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**New technologies, social perspectives and communication roles
within the Knowledge Society**

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“Technology is neither good nor bad; nor is it neutral.”

(M. Kranzberg)

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Chapter 1. Introduction

Nowadays the entire process of creation and communication of knowledge is in the middle of a profound transformation. In the background there is our Web civilization, got used to a technology encapsulated into everyday objects, into multimedia devices and digital artifacts, or embedded within artificial environments and intelligent systems. Technology-augmented tools are offering the possibility of expanding natural boundaries, of enriching our senses and awareness: they are pervading every single moment of our life.

Unfortunately, when dealing with technological issues, we often use to separate objects into disciplinary knowledge, while at present we have the necessity to tackle the arising complexity of our world, focusing on what interconnects objects of knowledge, instead of what separate them. We are living in the emergency of an “ecologizing” thought, as underlined by Edgar Morin¹: “each event, information or knowledge is in a relation of inseparability with its cultural, social, economic, political and natural environment, and today this is particularly true. Moreover, we have to discover how each single event could change or clarify that precise context. Dealing with the thought of complexity, it is not enough to inscribe each thing or event within a “frame”, but we have to look for connections and feedback loops between each phenomenon and its context, and the reciprocal connections all-parts.” This vision has been the *leitmotif* of my research interest, during these three years of doctoral course.

After deepening the Knowledge Society as conceptual “frame”, the thesis tries to approach what is happening in our society, where new technological devices are modifying our lifestyles and activities, pervading the environments where we conduct academic research, read write or publish new cultural contents, teach and learn at school. Actually, social and academic networks, virtual and augmented worlds, tablets and e-readers, large interactive screens and Interactive WhiteBoards are populating our space and time, changing our way of generating and sharing knowledge.

¹ In “La testa ben fatta. Riforma dell'insegnamento e riforma del pensiero”, Raffaello Cortina Editore, Milano 2000, pp. 19-20.

The aim of the thesis is to describe some of the latest possibilities offered by the mutated technological scenario, influenced by the Ubiquitous Computing paradigm, by arising interfaces, and by virtual/augmented world opportunities.

The analysis of different case studies and personal experimentations exploiting these technologies will show new bottom-up movements and the deconstruction of established roles within research, cultural and educational contexts.

The final purpose of this work is to find connections and to describe these complex phenomena, with the unified approach of the knowledge circulation process, proposing at the end the sociotechnical framework or *backbone* of the Knowledge Society.

1.1 Methodological remarks

Even with different degrees of deepening, I have tackled three different disciplinary areas in the course of the thesis, joining my personal interests with the interdisciplinary purpose of the doctoral course: computer science, educational research and sociological studies. In the following I am going to explain the methodological effort, which can be traced along this personal path, in developing the context and the contents of the thesis.

A literature survey and some doctoral courses on different computer science research areas and topics have allowed to deepen Technology Enhanced Learning, Computer Supported Cooperative Work and Learning² and Interaction Design³. In dealing with Ubiquitous Computing issues, I have participated to the 8th and to the 10th Pervasive Computing and Communication Conference in 2010 and 2012, in Mannheim and Lugano respectively.

I have studied and tried different technological devices and paradigms: large interactive screens and Interactive WhiteBoards (IWBs), e-readers and tablets during expositions, such as “ABCD - the Italian Education Exhibition” in Genova and within the laboratory⁴ on Innovative Technologies for Interaction and Services (ITIS), at the Department of Informatics, Systems and Communication (DISCo) of the University of Milano-Bicocca.

Moreover, augmented reality features and a Cave Automatic Virtual Environment (CAVE) have been experienced within the Virtual Reality Development Centre in Lomazzo (Co) and testing personally the features of the Icube by EON Reality. As a matter of fact, within a three-year period some technologies have gone out of fashion, while others have captured the attention of the world of research and of the public.

In order to widen the initial technological focus, and to discover social implications in the use of the described devices, I have continued the study of the literature and of particular case studies related to the three contexts of the thesis: research, culture and education.

² Doctoral course by Prof. A. Mørch (University of Oslo).

³ Doctoral course by Prof. G. De Michelis (University of Milano-Bicocca).

⁴ <http://siti-server01.siti.disco.unimib.it/itislab/research/>.

I have tried to identify present aspects of widespread Virtual Research Environments, to suggest the feature of the future ones.

I have participated to national conferences and meetings, such as “FOCUS 2011-The book tomorrow: the future of writing” and “If Book Then 2012. The future of publishing now”, to catch current issues and debates on changes in the book world.

I have attended two courses in order to deepen how to insert a specific technology, that is the Interactive WhiteBoard (IWB), and how to approach an experiment within an educational setting: “Core competences in the use of the IWB in the didactic of disciplines⁵” and “The use of observation in educational contexts. Theoretical perspectives and implications for practice⁶”.

I have conducted the experimental phase of the thesis together with the experiences of tutorship for the Department of Informatics, Systems and Communication, in order to design, develop, apply and observe technologies and paradigms on the field, thanks to two different experiments, which have been planned within two primary schools: the first in Arona (No) and the second in Canegrate (Mi), during 2010-2011 and 2011-2012 school years respectively.

In order to exploit the multimedia and multimodal opportunities of the Interactive WhiteBoard (IWB) for collaborative learning lessons, I have proposed two different projects: a digital storytelling experience called “FairyTale Box” in Arona, and a Technology Enhanced Music Project in Canegrate, where teachers will probably continue with a second phase of experimentation in 2013.

The first digital storytelling experience has been exciting because it has given completion to the initial studies on the use of IWBs, started during the thesis for the master degree. Some preliminary results and issues have been published in the proceedings of two international conferences⁷.

The second experience about music has been particularly challenging, because I had the opportunity of combining my technological background, having a bachelor and master degree in computer science, with my musical one, having both an Academic Diploma of 1st level in piano and one of 2nd level in Musical Disciplines.

The experiment in its whole has involved 6 primary classrooms (139 pupils) and their six teachers, using both traditional and digital research instruments: participant observation, systematic observation (videotaping classroom activities), pre/post questionnaires for teachers and questionnaires adapted for pupils.

During the last period of the thesis I have joined descriptive and reflective moments.

On one hand, I have studied the literature and participated to other seminars, in order to define the actual concept of Knowledge Society, thinking to its sociotechnical framework, which is the background of the thesis: a paper is under peer review for an international journal.

On the other hand, I have tried to use the knowledge circulation process as the lens through which new technologies and communication roles, both studied from the literature

⁵ Extracurricular course by Prof. S. Mantovani (University of Milano-Bicocca).

⁶ Extracurricular course by “Laboratorio Formazione” (MIUR).

⁷ PerCom2010 and ICALT2011 (see References for details).

and tested personally on the field, can be interpreted. On this subject an abstract has been accepted by the Australian International Cultural and Educational Institute for the Online Conference on Multidisciplinary Social Sciences and the relative article is under peer review.

1.2 Contents of the thesis

Taking into account these methodological remarks, the contents of this thesis have been articulated in the following chapters.

The **second chapter** starts with a general overview of the Knowledge Society concept, different from the Information Society one. Actually knowledge lives within society and circulates with a never-ending circulation process, through which knowledge is generated, institutionalized, diffused and socialized.

