Literacy, Digital Literacy and Epistemic Practices: The Co-Evolution of Hybrid Minds and External Memory Systems

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English abstract

In many societies, artificial memory systems are essential resources for preserving information and developing knowledge. Such systems imply that information is documented outside the human body by means of graphic signs on material artifacts (texts, images). The concept of hybrid minds points to the manner in which human cognitive and communicative activities are dependent on, and integrated with, increasingly complex and powerful symbolic and material cultural tools. Users of such resources need to develop specific epistemic practices and literacy skills that are coordinated with the affordances of their tools. In the present article, some of the ways in which cultural tools and people's literacy skills have co-developed are discussed. It is argued that current external memory systems add powerful processing capacities and analytical functions to previous technologies. This implies that notions of learning and literacy skills are undergoing change as people adapt to, and reconfigure, the functionalities of recent digital tools.

Keywords: Literacy, digital literacy, artificial memory systems, learning.

Introduction

The term literacy, allegedly, does not exist in most languages. Yet, the phenomenon is central to modern societies, and many academic disciplines, as diverse as neuroscience, social history and literature, consider issues of literacy to be a central part of their current research agenda. Traditionally, the term has been used to refer to the ability to read, write and use printed texts in various contexts, but owing to changes in the media ecology this particular focus on print technology is now seen as dated and too narrow by many (Kress, 2003). Some scholars argue that we should think in terms of literacies in the plural sense (Østerud, 2004), and others have suggested that a range of new terms rooted in the concept of literacy should be added to our vocabulary including media literacy, visual literacy, science literacy, information literacy, digital literacy, statistical literacy and multimedia literacy. Today, we even encounter expressions such as health literacy, art literacy and technological literacy. This proliferation of terms testifies to the role issues of literacy and, more generally, the ability to handle information has come to play in public and scholarly debates about media, schooling, work life, and contemporary society in general. As the concept expands, however, it becomes slippery and difficult to use for analytical purposes (and many would argue that it was never very clear in its more traditional and restricted definition, anyway). In many instances, the term literacy currently seems to be used as a synonym for expressions such as knowledge, competence and learning.

No matter which definition we prefer, we find at the core of the concept of literacy issues of how people engage with information, messages and symbols mediated through resources that lie outside the human body, i.e. through inscriptions and various kinds of technologies. As Barton and Hamilton (1999) point out, symbolic systems and inscriptions are interesting to analyse since they mediate between thinking and a social world of human activities. Thus, writing has "a psychological basis", and "any piece of writing is an external representation or outcome of an internal cognitive process" (p. 793). At the same time, however, "writing is 'out there'; it exists along with other social artifacts of culture, and forms part of a broader social context" (ibid, p 794) for which it is consequential. It is therefore reasonable to assume that powerful symbolic systems such as writing have significant implications for human cognitive practices, for institutions and for society at large. As Goody (1987, p. 3), puts it: "[s]ystems of communication are clearly related to what man can make of his world both internally in terms of thought and externally in terms of his social and cultural organization."

What we now call digital or media literacy – the engagement with digitally mediated information – emerges as a response to the most recent transformations of technologically mediated communicative practices. However, there is a long history behind these recent developments both in terms of the meaning-making practices of individuals and in terms of media ecology in society. In the present article, I will approach issues of literacy from the point of view of an interest in sign-making, sign-reading and materiality from a sociogenetic perspective. In particular, my focus will be on how people build up social or collective memories by developing technologies for preserving information, and how such designed external memory systems, in turn, shape the meaning-making practices of individuals and groups. The background of this focus is an interest in understanding the interplay between media technologies and the cultivation of human reasoning through learning how to use signs and how to use the technologies that mediate them. As pointed out, these issues must be addressed at different levels of inquiry since they concern questions all the way from the communicative development of individuals during ontogeny to matters of how power and control in society are exercised. As we infer from the quote by Goody above, technologies of communication

are never neutral; on the contrary, they co-determine what we conceive as rational forms of argumentation (Ong, 1982; Horkheimer & Adorno, 1969), and they play a crucial role in how schools and other institutions involved in social reproduction privilege specific types of knowledge and skills. However, in the following the focus will be on some of the consequences of literacy and the use of texts for the epistemic practices of individuals.

