also has a mini-computer that can be used for practising arithmetic, French, and for playing games. The family does not possess any other computer.

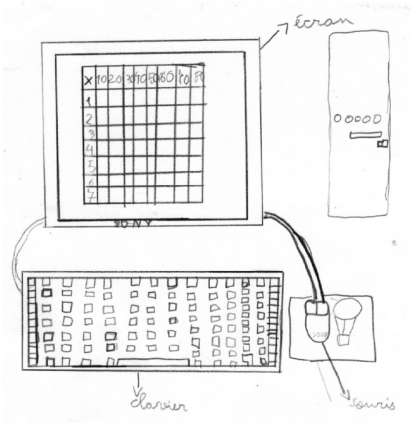
Hakima would rather have a computer like those of her school, "because there are a lot of things inside". When asked who placed this "lot of things" in the computer, Hakima answers that they were put inside by the person who constructed the computer. At school, Hakima uses computers for learning through the software programmed by her teacher. She does not remember the names of the software she uses although she appreciate working with computers.



The CPU ('named Drive') is what allows one to switch on or off the computer, which apparently is the screen + the keyboard, in Hakima's mind. The disks that can be put inside the drive are similar to CDs except that they contain "things for computers", for instance "some exercises, but that are more difficult".

Rachid

Rachid is a 10 years old boy. He has 2 little brothers (aged 8 and one) and one big brother (aged 19). He lives with his whole family. He has a Nintendo, with which he plays sport games and action games, mostly during weekends, but no computer at home (at his cousin's, he can play many games, that he is not able to name) on a computer. At school, he only uses computers during the computer sessions, mostly in order to train in grammar and mathematics. Sometimes he also plays games or makes drawings. Rachid does not long for any other activity with computer that could be made at school.



During the interview, Rachid told that he would like a computer "which has everything" as the one he drew. The CPU (never named so) is what is used to put the floppies and to switch on the computer. Rachid confesse he has forgotten the cable that joins this CPU "to the computer". The keyboard is what one writes on, "there are letters on, and you type on the buttons". There are two buttons on the mouse, "this one, we move it more than this one". Rachid has seen the drawing of the carpet at his school computer room, but he does not associate it with any meaning.