New paradigms arise: society is becoming a laboratory for collective experimentation in promoting innovation and for public engagement in science, thanks to the circulation of an “enabling” knowledge; moreover, new collective approaches are emerging within the knowledge economy, in which ICTs and communities of people are the new forces, shaping the actual socio-economic landscape.

Combining the bottom-up possibilities offered by Web 2.0 and the top-down vision of Web 3.0, we are trying to achieve a man-machine-hybrid computing, in which humans and computers excel at orthogonal tasks, while tackling the present (and future) “big data” deluge. After connecting data, people and knowledge, the promise of the next web is to connect intelligence.

The **third chapter** deepens this new technological horizon, analyzing in details some emerging fields of research and their paradigms. It presents the ubiquitous computing vision of “embodied virtuality”: thanks to physical and mental disappearance, technology, encapsulated within common devices, is going to pervade our everyday activities inside laboratories, offices and schools (e.g. tabs, pads and boards).

Parallel changes are affecting the design of interfaces: after graphic user interfaces or “painted bits”, widespread tangible user interfaces or “malleable bits” are offering new multi-touch and multi-user interaction possibilities. Nowadays, natural user interfaces are incorporating touch, speech, in-air gestures as input method, while future studies on organic user interfaces will change the world of interfaces from “stones” to “skins”.

In opposition with the “embodied virtuality” concept, the virtual reality and augmented reality paradigm are explained using the virtuality “continuum” between real and virtual worlds. The chapter ends describing a more general framework of mediated-reality.

The following chapters have the purpose of analyzing the actual use of widespread technologies, such as academic social networks, electronic books and Interactive WhiteBoards, within three different contexts: research, culture and education respectively.

Chapter four, after a short deepening on the meaning of the interpersonal tie and its importance in creating social capital, offered in particular by “weak ties” or “bridging ties”, tackles the issues of sociotechnical capital within internet communities. Academic social networks are described firstly through the property of findability and the rules of participation of people, then through present academic social networks, tailored to scientists’ needs (ResearchGate, Academia.edu, Mendeley⁸...).

The analysis of two case studies offers the possibility of highlight current features of these Virtual Research Environments for scientists: the scenario is quite fragmented, with different tools for managing each single phase of a research project and which are not integrated within an unified platform. Moreover, new forces and trends are affecting the way of making research: the increased level of collaboration and OpenAccess logics are changing roles and dynamics within the scientific community, also tackling new challenges of data-intensive science.

Finally, a personal experience within a Cave Automatic Virtual Environment (CAVE), that is the Icube, shows the possibilities offered merging real/virtual/augmented instruments within the world of research: a Mixed Reality Research Environment is needed.

Chapter five illustrates what is happening in our cultural environment after the introduction of electronic books, which reshape themselves continuously, through digitalization, augmentation, and hypermediation processes.

All these changes affect the identity of the “book”: it is not easy to define what is actually an electronic book and what are the main features. Moreover, the most interesting challenges do not modify only the “mean”, but the concept of authorship itself, the user experience, the ways of text exploration, suggesting new personalization and socialization opportunities. Technological issues, such as current standards (ePub3), accessibility problems and copyright policies, expressed by Digital Right Management (DRM), most of the time disturb both writers and readers.

Two personal experiences at international conferences, that is “The book tomorrow: the future of writing” and “If Book Then Conference” collect voices and perspectives of writers, readers, publishers and librarians of different countries, in order to identify and describe new business models and new roles within the book world.

Chapter six offers an overview of the diffusion of technologies within the actual school system, which is not limited to a general description of digital natives needs and to new didactical tendencies of facilitating students participation through new technologies.

I propose the vision of a “pervasive classroom”, in which technology permeates everyday devices and activities and where present Interactive WhiteBoards (IWBs) constitute the first step of a “pervasive school”, defining its Space Model in line with the ubiquitous computing paradigm.

Moreover, the study of the use of IWBs suggests that, with proper didactical strategies, this large shared device could stimulate a more active participation and new collaborative learning opportunities among students, together with a decentralized role for teachers.

⁸ The proposed thesis has been written exploiting the reference management application Mendeley, with the use of the add-in for the Word processor, to test the tool itself in daily use.

This hypothesis is confirmed by the preliminary results of two different experiments, conducted within two primary schools, where I have carried out a qualitative-quantitative research-based project involving two different subjects: literacy and music.

Finally, **chapter seven** summarizes the path of the thesis, framing the features of the sociotechnical framework of the Knowledge Society: the *backbone*. The knowledge circulation process, previously described, is then rethought and applied to the three proposed contexts (research, culture and education) and to their symbolical technologies (academic social networks, electronic books, Interactive WhiteBoards).

I reflect upon the introduction of these new technologies and the arise of new communication roles and processes regarding researcher-research communities, writer-publisher-reader and student-teacher relationships.

The process of thickening of the information unit till a bit of “knowledge” and the development of new knowledge types are discussed. The final section of the chapter outlines the importance of achieving a mature digital wisdom and awareness to ensure the continuity within the production and circulation of knowledge.

Open issues within present Knowledge Society should be tackled by a mixed approach, intertwining social science and computer science research.

The thesis ends with the two appendices, reporting the questionnaires given to pupils during the literacy and the music experiments, tailored to their age, and the list of references⁹.

⁹ The section “References” represents the bibliography of the thesis. The books and journals inserted in the footnotes, which are mentioned within the text, have been included for completeness.

Chapter 2. Deepening the concept of Knowledge Society

In this initial chapter the Knowledge Society concept will be considered in its multi-faceted features, dealing with the transition from Information Society to Knowledge Society, taking into account the socio-economic transformation that the actual Society of Individuals is living, and reconsidering the role of that network society (Castells, 1996), which has exploited the Internet first, the Web 2.0 now and will discover the potentialities of the Semantic Web and of “big data” for new knowledge-based economic activities in the next future.

2.1 From Information Society to Knowledge Society

Two long-term processes are actually working jointly, although at two different and uneven speeds: the Knowledge Society and the Society of Individuals (Cerroni, 2007); in the first part of this paragraph we are going to focus on the Knowledge Society concept, while the Society of Individuals will be described only further ahead and then deepened in paragraph 2.2.

As above mentioned, our society, which is pervaded by knowledge, is different from all the others, for its specificity, and so it is necessary to understand its different features through a new open-mindedness: firstly, we are going to explain the shift from an information-based society to a knowledge-based one, without considering them two different periods, but because a new definition of “knowledge” is needed.

The first speaking of Information Era and knowledge industry is Fritz Machlup (1962), an Austrian-American economist, who measures long period tendencies marked from the growth of service industry and from the appearance of the Information and Communication Technology (ICT) sector. He captures the general attention on this new “knowledge economy” (Cerroni, 2006). The differences between Information and Knowledge are totally blurred at that time.

More recently, the Information Society concept (Castells, 1996) fluctuates among information, information technologies and knowledge, but “knowledge” is considered as synonymous of the exchanged information, being reduced as an exchangeable quantity, that

can be abstractly repeated (bit). Here the Information Society theory shows its theoretical weakness, because knowledge is not a storable resource, but lives within a never-ending circulation process.

Moreover, it is not possible to relegate information within a society sector, considering what the sociologist David Lyon (1988) argues¹⁰, speaking of Information Society and Information workers:

[...] The facts do not suggest the existence of an Information sector, but the enhancement of a wide variety of computer science-based activities [...]. A lot of jobs would be more and more computerized, but this does not mean that a new sector will emerge.