Graphic representations, social change and hybrid minds

Writing is commonly seen to have emerged about 5,000 to 6,000 years ago in ancient Mesopotamia, which is present-day Iraq (Kramer, 1963; Schmandt-Besserat, 1996). At that time, in growing city-states with complex economies and increasing divisions of labour, writing became a significant mechanism for social coordination. In these urban settings, trade and commerce flourished, and bureaucratic practices were instituted to organize social life under the new circumstances. A range of documentary practices was invented: book-keeping to keep track of the flow of goods, contracts to confirm business agreements and receipts to verify the exchange of goods. Life in a city implied that a range of administrative matters pertaining to the ownership of land, taxation and similar issues had to be handled, and, given the complexity of these urban environments, salaries had to be paid to those who were employed to run city affairs; clerks, soldiers, legal officials and so on. Writing became the solution to many of these practical problems of social coordination, and what emerged is what in the literature is referred to as document societies, where information is preserved outside the human mind/body through the use of signs imposed on material objects (Burns, 1989). Somewhat later, documentary practices were extended to include poems and stories to form what is seen as one of the oldest literatures in the world (Green, 1989; Kramer, 1981).

The cuneiform writing that emerged in the city-states of Mesopotamia, however, was a product of cultural transformations that had been going on for many millennia. Predecessors of cuneiform signs appeared as early as 10,000 years ago (Schmandt-Besserat, 1989), and long before that visual symbols had been used in rituals and other settings. Body painting, personal ornaments and grave decorations, for instance, are very old forms of intentional visual symbolism. The oldest cave paintings are about 30,000 years old (Klein & Edgar, 2002, p. 260), while other artifacts with visual symbols date back even further. Sticks with distinct notches, symbolizing the lunar cycle (Marshack, 1972) or, alternatively, recordings of kill scores (d'Errico, 1998), date back about 40,000 years (cf. Marshack, 1972, for images of early artifacts with visual symbols).

In his account of the emergence of "the modern mind", the evolutionary psychologist Donald (1991, 2001) argues that "symbolic use of graphic devices" (1991, p. 275) is a critical component in what was to be a major change in the human ability to preserve and develop knowledge and more complex forms of life. Through the invention and use of visuographic symbols (images, ideograms, letters and digits, etc.), it became possible to design external memory devices that have qualities that are very different from human, biological memory. Such devices – external symbolic storages (ESS) or artificial memory systems (AMS) – are virtually unlimited in their capacity, often permanent, publicly available, and they may be accessed and reformatted relatively easily (cf. Donald, 1991, p. 314). While the human brain and sensory system are products of biological evolution, external symbolic storages make up an invented technological environment that has little to do with biology. ESS/AMS – texts, lists, drawings, databases and so on – are designed by humans for specific purposes, and they look very different in different cultures and societies in terms of the design of symbol systems and artifacts. Scripts, numerical systems, symbols, measurement systems, instruments for navigation and so on can be designed in any number of ways. Also, the materials used for

documentation vary; writing, for instance, has been made on clay, rock, papyrus, parchment, paper and various types of animal skin.

External symbolic storages make it possible to build up an "external memory field" (Donald, 1991), or a social memory, of enormous proportions. In such an environment, human experiences may be continuously externalized by the cognizing individual, i.e. they may be "offloaded" (Dennett, 1996) from the biological brain to be documented in artificially created media, where they become accessible to others in the community. Cognitive activities – thinking, reading, perception, problem-solving – in such circumstances will take place largely through coordination with these artificial technological resources for meaning-making. Remembering is done by means of texts, lists or databases; calculations are carried out by paper and pencil, by calculators, by computer software or by any of the other artifacts invented for this purpose; navigation is supported by charts, compasses and navigators, and so on. Hybrid minds operate in environments of external symbolic storages where human reasoning is located at the intersection of the human mind and external, technological resources that have often been crafted over long periods of time to reach their current form (Cole & Derry, 2005). Or, put differently, cognitive activities are distributed between minds and external tools (Hutchins, 1995).