Even if nowadays we refer to the same concepts, using the words Knowledge Society and Knowledge workers, Lyon recognizes the strong ties between technologies and the contemporary society: information technologies are an integral part of all human activities.

Another difference between information and knowledge lies in the fact that information is hived off, can be translated into binary sequences and circulate, while knowledge is always built into, is for Aristotle a thought “of someone on something in a certain context and with certain purposes” (Cerroni, 2006).

It is now clear that the reduction of knowledge to digital information and its technologies shows all its limits: for instance, processes involving information are reversible, while knowledge society processes are not always reversible.

Around the debate on Knowledge Society, Ilkka Tuomi (2001) describes three waves¹¹: the first between 1970 and 1990, called Information Society; the second after 1990 with the first appearance of the Internet; the third, which is nowadays concentrated on the connection between the diffuse technological change and all social shifts, considering three social domains, that is everyday life (e.g. body, family, working activities, lifestyle), production systems (e.g. networks of innovations, human-centric design, knowledge management, environmental, social and cognitive sustainability), institutions and culture (e.g. policies, governance, cultural production, social and religious movements, pedagogical and educational models, science system).

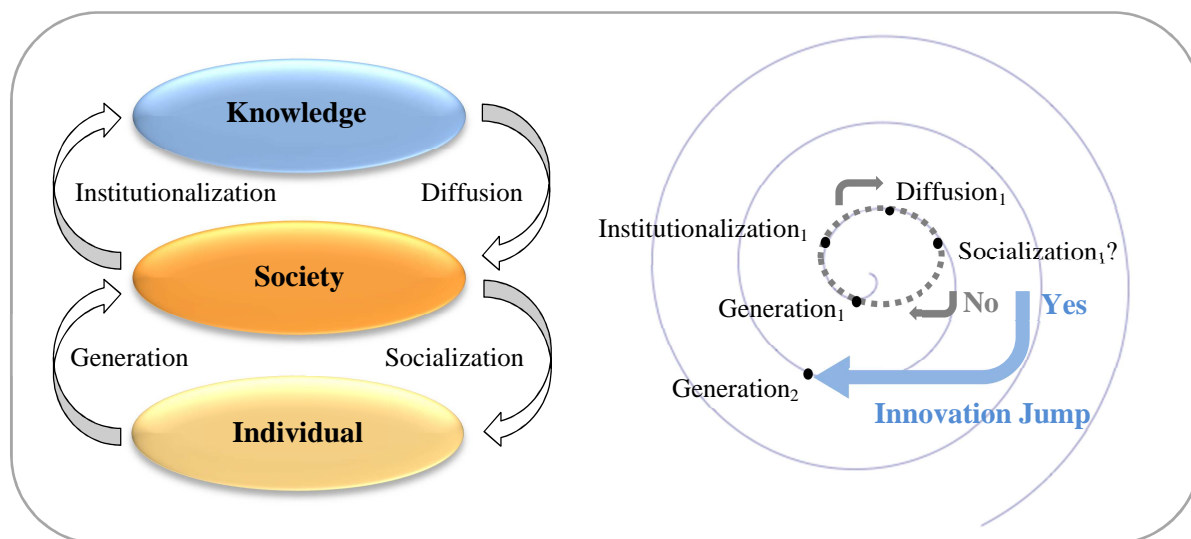
This overview of most of the various processes involved in the third wave shows all the complexity of Knowledge Society concept, that becomes relevant during the second half of the XX century.

We have seen that knowledge circulates within society and lives within a never-ending knowledge circulation process, where a “before and after” does not exist and the viewpoint is interpretative and not linear. Beyond a previous knowledge circulation model, which describes knowledge creation within organizations (Nonaka & Takeuchi, 1995), knowledge circulates within society through four phases (see picture 2.1, left): generation, institutionalization, diffusion and socialization (Cerroni, 2007). The first, generation, assures the production or acquisition of new knowledge, and nowadays is (almost) a social activity: the times in which lone thinkers mused over problems in complete isolation are over.

¹⁰ In “La società dell’informazione”, Il Mulino, Bologna 1991, p.109.

¹¹ In “From Periphery to Center: Emerging Research Topics on Knowledge Society”, Technology Review, 116/2001, TEKES (National Technology Agency of Finland), Helsinki, pp.70.

The second, institutionalization, allows the identification and organization of knowledge, a process dramatically changed by, for instance, research, academic, and business networks, widespread technological environments for organizing and sharing knowledge, new discoveries, research interests and efforts (e.g. grid computing). The third, diffusion, refers to the utilization, dissemination and communication: new ideas are materialized into meanings and objects that are exchanged through communicative processes, materials and symbolical. Finally, the fourth, socialization, enables internalization, education and regulation processes, through which new knowledge is widespread among individuals.



Picture 2.1 The knowledge circulation process

This last phase of the knowledge circulation process, that is the socialization, is the most critical. Knowledge, in whatever field, empowers its possessors with the capacity for intellectual or physical action (David & Foray, 2001). The access to knowledge, even if embedded into objects, requires pre-existent knowledge, that is the ability to critically and systemically assimilate contents, using reasoning, practical and theoretical knowledge, ideas and beliefs. Within this conceptual frame, education has the primary role to develop the cognitive capacities and intellectual frameworks than enable humans to interpret, select and utilize information in ways that augment their capabilities to control and enhance the material circumstances and qualities of their existence. If the socialization phase is not completed (see picture 2.1, right), the knowledge circulation process does not continue as a spiral that grows, but after a first cycle, it restarts from the same point, cycling and slowing down the knowledge circulation process. Otherwise, thanks to an *Innovation Jump*, because all the individuals have been socialized to a new discovery/technology, the spiral can grow more and more with the generation of new knowledge.

For instance, if we think to the adoption of new technologies, at the same moment, people belonging to the grey cycle are those, for instance, who do not have internet access (e.g. of a first level of digital divide), while people who have already been socialized to the use of internet go on with the knowledge circulation process, enhanced by the use of the net. After another cycle, at the same moment, while the first adopters of internet are now mature users of web technologies and applications, those, who have recently accessed to the internet, use

it in a different way (Peter & Valkenburg, 2006) and for different purposes (e.g. of a second level of digital divide, known as usage gap).

We have seen that the Knowledge circulation paradigm is more complicated than just a spiral process, where knowledge is produced, organized, shared and socialized (Cerroni, 2006):

The evidence of what we call Knowledge Society is both in the diffusion of new more artificial products, products of material and intellectual synthesis, and in the production of synthesis of different points of view, with more general descriptions, interpretations and predictions, sharable synchronically (space) and diachronically (time).

Nowadays, not only things and objects are injected by knowledge, but even space and time dimensions are changing thanks to new knowledge opportunities. On one hand we are re-producing nature: thickening spatial matter of nature we are going towards molecular manufacturing; on the other hand, knowledge is pervading our time, penetrating each moment of our life and for all its span, that is growing beyond every natural boundary.

In this way the “knowledge” is embedded in every kind of product: for instance, the enrichment of senses, tele-presence, and virtual presence are multipliers of our space-time presence. All that we call “virtualization” is not a de-materialization but a re-materialization of objects, equipped with “virtuous” materials, that own designed properties.

In this way, new ideas are materialized into meanings and objects that are exchanged through communicative processes, materials and symbolical, and capillary widespread within social life, socializing individuals (Cerroni, 2005).

As said before, one distinctive aspect of Knowledge Society is its strong tie with the Society of Individuals: our society is built thanks to these two distinctive processes of big significance.

The first, the development of Knowledge Society, lies in the progressive active involvement of all citizens in Knowledge circulation process, while the second, the society of Individuals, consists for Norbert Elias (1939) in the progressive “social differentiation, diversity of single persons and individualization”¹². Society equalizes all citizens inasmuch as individualizes everyone.

As Knowledge Society should be globally participated, the Society of Individuals should be imbued with knowledge, that frees from manual and cognitive duties, empowering the individuals. Considering that knowledge is a “naturally” exclusive product of human species and human nature is always social, knowledge is constitutively social.

Considering its social nature, knowledge is considered as a global public good¹³, because it is non-rivalrous and non-excludable: it is not possible to have a knowledge market.

More than a century ago, John Powell underlined one of the most intriguing features of knowledge: “the possession of property is exclusive; possession of knowledge is not exclusive” (Stehr, 2010). Unfortunately, some forms of knowledge are exclusive and become private goods as a result of legal restraints, such as patents or copyright restrictions.

¹² In “La società degli individui”, Il Mulino, Bologna 1990.

¹³ In “Towards knowledge societies”, Unesco Publishing, 2005,
<http://www.unesco.org/new/en/communication-and-information/resources/publications-and-communication-materials/publications/full-list/towards-knowledge-societies-unesco-world-report/>.

Treating knowledge as a public or private good has different consequences. Most of the time, within scientific context and economic system, it happens that incremental or new knowledge is the one which is protected. If knowledge is protected, the growth of knowledge is hampered, but at the same time if knowledge is not protected, economists agree that the incentive to invest in new knowledge disappears; within this view, monopoly rights are essential for the growth of knowledge and inventions (Stehr, 2010):

In contrast to incremental knowledge, the general mundane and routinized stock of knowledge consists mostly of knowledge that is non-rival in use as well as non-excludable; that is, this type of knowledge may very well constitute public goods.

Conveying a monopoly right to the beneficial economic exploitation of an idea (in the case of patent rights) or of a particular expression of an idea (in the case of copyright), that has been disclosed, rather than being kept secret, allows the organization of market exchanges of “exploitation rights”. Assigning pecuniary value to commercially exploitable ideas, people have the economic incentives to go on creating new ones, as well as finding new applications for old ones.

Allocating these rights to those who are prepared to pay the most for them, the workings of intellectual property markets also tends to prevent ideas from remaining in the exclusive (secret) possession of discoverers and inventors.

Another general principle that finds widely expressed approval is that of harmonizing intellectual property rights institutions internationally, so that arbitrary, inherited legal differences among national entities do not interpose barriers to the utilization of the global knowledge base in science and technology.

All these principles should encourage knowledge circulation, but it is clear that we live in a paradoxical situation: a proliferation of intellectual property rights inhibits access to information in areas (basic research in general, the life sciences, software) where new knowledge had remained largely in the public domain, even if the technological conditions (codification and low-cost transmission) allow individuals to enjoy instant access to new knowledge (David & Foray, 2001).

The generation of further knowledge is among the major important uses of new knowledge, and, at the same time, there are enormous uncertainties surrounding the nature and timing of the subsequent advances that will stem from any particular breakthrough. It is far more certain that there will be a greater flow of entailed discoveries if the knowledge upon which they rest remains more accessible and widely distributed.

For instance, we should consider the serendipitous aspect of knowledge discovery: consulting and comparing big amount of scientific papers or databases, researchers can make important discoveries, that should become more troublesome or expensive if that information space is full of property rights.

The access problem does not consider only patents and copyright issues, but is related also to scientific and technological knowledge within developing countries.

The digital divide problem exists, but the more difficult and more fundamental problems are not simply those of providing greater technological access to information streams (David & Foray, 2001).

We have underlined that the access to information is different from the access to knowledge: while the first is near-at-hand, the second needs the development of specific abilities and skills.

As a matter of fact, knowledge is the result of a never ending historical and social process, and it is of primary importance to enable ours and next generation to enrich this cultural heritage, providing the proper educational means to understand it and exploit it at best.

With a wider meaning, the term “knowledge” can be considered as the capacity for action. Nico Stehr derives it from Francis Bacon’s famous metaphor that knowledge is power (*scientia est potentia*). Francis Bacon suggests that knowledge derives its utility from the capacity to set something in motion: using modern examples, new communicative devices, new forms of power, new regulatory regimes, new chemical substances, new political organizations, new financial instruments or new illnesses.

Stehr defines “enabling knowledge”, that knowledge which is sensitive to and makes reference to concrete conditions of action, that are open to action. Possession of knowledge is not only a cultural issue, but it enhances agency. At the heart of civil society, of the Society of Individuals is agency. Agency is the ability of citizens to set goals, develop commitments, pursue values, and succeed in realizing them, thanks to their knowledge.

Considering knowledge as necessary or sufficient condition for democracy lead to diverse interpretation on the model of society that will be developed (see paragraph 2.2).

Comparing John Stuart Mill and Alexis De Tocqueville’ judgment on democracy, Stehr underlines that while Mill¹⁴ has considerable confidence in the independent capacity of enlightenment, seeing education, knowledge and intellectual skills as *necessary* conditions for the strength of democratic regimes, De Tocqueville views knowledge as a *sufficient* condition for democracy. From Mill’s assumption, it follows that intellectuals and scientists are the new authorities that are bound to play a significant political role in democracies. In the case of De Tocqueville, it is the ordinary citizen, our emerging *science citizen*.

Taking into account all these remarks on the deep meaning of the world “knowledge” and the opening issue about the shift from an Information Society to a Knowledge Society, we are going to tackle the problem of knowledge codification and transmission (David & Foray, 2001).

What it is that is passing through the electronic pipelines: knowledge, information or data? Something of each, actually. It all depends on the nature of the relationship between the senders and recipients.

What we mean by knowledge, as above mentioned, is fundamentally a matter of cognitive capability. Information, on the other hand, takes the shape of structured and formatted data that remain passive and inert until used by those with the knowledge needed to interpret and process them. As Polanyi¹⁵ said, there are elements that therefore remain “tacit”: “we know more than we can say”.

¹⁴ Mill wrote a review of “Democracy in America” by De Tocqueville, being a great admirer of the classical study of American society.

¹⁵ In “The Tacit Dimension”, Garden City, New York: Doubleday & Co. 1966.

Knowledge reproduction has therefore long hinged on the “master-apprentice” system, in which a young person’s capacity is molded by watching, listening and imitating, or on interpersonal transactions among members of the same profession or community of practice (Wenger, 2006). These means of reproducing knowledge may remain at the heart of many professions and traditions, but they can easily fail to operate when social ties unravel, when contact is broken between older and younger generations and when professional communities lose their capacity to act in stabilizing, preserving and transmitting knowledge.

In order to preserve it, knowledge may be codified: so articulated and clarified that it can be expressed in a particular language and recorded on a particular medium. In this way, knowledge is detached from the individual and the memory, and communication capacity created is made independent of human beings (as long as the medium upon which the knowledge is stored is safeguarded and the language in which it is expressed is remembered).