A hybrid mind, thus, does not stand alone, disconnected from the outside world. On the contrary, the world it inhabits is largely made up of cognitive and material artifacts – cultural tools or instruments in the Vygotskian sense (Vygotsky, 1978, 1981) – designed to function as prosthetic devices in cognitive, communicative and social activities. A hybrid mind is made for "*multiple mergers and coalitions*" (Clark, 2003, p. 7, italics in original) with external resources, and it has access to cognitive amplifiers (Nickerson, 2005) and mindware (Clark, 2003) in a manner which is unique. As Donald (2001), borrowing from Shakespeare, so aptly puts it: it is a mind so rare. We constantly transcend our limited biological capacities by collaborating with cognitive and physical artifacts that have emerged through history, and we generally do so without being aware of how these resources were invented and transformed. They have often been naturalized and we perceive them as simply there for us to use.

External memory systems and epistemic practices

An external memory field that is available to members of a community and important for social activities tends to expand. New entries to it are made as new experiences are documented; the communicative environment available through external symbolic storages is "always undergoing creation. It is, as it were, 'work in progress'." (Ingold, 1992, p. 56). From a psychological point of view, there are several important consequences of this dynamic. The presence of an external memory field encourages conceptual and symbolic invention of visuographic representations. New modes of painting, scratching, carving and designing symbols emerged over time and, as we all know, there is no end to innovations of these kinds. Both material artifacts and symbols are modified as varied groups of users interact with the social memory. The documentary practices through cuneiform writing and the design of symbolic constructions such as tables and lists that appeared in Mesopotamia are illustrations of this dynamic. New social circumstances generate new symbolic systems and new contexts of use (Schmandt-Besserat, 1996; Senner, 1989).

At the psychological level a significant feature of the use of visuographic representations is that it relies on familiarity with specific interpretive conventions, i.e. insights into how a message may be designed and how it should be understood. This is where issues of literacy come into the picture,

and, in the words of Kress (2010), both the person producing the sign and the person reading it have to engage in "semiotic work" relevant to the representation in question and to its context of use. Reading, writing and other forms of sign-making are acts of communication between members of an interpretive community, and insights into how conventions for meaning-making should be used are not given by nature, but acquired through experience and enculturation (Crook & Light, 2002). When symbolic systems become complex, as they did in ancient Mesopotamia, some kind of instruction is necessary and it is no accident that the first schools were founded in this environment. Mastering all the varied cognitive and manual skills associated with writing was possible only through a systematic training following some kind of curriculum (Burns, 1989). Hundreds of signs, grammar and rules of composition had to be learned in what seems to have been rather austere and authoritarian conditions in the first schools to appear in history, the so-called *edduba* (Falkenstein, 1948; Kramer, 1981).

External memory systems thus require semiotic work that relies on familiarity with conventions for how symbols and codes may be designed. The minds and symbolic repertoires of users have to be coordinated with the modes of expression utilized in artificial memory systems for the merger that Clark (2003) describes to take place. Externalizing human experiences and representing them in material form implies that they are reified or fossilized, or, expressed differently, converted into information (Liedman, 2001). What we encounter in our engagement with documents are signs or indicators of human observations, reflections and insights that have been committed to a material form. Such a sign is never complete or exact, and signs do not have literal meanings (Rommetveit, 1988); rather, the referential function operates through approximations and grounding in cultural practices. Reading and the use of signs always rely on an active, cognizing person as a part of the equation. He or she must add what is not there and be familiar with some of the conditions that apply to using the symbols. Reading and other interpretative acts are grounded in the hermeneutic practices of communities, where messages are reinterpreted and re-specified in a particular context and for particular purposes.

Learning in societies that have access to extensive external memory systems implies knowing how to use these resources for meaning-making in various settings. Thus, unlike in the case of oral societies, information and previous experiences can be preserved without committing them to memory, and the development of a social memory is not limited by the capacities of the human brain to store information (Ong, 1982). Hybrid minds learn by appropriating insights that have been documented, but, and this is important, they also learn by knowing something about how the external memory field is organized and how it may be productively used (Donald, 1991). Our knowledge has to include insights about what may be accessed in ESS/AMS; we have to have various kinds of meta-knowledge. Thus, my proficiency in a foreign language that I have some basic familiarity with is much improved by the presence of artifacts such as a dictionary, a thesaurus and a grammar, and by my knowledge of how to use such tools productively when searching for translations, synonyms or information about the syntax. Grammars and dictionaries are not self-explanatory, but require relevant epistemic practices to function productively in the hands of the user. In a similar vein, my ability to perform complex calculations such as multiplying three-digit decimal numbers with cultural tools such as paper and pencil or a calculator is far superior to my mental arithmetic (Säljö, Eklund, & Mäkitalo, 2006). In fact, the use of a calculator makes the multiplication 332.24 by 356.87 just as easy to perform as multiplying 2 by 2. But it is not just being able to perform calculations that is important; my knowledge about how I can use a device and its various resources (its memory, its preprogrammed functions, its representations and so on) are equally decisive.