In the codification process we try to reduce (partially) human knowledge to information and in the course of such transformations, almost certainly something will be altered, and, quite likely, other meanings will be lost. For instance, when a young technician receives a user’s manual, he or she is not directly given knowledge on “how to run the machine”, but only a set of instructions. When this technician has “learned to learn” and is dealing with a standard machine, knowledge reproduction becomes almost instantaneous and assumes characteristics close to those of information reproduction. In more complex cases, however, the codified knowledge, while certainly useful, will only provide partial assistance: knowledge reproduction will then occur through training, practice and simulation techniques (e.g. aircraft pilots, surgeons).

There is a second and crucial function of codification, which consists in translating knowledge into symbolic representations so that it can be stored on a particular medium. This creates new cognitive potentialities that remain inconceivable so long as the knowledge is attached to individual human beings, and only heard (when spoken) or seen (when put into practice) through interaction with those people.

Inscribing, through writing, graphics, modeling, and virtual objects makes it possible to examine and arrange knowledge in different ways and to isolate, classify and combine different components. This leads to the creation of new knowledge objects such as lists, tables, and formulas. These are fundamentally important in that they open up new cognitive possibilities (classification, taxonomy, tree networks, simulation).

Advances in information technology-based recording methods are crucial here, for they allow representations of knowledge to progress from the so-called “pre-literate” stage (gestures and words) to the literate (writing and drawing) and then post-literate stages (modeling structured interactions).

Thanks to new technologies, used for codification, transmission and free sharing, our society could try to become a real Knowledge Society, in which the knowledge circulation process does not encounter access barriers of any kind and knowledge is really perceived as the trigger to change the life of each single individual.

2.2 Public engagement and collective experimentation

Nowadays, for “taking European Knowledge Society seriously”, we have to deal with the ambitious goal of Europe to become “the world’s leading knowledge-based economy” by 2010, using scientific knowledge instrumentally for competitive economic advantage, as said Tony Blair in 2006 “competing on intelligence, on innovation, on creativity” (Felt et al., 2007).

There is a profound ambiguity in the Lisbon Agenda: on one hand, the European Union underlines the explicit policy commitment to public engagement and respect for public doubts or skepticism; on the other hand it is clear the growing pressures to translate fresh research insights rapidly into globally-marketable commodities and to reorganize science accordingly. It is now necessary to explain how these two apparently contradictory commitments, in the same important policy domain, can be reconciled.

So, in the background of the European Knowledge society there are the following main concerns: the European public unease with science and the necessity to improve the involvement of diverse elements of democratic civil society, in order to address urgent European policy challenges and to accelerate innovation in Europe. In the next section, these issues will be deepened and discussed.

The place of science or better techno-science is seriously weakened by this public unease and disaffection, which are not indiscriminate, but selective in particular fields of science, with wider areas of acceptance, even enthusiasm. Much effort should be invested in the aim of restoring public trust in science.

The public unease with science is related to issues at the intersection of “science” and “risk”. Risk assessment has been increasingly institutionalized as regulatory tool since the 1970s, but with absolutely no complementary questions about social benefits. The shift of emphasis from risk to precaution is a result of taking the scientific risk knowledge seriously, not of rejecting it. An intellectually rigorous treatment of the various kinds of uncertainty in scientific risk knowledge leads inexorably to the exposure of foundational contingencies, and to open deliberative questions of human ends, purposes and priorities, which underwrite the precautionary approach.

Moreover, social scientist point out that all but few individuals are deprived of the “capacity for individual rational judgment either about the quality of the evidence proffered or about the tightness of the theoretical reasoning applied to the analysis of the data. The ‘harder’ the science, the truer this is”. It is widely assumed in the field of “public understanding of science” (B. Wynne¹⁶, 1992) that scientific illiteracy decreases citizens’ democratic capacities, including the possibility of democratic governance of science. Stehr speaks of a state of precarious balance affecting the autonomy and dependence of science in modern society. The loss of close intellectual contact between science and the public is perfectly compatible with both a diffuse support for science in modern society and with an assent to legal and political efforts to control the impact of science and technology.

¹⁶ In “Public understanding of science research: new horizons or hall of mirrors”, *Public Understanding of Science*, 1(1), pp. 37-43.

In this way, citizens have difficulties in engaging in complex policy issues and the most obvious effect is a widespread public skepticism towards the consequences of modern science and technology. Would societal problems would be worse if we did not rely on a caste of policy experts?

Paradoxically, we are in the emerging era of public participation in science.

Science and technology based innovations are judged by civil society against the background of their worldviews, value preferences and beliefs. If we consider, for instance, stem cell research, medical genetics or genetically modified foods, within the context of knowledge, politics, and public discourse about authorizing innovative capacities to act, the balance of power between science and civil society is now shifting toward civil society (Stehr, 2010):

Scientific knowledge constitutes one of the most important conditions of modernization in the sense of a persistent extension and enlargement of social and economic action that science, unlike any social system in modern society, generates.

Stehr identifies two models in dealing with scientific knowledge: the model of instrumentality and the capacity model.

The instrumental model is based on the assumption that there tends to be a steep gradient of knowledge between science and society; science speaks to society and does not only do so with considerable authority but also with significant success, while society has little if any opportunity to talk back.

Within the capacity model the social sciences and the humanities exercise practical influence as producers of enabling ideas and meanings on society and its actors. The capacity model stipulates that social scientific knowledge is an intellectual resource that is contingently open and complex and thus can be molded in the course of “travel” from the social scientific community into society.

In sum, public engagement and participation in science is not hazardous for the scientific community; it is part of the social architecture of democracy. We are slowly moving from what has been the case of expert rule to a much broader, shared form of knowledge claiming governance. In this process, the social sciences and humanities play an important role, in the sense of enhancing capacities to act.

The new sociology of scientific knowledge has created the perspective that the production of scientific knowledge is in many ways very similar to other social practices and that the wall between science and society is lower than frequently assumed.

The possibility for democratic negotiation and scientific practice has to be seen as part of a larger social enterprise and a larger social context in which both professional scientists as experts and the lay public engage in discourse (Stehr, 2005). The cases of climate change and AIDS activism are rich examples of social processes in which the boundaries of expert and lay public are quite malleable.

After an overview on the problem of public unease with science and the general issue about “public understanding of science”, we are going to explain what kind of innovation models are developing within the actual Knowledge Society.

Considering innovation, this is not limited to technological one: the most so-called technological innovations are socio-technical innovations.

The linear model ‘science’ to ‘technology’ to ‘social progress’ is only one possible innovation model and actual patterns of innovation are more complex: feedback loops, user-induced innovation, and societal developments rather than technological developments leading the way (Felt et al., 2007).

One striking feature is the recent shift from the idea of centralized organization of innovation to explicit recognition of the importance of distributed and more diverse innovation, even if that means some loss of control for central actors. An example would be the present interest, with a number of big companies, in open innovation, but maybe the most famous example is the possibility of developing open source software by user-communities: these forms of distributed innovation must receive more attention.

The regimes of innovation contains a model, or paradigm, that is a notion of how things must be done, which is also a model of society. The shaping of society visible within the Lisbon Agenda is underpinned by the linear model, leading to implicit or explicit assertions that “science is the solution, society the problem”. Society has to become more entrepreneurial, become more accepting of, or even keen on, new technology.

In the following we are going to mention three influential representations of innovation.

First, innovation is considered as codified and replicable information, users have the capacity to pay for it, innovation may be diffused globally, without having to take local contexts into account. Second, and continuing the idea of a competition where the “winner takes all”, is the conviction that the only good position is to be the first (e.g. MS Windows Office): innovation becomes a collection of “premiers”. Third, innovation is linked to entrepreneurship and to popular ideas, pressed by innovators themselves, about the heroism of innovators fighting against odds: innovation is produced by heroes with outstanding qualities (e.g. star scientists, world industry champions).

An alternative storyline is centralized innovation: innovation produced and/or orchestrated by a central focal agent. Many big public research institutes have been following the model of centralized innovation as well, and big mission-oriented R&D programs like the US Apollo Program and the “war on cancer” have central orchestration as a characteristic feature.

Centralized innovation is in opposition to the notion of open innovation and more generally distributed innovation. Distributed innovation is observed in situations where heterogeneous actors, who hold complementary pieces of knowledge, interact and form networks or creative communities; they cooperate in quite informal ways and co-construct the technology and its use.

The case of OSS (Open Source Software), and more widely development of open-access tools in information technologies, shows that the distributed model of innovation can be more user centered and that one of the motives of its promoters is to redistribute agency, knowledge and power. In other words, there is a normative model of society being performed as well. One of the key features is the invention of collective property rights, through the creation of the General Public License (GPL or copyleft): the right to use it at no costs, the right to modify it, and the right to distribute modified or unmodified versions at no costs.

Considering the Lisbon Agenda innovation targets, the dominant question is how to achieve as much innovation as possible, as fast as possible.

It should not just be about the more and the faster, the better. Innovation is distributed, many actors are involved, and there is no simple route to success.

Considering the different patterns, we identify two main ones: the producer-led pattern of pushing techno-scientific promises, and competing on that basis; and the user-led pattern visible in open-source software development and innovation.

These two specific ways to organize and promote innovation and technological change in contemporary societies have been labeled as the regime of economics of *techno-scientific promises* and the regime of economics and socio-politics of *collective experimentation*.

According with the authors (Felt et al., 2007), a vibrant European knowledge society must be built on collective experimentation. Technological promises can, and should be, incorporated, but they should help, not lead.

The economics of techno-scientific promises (ETP) must include more than financial and short-term commercial considerations. Studies of earlier innovations show the proponents of the “new” have to fight the “old”, and may not always win. On the other hand, the “new” is not, by definition, better than the “old”. Technological promises have to be tested dynamically, not just pushed as such.

ETP are particularly visible in the mode of governance of so called new and emerging techno-sciences: biotechnologies and genomics, nanotechnologies, neurosciences, ambient intelligence, to make some examples. We identify a number of distinguishing features: first, the emerging technology (biotechnology in the 80s, nanotechnology now) “will solve human problems” (e.g. health, sustainability) through a wide range of applications; secondly, ETP draw on an uncertain future, and derive its force from the uncertainties; thirdly, the associated economy has a strong sense of urgency. There is no role for civil society other than as a collection of prospective customers, but this view is not specifically European. As the USA National Science Foundation report on Converging Technologies (Roco & Bainbridge, 2002) phrases it: “we must move forward if we are not to fall behind”; finally, the economics of techno-scientific promise requires intellectual property rights to be safeguarded at an early stage and emphasizes patenting of basic knowledge.

The regime of ETP works with a specific governance assumption: a division of labor between technology promoters and enactors, and civil society.

The previous model starts to function as a political order, with a tyranny of urgency and naturalization of technological progress. Civil society is then taken into account only as the final and undifferentiated passive recipient of innovation, and when resisting, labeled the enemy of innovation. This approach to civil society is for some reason very similar to the one of the instrumentality model by Stehr.

An alternative regime is emerging about democratizing innovation, but not in the sense of political democratization where citizens would have more voice, and be listened to. However important democratization might be, attention is drawn to something else: phenomena like user-induced innovation and community-based innovation. Some concrete examples are drawn from the information and communication sector (where the distinction between developers and users is not sharp) and introducing the notion of co-invention.

These examples show the emergence of a new regime, the regime of collective experimentation, in which *society becomes a laboratory*. However, the experimentation does not derive from promoting a particular technological promise, but from goals constructed

around matters of concerns and that may be achieved at the collective level. Such goals will often be further articulated in the course of the experimentation.

The regime of collective experimentation faces challenges because such embedded innovation is laborious, typically loosely-coordinated and slow; as it should be, because users and other stakeholders have their own contexts and logics to consider. Inspired by the ‘slow food’ movement, one can now proclaim a ‘slow innovation’ program.

These two regimes of technological promises and of collective experimentation, were characterized as alternatives. There are struggles between innovations and innovation patterns located in the two regimes; but it is not a complete dichotomy. Both regimes are part of the overall trend to recognize and emphasize distributed innovation. The two regimes highlight and incorporate different features.

From my personal point of view, this two opposed regimes should be considered as complementary aspects for a new regime, where the *urgent, leading and clear technological promises* and the *slow, participative and chaotic laboratorial innovation* can be reconciled. Within a perspective of contaminating disciplines (e.g. interaction design and social studies), as the reflective practitioner is the designer that “learns and conducts professional artistry through processes of reflection-in-action, in which knowing and doing are inseparable” (Binder, De Michelis, Ehn, Jacucci, & Linde, 2011), the reflective citizen should combine knowledge-enhanced reflexivity and technology-enhanced action within activities “full of passion, imagination and engagement, more like creative innovations than rational decision-making processes”. As a matter of fact, both the regime of collective experimentation and the one of techno-scientific promises have to imagine an experience that does not exist yet, as in the design process, so the proposed scenario can be shared both by designers and citizens, as new policy makers of the actual Knowledge Society. The reflective citizen should be inspired by design as a new political instrument, not based on contrapositions and contrasts, but as a new lens to change view and perspective in front of social, environmental, political and ethical problems and challenges.

Moreover, as proactive figures of innovation and promoters of transformative processes, designers should be really in strict contact with citizens with a precise contract with them: a sort of political performance, with the word ‘performance’ in the sense of performing a contract: “you promise you would do something, now you have to carry that promise out, bring that promise through to completion¹⁷” (Acconci & Moure, 2001). Nowadays, design is arising as a new concept: we have to consider it as a mode of inquiry than a professional competency or a particular domain of expertise: design as a democratic innovation becomes a question about everyday practice, for envisioning emerging landscapes of design, where, in an “agonistic democracy”, we can hear a polyphony of voices and mutually vigorous but tolerant disputes among groups in public spaces and where different projects confront each other and the world¹⁸ (Mouffe, 2000).

A global collective experimentation might happen, but at this moment, can be no more than good intentions. Actually, some communities are experimenting new models of governance and innovation.

¹⁷ In “Vito Acconci: writings, works, projects”. Barcelona Polígrafa.

¹⁸ On “agonistic struggle” at the core of democracy, see “The democratic paradox”. London Verso.

After considering the market expertise be the privileged knowledge source for new public management, an Australian experience focus on community oriented instruments and community based knowledge (Hess & Adams, 2007).

Local area networks can give a dynamic contribution to innovation, wellbeing and prosperity. The assumption of this experience is that knowledge needs to be constructed and mediated through co-operative process of discovery with those affected by it. Current emphasis is on community strengthening through the creation of sustainable networks developing collaborative relationships, and seen as the key to the linking up of government, business and community organizations needed to address the complexity of contemporary problems.