Learning – in the Vygotskian sense of appropriation – in the context of extensive artificial memory systems, thus, is not a single cognitive process. Rather, it is dependent on the mastery of a range of epistemic practices that have to do with consulting your own memory, knowing how to make productive use of the external memory systems available and how to find, extract and transform the relevant information. The latter process includes skills of knowing where to search for information and how to evaluate and reorganize it in manners suitable for specific purposes. Reading and interpretive practices also vary across situations; we read a manual on how to use a technical gadget with one set of criteria for meaning-making, while we use different ones when reading a poem or a novel. Familiarity with genres of texts and expected meaning-making practices is therefore necessary. Also, the second or third time we read a piece of text, we may interpret it very differently, since our experiences are different and our motives for reading may have changed. Every "act of reading thus constitutes a different interpretation of the text directly conditioned by the reader", and "the book enjoys the freedom to "roll" in all directions; it lends itself to free reading, interpretation and use." (Cavallo & Chartier, 2003, p. 6). Thus, one has to ascribe some agency to texts and other forms of documentation; they lead their users in specific directions.

The dialectic between readers and texts

External symbolic storages are designed by people with some purposes in mind, and they represent and organize information according to what is considered relevant. The semiotic work put into designing a text, a database or another medium has implications for the work that readers/users/learners have to do. The history of reading printed media yields evidence of many interesting shifts in this dialectic between how external systems are organized and the nature of the semiotic work engaged in by users. Reading during Antiquity and well into the early Middle Ages was predominantly an oral practice where texts were read aloud to audiences. This reflected the fact that texts existed in what was still a mainly oral culture where speech was the primary form of communication. When reading, the orator should obey the rules of public speech and, in order to facilitate for the listener, read "aloud with proper articulation of the sense and rhythms" (Parkes, 2003, p. 93). Also, most reading during the first Christian period was done for religious purposes where the primary, and perhaps sole, motive for reading was to engrave into the reader's mind the words that would lead to "the salvation of one's soul." (ibid, p. 91).

When texts became more widespread during the medieval period, several interesting changes in the artifacts as well as reading practices occurred. Some of these changes reflect the fact that the preservation of information, in most cases God's words or deliberations on these, was no longer the only motive for engaging in reading. One such significant development of a technological nature with clear implications for reading practices was the introduction of word separation in texts. Until the 11th century, texts were written using the *scriptio continua* form with no spaces between words (Saenger, 1982). The "absence of spaces and the lack of standardized spelling made every reading a sounded experience" (Svenbro, 2003, p. 44), where vocalization was more or less unavoidable to make the text intelligible. The reader had to actively search the lines to find the word units that would make it possible to follow the text. This made the reading process laborious and slow, and the vocalization was part of a cumbersome mental process that occupied most of the reader's attention.

Silent reading emerged among monks who had to work in silence. To facilitate such practices, word separation was introduced and gradually a number of other changes in text conventions with implications for reading practices appeared. These included conventions such as "emblematic

punctuation, discrete clauses, the ordering of both words and clauses within complex sentences, and the use of conjunctions and adverbial conjunctions for the construction of compound and complex sentences" (Saenger, 2003, p. 131). Modifications of this kind "facilitated sequential understanding of meaning successively within the boundaries of clause and sentence" (loc. cit.), and thus reading took a different turn as a meaning-making practice. "Whereas the ancient reader relied on aural memory to retain an ambiguous series of sounds as a preliminary stage in extracting meaning, the scholastic reader swiftly converted signs to words and groups of words to meaning, after which both specific words and their order might quickly be forgotten" (loc. cit.).

Reading for meaning, and paying attention to claims, arguments, consistency and conclusions, were thus greatly facilitated by inventions that made text units more easily recognizable. In fact, the new representational technologies of word separation and more standardized ways of writing may be seen as the definite cultural breakthrough for units such as 'word', a term that is not used in languages which do not use writing, and 'sentence', which is also a literate construction (Scholes, 1993).

These changes in reading practices, however, did not take place in a social or political vacuum. They reflect the fact that reading became central to another institution during the Middle Ages; the school and the university. The "greatest change that scholasticism brought to reading lies in the importance of reading in the context of teaching" (Hamesse, 2003, p. 105). In schools and at universities "acquisition of knowledge became more important than the spiritual dimension of reading", and in these institutional settings it may be argued that "organized technical reading won out over spiritual reading" (ibid, p. 118). When learning and the more utilitarian needs of acquiring and producing knowledge became the prime motives for engaging with documents, texts were further modified to accommodate the needs of such readers. Aids to comprehension and efficient studying were introduced with features such as the "table of contents, the concept index, concordances of terms, alphabetically arranged analytical tables, summaries and abridgements" (ibid, p. 110). Even systems for marking quotations from other texts came into use in order to clarify to the reader whose arguments were presented in a passage (cf. Rouse, 1976; Saenger, 2003, p. 125). Other similar modifications that were introduced later involved changing the printed page itself by using headings and dividing text into paragraphs (Cavallo & Chartier, 2003, p. 35). To cope with the growing number of texts already published before book printing, compilations and summaries became widely used at universities. This made it possible to keep up with new knowledge without reading entire volumes, and this is a type of document that is still well-known to today's students. Compilations of texts, sometimes with lists of exam questions, still circulate widely in academia.

These examples of development in material artifacts illustrate the dialectic between the interests of readers/users of external symbolic storages and the evolution of the design of texts. The book and the page were transformed so that their appearances would be more adapted to the needs of someone studying. Silent reading is suited for a more reflective type of reading focused on extracting meaning from texts in order to ascertain if the message is interesting, informative or logical. This practice became the norm within libraries and in the study chambers of students, and it was greatly facilitated by the new organization of texts. Silent reading is also more flexible in several senses. First, the reader is able to read faster since one does not have to vocalize in order to be able to follow the text. Second, one does not have to worry about a listener. Third, a more extensive type of reading is possible since the reader does not have to read or even attend to every word. The redundancy of most texts is sufficient to make it possible to skip words and still understand sentences and passages. In a similar vein, since the reading process is an inner dialogue and there is no listener to take into account, the

experienced reader may skim over paragraphs and pages and still gain an impression of the main messages relevant to his or her needs.

Engaging with external memory systems thus requires familiarity with a varied set of epistemic practices that range from deciphering letters on a page through familiarity with meaning-making in relation to discourses and genres of texts and other media, to meta-knowledge about how such resources may be used. An academic author of today, for instance, is often held accountable not only for what is in the text, but also for what has been missed and should have been there had the literature search been performed properly. An important ingredient of our present epistemic practices, however, is that we must become skilled at judging what is not necessary or relevant for our particular interest. The expansion of artificial memory systems, and their diversity, also raises a number of interesting questions about what levels of competence should be expected of various groups of users. In socially and technologically complex societies even very experienced and skilled readers will not be able to handle all the genres and text types available.

Offloading information vs. offloading thought processes

The hybrid mind operating in the print culture that has dominated Western societies functions with a great many resources. Enormous amounts of information and human experiences are available as support in many activities through texts, images, tables and other similar prosthetic devices. Adding to this, many of the technologies that have emerged during the past 50 years increase capacities for preserving and organizing information. In many activities there are continuities where paper documentation exists alongside databases stored on hard disks or on USB sticks. Through digitalization, however, the ways in which we access and use the ESS/AMS are rapidly changing our cognitive and epistemic practices in daily activities. Some of the most important changes that are taking place have to do with the ways in which we access information. Nowadays, due to the development of mobile technologies, we have the resources of external memory systems available more or less continuously. We can search for information, access databases and perform many activities from our mobile devices. Again, this implies changes to the ways in which we use our intellectual capacities, and, as was the case with texts, these new artifacts will also change when new groups of users integrate them into their activities. For instance, many online calculator tools are created as resources for special purposes, such as calculating interest and mortgage rates when considering buying a house. Similarly, GPS navigators are tailored to the needs of diverse groups of users such as tourists, lorry drivers, etc. In education, we have seen how learning management systems and resources for networked learning have been developed to support alternative modes of organizing instruction for various kinds of users (Dirckinck-Holmfeld, Hodgson, & McConnell, 2011; Nilsen & Mäkitalo, 2010). At university level, new social media have been introduced that gradually reconfigure the ways in which students engage in learning and the communities and learning spaces they have access to (Francis, 2010). Learning in the context of such tools generally builds on previous literacy skills, but also often implies that new habits must be developed (Dewey, 1966). In all cases, some hurdles have to be overcome for a new tool and its affordances to be integrated into the repertoire of epistemic practices of the individual.