One of the key point is the social investment state on building the social capital that underwrites growth in human capital. The real success of this Australian experience within the Victoria state is not just in the increasing resources delivered into the community but in the redefining of relationships between the community and government.

This new paradigm called “community governance” shows social factors coming strongly back into public policy and management, such as deliberative democracy, networks, co-production, participants in communities, local constructivism and histories. The organizational structures of community governance are more like networks in which complex interactions throw up new ideas and create processes by which these are moderated across varied interests. In the community governance model we see networks becoming not only webs of influence and trust but also structures within which new knowledge regarding real world situations is created and shared with its value becoming agreed through processes of mediation.

For community governance approaches, the citizen becomes an active participant in their particular communities, and the knowledge they invent and create is ‘privileged’ in the policy process. These new practices are based on types of knowledge which have not historically been part of public administration and for this reason it is driving forms of public management innovation which may prove to constitute a new administrative paradigm.

From the Australian experience we can consider some general issues. First, distributed innovation includes diversity, not just of actors, but also of new options that are opened up for exploration. Socio-technical scenario approaches may do better here, but the dilemma between going for exploration or selective exploitation remains. Second, reinventing innovation requires reinventing the commons. The commons must be structured, there must be specific arrangements. One important observation is that there is no fully public science, there are always thresholds, circles of limited exchange (David & Foray, 2001):

Only when increasing numbers of communities displaying those very characteristics are formed across a wide array of cognitive fields, when professional experts, ordinary users of information, and uninitiated students are brought together by their shared interest in a given subject, will the Knowledge Society become a reality rather than a vision of a possible future.

2.3 The Knowledge Economy: ICTs and communities

Nowadays we are living a deep historical transition: an anthropological fracture with the past history; our society of individuals is living within a knowledge economy, where the technological convergence is becoming a real truth. Also the relationship with knowledge production and communication is part of this renewal (Cerroni, 2010), where both technologies and individuals play a crucial role.

The first issue to be considered when dealing with this new economical context is the speed at which knowledge is created, accumulated and, most probably, depreciates in terms of economic relevance and value.

We have seen that codification plays a central role in the knowledge economy (see par. 2.1) because it serves to further memorization, communication and learning, and forms a sound basis for the creation of new knowledge objects. In this way knowledge production and circulation are accelerated by new forms of codification and transmission.

Knowledge-based economies are not, of course, restricted to the realm of high technology, but science and technology do tend to be central to the new sectors giving momentum to the upward growth of the economy as a whole over the past few decades (pharmaceuticals and scientific instrumentation, information and communication technologies, aeronautics, new materials). Our society as a whole, then, is shifting to knowledge-intensive activities (David & Foray, 2001).

In this context the “need to innovate” is growing stronger as innovation comes closer to being the sole means to survive and prosper in highly competitive and globalized economies. The fact remains that companies and society in general are spending more time and energy on producing and adjusting to change. The knowledge production system is becoming more widely distributed across a host of new places and actors. More and more “innovators” tend to be appearing in unexpected situations: users as the source of innovation (see par. 2.2).

These new technologies, which first emerged in the ‘50s and then really took off with the advent of the Internet in the ‘90s, have breathtaking potential. They enable remote access to information and the means of acquiring knowledge. In addition to transmitting written texts and other digitalized items (music, pictures), they also allow users to access and work upon knowledge systems from a distance (tele-immersion in research), to take distance-learning courses within the framework of interactive teacher-student relations (tele-education) and to have unbelievable quantities of information, a sort of universal library, available on their desktops (or e-books).

First, development here has been a long, drawn-out process punctuated by the invention of the codex and the book, which took over from scrolls, the perfecting of paper, the book’s transformation into a knowledge tool (indexes, tables, footnotes and endnotes), improvements in the productivity of copy-making (from the “industrial” organization of the scriptorium through to the invention of the printing press), the proliferation of modern libraries and, finally, the advent of increasingly high-performance access and communication networks.

Second, information technologies enhance creative interaction not only among scholars and scientists but, equally, among product designers, suppliers and the end customers.

The creation of virtual objects that can be modified ad infinitum and are instantly accessible to one and all, serves to facilitate collective work and learning (Binder et al., 2011).

Third, the new technologies enable the exploration and analysis of the contents of gigantic databases, which is in itself a potent means of knowledge enhancement (in natural, human and social sciences and management alike).

Finally, the above three ways in which information technologies affect knowledge creation can be combined in the development of large-scale decentralized systems for data gathering and calculation and the sharing of findings. Such extensive systems characterize the research being done these days in the fields of astronomy, oceanography and so on and will be deepened further on (see par. 2.4).

However, in spite of the infinite possibilities offered by new technologies, we have to take into account two significant issues about “online” knowledge: trustworthiness and storage problems.

Considering the first issue, new methods need to be devised to “certify” the knowledge circulating on the Internet within a context where inputs are no longer subject to control, unlike the knowledge disseminated by scientific journals, for example, whose quality and reliability are validated through the peer-review process.

Regarding the second one, our societies are confronted by an almost paradoxical situation: we have never before had such powerful storage and memorization technologies at our disposal, yet memory itself appears to be in danger.

First, with information technologies, we are not saving documents but sets of instructions that need to be interpreted and managed by the right hardware and software. We perceive the risk of irremediably altering society’s overall memory.

Second, the unit costs of short-term storage and data retrieval may have fallen, but significant problems remain with respect to memorizing, filing and accessing old documents. The new electronic media are unstable compared with paper books. This has made “storage” of information in the digital age less a matter of archiving than a process of recurring renewal, a cultural task for which literate societies turns out not to be well-prepared. By the way, these are the same motivations for which electronic books have not yet substitute paper books (see chap. 5).

As anticipated in the previous paragraph, not only public engagement in science or collective experimentation for promoting innovation in society are more than ever *community-driven activities*, but nowadays all knowledge-based activities emerge when people, supported by information and communication technologies, interact in concerted efforts to co-produce (e.g. create and exchange) new knowledge.

Typically, this involves three main elements: first, a significant number of a community’s members combine to produce and reproduce new knowledge (diffuse sources of innovation); second, the community creates a “public” space for exchanging and circulating the knowledge; third, new information and communication technologies are intensively used to codify and transmit the new knowledge (David & Foray, 2001).

Communities of programmers engaged in creating and improving Open Source Software (see par. 2.2) resemble “open science” research communities in many of these aspects, and, like them, are not able to extract economic revenues directly from the sale of the new

knowledge and information-goods that they create. Some business-to-business communities, however, also have modes of operation that share some of the same features.

Doctors represent another instance of communities, in this case communities of professional specialization, that are undergoing a transition towards the higher frequency of peer-to-peer information transactions. Many doctors now document their new clinical knowledge and make it available to others through easily accessible electronic databases, becoming a real Community of Practice (Wenger, 2006).

Communities characterized by all three of the aforementioned components display a certain number of virtues. The potential for producing and reproducing knowledge will become greater as a community expands; but then so will the costs of data search, the risk of congestion and anonymity amongst members, which can, in turn, represent a source of acute problems of trust. On the contrary, a knowledge community is also a fragile structure, based on informal rules (reciprocity, disclosure): it can rapidly disintegrate when their members lose the ability or the dedication to follow those rules, and, instead, seek to further their individual interests through non-cooperative action in the realm of markets.