If we return to the perspective suggested by Donald, the external memory field is currently expanding and undergoing dramatic changes in terms of its design and accessibility – the merger between human reasoning and external tools is becoming increasingly intimate. One interesting aspect of this development is the changes that appear in relation to print technology. In the case of print, the main function of externalization through texts is that it has been possible to offload information

and preserve it for the future. What is currently happening, however, is that external resources are rapidly becoming more powerful when it comes to searching, organizing and manipulating information. Expressed differently, information processing that previously used to be carried out by people is now being handled by software instruments that operate on information in external memory systems. Some examples of such devices that are relatively widely used are:

- Search engines
- Spell and grammar checks
- Statistical analysis packages
- Book-keeping programs
- Graphical and specially dedicated calculators
- Face recognition devices and other optical readers
- GPS navigators
- Route planners
- Digital breathalysers
- Electronic blood pressure monitors
- Sonar sensors (e.g. Fish Finder)

If we look at specific professional domains, such as architecture (Computer Assisted Design, CAD, health care (devices monitoring bodily functions, scanners of brains and other parts of the body), logistics (equipment following the movements of ships and parcels, etc.) and many others, we will find a range of resources that support daily practices. Many of these technologies are customized to fit the particular needs of a specific company and its operations, and they are designed to document activities and to perform operations that produce outputs that can be used for monitoring the organization. When employed at a company using such systems, one often has to spend considerable time learning how the locally configured technologies function and what can be done with them (Eklund, Mäkitalo, & Säljö, 2011)

What is interesting if we consider this development in relation to issues of learning is that tools or instruments of this kind to a large degree "black box" the processes they perform. For instance, a bookkeeping program contains a database where transactions are documented in accordance with the intellectual technology for double bookkeeping that goes back at least five centuries to the merchant houses of Northern Italy (Lauwers & Willekens, 1994). However, in addition to preserving and organizing the information in expected manners, the software makes it possible for the skilled accountant to perform a range of analyses that sometimes return results literally within seconds; establishing sales volumes, estimating marginal gains, comparing revenues from different markets, predicting trends, etc. This implies that the instrument incorporates analytical processes that are performed algorithmically when given proper instructions. The user does not have to perform all the transformations that are involved in going from the documented information to the final outcome of the analysis; these steps have been offloaded. In a similar vein, a search engine quickly scans vast amounts of information that are of interest to a particular user. The procedure can also be repeated several times and varied in terms of its objectives at very little intellectual or physical effort for the user. The database and the documented information do not have to be reorganized, they lend themselves to multiple manipulations. The power of such resources in terms

of the number of operations that can be performed is enormous. Search engines can easily find hundreds of thousands, even millions, of documents in the flash of a second.

Understanding the phenomenon of black boxing is essential when it comes to analysing learning and the epistemic practices that go into digital literacy. In fact, it is an interesting challenge to many established assumptions about learning and knowing. Externalization in relation to tools that become black boxes involves not just information, but also analytical procedures that previously had to be performed by individuals through a series of steps. The success of such instruments lies in their co-ordination of conceptual structuring of information with a capacity to perform specific manipulations that close the gap between information and an outcome that the user is interested in. Latour (1999, p. 304), in an often quoted passage, makes a parallel between how machines and concepts operate in such cases of black boxing: when "a machine runs efficiently, when a matter of fact is settled, one need focus only on its inputs and outputs and not on its internal complexity."

Mastering tools that contain complex forms of black boxing is an important ingredient of epistemic practices relevant to current external symbolic storages and the issues raised in response are central for education at all levels. Technologies provide "access points" to knowledge (Giddens, 2002) in the sense that users can access, search, iteratively reorganize and analyze information in a number of ways. The user will learn how to use a search engine, a spell check or a GPS navigator as an instrument for a specific set of practices, but will most often have little knowledge about its technical design or the programming that goes into it. After some exposure to the tool, it will become increasingly transparent and integrated into the users' habitual coordination with the world.

From the learning and literacy points of view, such tools imply that users' knowledge and skills, as it were, are parasitic on the collective insights that have emerged over a long time and which have been entered into the instrument in a crystallized form: algorithms, grammatical rules and concepts, etc. The user will manipulate the artificial memory system in a number of ways in order to see what comes out of the processing that goes on in the machine, but he or she need not, as Latour points out, worry about the complexities of the machinery that performs the transformation from data to some kind of result.

Our increasing reliance on such powerful cultural tools raises interesting issues in terms of what competences are necessary to acquire in order to master the conceptual constructions and operations built into the tool. Educators worry about what kinds of conceptual understandings emerge from extensive engagements with such artifacts, and if someone using an advanced calculator or a spell check 'really' learns to calculate and spell in the established manner. The tools also raise questions about what the learning trajectories will be like for beginners who learn by using artifacts with powerful black boxed processing capacities (Hillman, 2011). What is, in the words of Huh, Newman and Ackerman (2011, p. 2145), necessary to "white box" for the user to understand the operations that a tool performs? And how far in terms of white boxing do we need to go? These are very interesting issues, which are difficult to answer since understanding is relative to the task one wants to perform. Understanding in the sense that one masters a set of practices such as bookkeeping or navigation with tools with advanced processing capacities will require one form of white boxing, while understanding the conceptual principles and algorithmic operations built into the instrument will require a rather different type of semiotic work on the part of the learner/user. In the latter case, converting a black box into a white box may be quite a laborious undertaking. Considering how ubiquitous such resources are, the effort and time needed to engage in such extensive exercises would

be considerable, and would, most likely be considered as rather pointless by those who are aware of the shortcuts that such technologies offer.

Concluding remarks

The omnipresence of digital tools with capacities to manipulate and transform information available through external symbolic storages, requires specific skills that may be historically new, at least if we assume that they should be mastered by large sections of the population. In this sense, the concept of digital literacy may be seen as pointing to added competences in comparison to those we associated with print literacy. These include operating in virtual environments and mastering the tools through which you get access to and manipulate information in the external memory field. As Østerud (2004) points out, some "tool literacies" are necessary in such settings. Adapting to these resources also implies that our meaning-making practices – issues that have to do with what Østerud refers to as "gestalt literacies" – will change and become more diverse. For instance, extensive reading, skimming texts and documents will become a more frequent practice and we will have to be more particular about what we read intensively. Our knowledge about how artificial memory systems are organized must also deepen since the knowledge we need may already be available if we know where to search for it and how to combine what we find.

Another interesting issue concerns what Crook and Light (2002, p. 162) refer to as the "dynamic concerned with the traffic at the borders between the formal and informal." Many digital resources and the more iterative learning styles they foster, are already part of our everyday activities where they fulfill performative functions when we want to remember or solve a problem. We know many of these resources and our practices are conditioned by their continuous presence in our activities; we achieve results by using them. However, knowing how to use such resources in everyday affairs is not the same as knowing how to use them as part of a disciplinary or professional community. Here, the expected uses of many of the digital resources we are already familiar with have to be coordinated with the goals of, for instance, understanding a concept or a method. Some critical elements that may easily become black boxed in advanced technologies will have to be white boxed for their successful enculturation into a community to take place. However, the learning trajectory in such settings will also be affected by the presence of these resources. When we take shortcuts through black-boxed tools, we may gradually discover some of the concepts and procedures that regulate their operations. Through the development of powerful digital resources, our access points to knowledge and information in many human activities have changed, and there is no return, but information and crystallized instruments with impressive processing capacities do not automatically generate knowledge. It takes a person and a mind, in this case a hybrid mind, to transform the outcome to something that is consequential, valuable and that we will recognize as knowledge.

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