So, the development of the knowledge economy has seen, *inter alia*, conventional organizations infiltrated by individuals whose continuing attachment to an “external” knowledge community makes them all the more valuable to the organizations that harbor them as regular employees (e.g. engineers, scientists, programmers). By penetrating conventional organizations, these communities become agents of change for their industry, and, indeed, for the economy as a whole.

As anticipated in the first paragraph, ICTs and new technologies are changing both our *space* and *time* dimension. As a matter of fact, another significant issue in nowadays knowledge-economy is clearly that the influence of geographical distance is waning.

A British economist underlines¹⁹ that in “half a century’s time it may well seem extraordinary that millions of people once trooped from one building (their home) to another (their office) each morning, only to reverse the procedure each evening. [...] Commuting wastes time and building capacity. One building, the home, stands empty all day; another, the office, stands empty all night. All this might strike our grandchildren as bizarre” (Cairncross, 1997). This remark suggest that ICTs are not fully exploited in their potential, or better the society is not ready for this kind of change. The problem is more cultural than technological.

We have also to consider some development²⁰ of a home-production economy in light of the fact that it costs less to transport knowledge than people (Mokyr, 2001). And this is totally true. Such developments, however, are likely to continue being impeded by all manner of apathy for some time to come. Much has to be done as regards the redesigning of space in line with the opportunities offered by the knowledge economy. It is the personal interactions of the workplace, the stimulus provided by a change in environment from one's domestic habitat, that makes work enjoyable.

¹⁹ In “The Death of Distance: How the Communications Revolution Will Change Our Lives”, Boston Harvard Business School Press.

²⁰ In “The rise and fall of the factory system: technology, firms, and households since the industrial revolution”, Carnegie-Rochester Conference Series on Public Policy, 55(1), pp. 1-45.

Another relevant problem, that we are going to present shortly is related to the asymmetry within knowledge-economy: knowledge is not being developed to the same degree in every sector.

Today it remains astonishing to observe the contrast between fields of economic activity where improvements in practice are closely reflecting rapid advances in human knowledge, such as is the case for information technologies, transportation, and certain areas of medical care (surgery and drug therapy), and other areas where the state of knowledge appears to be far more constraining.

Besides, technological advances generate better scientific instruments, which in turn help to improve experimentation methods. The inter-linkages between “science-enlightened technology” and “technology-equipped science” provide the basis for the rapid development of knowledge in some areas.

For instance, education is not a field that lends itself well to experimentation: what works with a pilot school may prove hard to replicate elsewhere. Part of the problem is that experimental approaches are impossible to describe in precise enough detail to be sure that they really are being replicated.

As a rule, the profession of teaching is not organized to keep practitioners informed of alternative approaches and solutions tested by others; instead they proceed by intuition and imitation of recognized practices in the repertoire of “master teachers”. Opportunities for regular knowledge exchanges between educational researchers and teachers are few and far between. A good number of sectors are not benefiting from the “science-enlightened technology” model, and the question is how they can enhance knowledge at similar speeds to the science-based sectors. It is necessary to develop a methodology for documenting, assessing and promoting practice-based innovations. There are other ways in which science can interrelate with technology and developing them can help to improve the advancement of knowledge in some sectors.

There is a big difference between the existence of knowledge in some place or the other and its availability to the right people in the right place at the right time. The whole question revolves around the capacity of the new information technologies to enable better integration of knowledge through helping bring down the cost of transporting it and paving the way for local concentrations of virtual activities.

Some researchers, however, argue that the intensive use of powerful communication technologies such as the Internet may promote uniformity to the detriment of diversity. Facilitating the voluntary construction of highly homogeneous social networks of scientific or political communication therefore allows individuals to filter the potentially overwhelming flow of information. But the result may be the tendency of over-filtering, which eliminates the diversity of knowledge and that circulates, and thus diminishes the frequency of radically new ideas (see chap. 4). It seems difficult to use the available “search engines” to efficiently emulate the mixture of predictable and surprising discoveries that typically result from a physical shelf-search of an extensive library collection.

What really needs to be done is to establish and develop interdisciplinary communities made up of a heterogeneous range of members, where information technologies can serve to support the integration and the discovery of knowledge.

At this point, we are concluding the paragraph describing two significant examples within the actual knowledge-economy, which have been able to exploit at best technologies, their communities of developers and, last but not least, the end-users, with their desires and suggestions.

The *first example* is related to the innovation leader Steve Jobs, who has driven Apple and Pixar to planetary success (De Michelis, 2012). But when taking into account the invention of YouTube, FaceBook, Twitter, or Yahoo and then Google, we cannot consider these giants be the product of a brilliant invention and we cannot attribute to fortune the success of these innovations in our lives. There is something more. In the scientific field, it is widely discussed a model in which innovation, especially the most radical and disruptive, is developed in two cycles: during the first is devoted to conceive a new technology, a new device, while during the second this idea is then developed into a product for the market. A clear example of the explained process is the spreadsheet, with the transformation from the first prototype Visicalc to Lotus 1-2-3.

All Apple inventions, from the Macintosh to the iPad, from the iPod to the iPhone have been developed considering this model, but they would never have been the innovative products we all know, if their desirable feature were not be conceived around users behaviors and needs, considering their desires. In this case we can speak of interaction design of the best species (Binder et al., 2011), because in Steve Jobs the designer and the user coincide.

The *second example* encompasses other actors, such as Google, Facebook and the like, which, even if not so innovative at their first appearance on the market, have developed with their users a co-evolutionary process, assigning to the listening of users by designers a crucial role. If we think to both Google and Facebook the distance of the first versions from the actual ones is the evidence of how users, with their desires and behaviors have changed the platforms. This is not interaction design in strict sense, but an extraordinary ability of listening end-users. For Steve Jobs the secret of innovation is “saying no to 1000 things”, but surely he said yes to creating a lasting company, prepared to a continuous innovation process, which can enhance their talented people, in developing a product involving all participants, to precise the idea that substantiate it (Elliot & Simon, 2011).

One of Steve Jobs’ most interesting things is that there is a method in his geniality, and we can learn from that. The multi-disciplinary management team and the conception of space in the company bases are considered as decisive organizing factor: the inner square of both Pixar and Apple bases is the place of meetings, conventions, serendipitous appointments, and where feeling members of the same community. Moreover, the role of Steve Jobs in his companies is radically different from others: he is inside the processes and influences them day by day, evaluating evolution and quality, without limiting his role to devise company’s functions with economical purposes. He is in the era of business design²¹, while his colleagues are in the one of business administration (Butera & De Michelis, 2011).

Entrepreneurs should be in the middle of the creative processes of their companies, from product design to customer experience, from marketing strategies to communication, exploiting ICTs and user communities to assure an economy, really based on new knowledge production and circulation.

²¹ In “L’Italia che compete. L’Italian Way of Doing Industry”, FrancoAngeli - Fondazione IRSO.

2.4 Fostering a global knowledge through the Web

Recent developments on the web lead us to believe that the web is on the way to providing a platform not only for information acquisition and business transactions but also for large scale knowledge development and decision support (Thomas & Sheth, 2011). Within this paragraph a short overview of past, actual and new web possibilities will offer a complete scenario in which the Knowledge Society is actually developing and will develop in the next future.

After the invention of the World Wide Web in 1991 by Sir Berners Lee, the web has been involved in a never-ending transformative process, with significant steps, whose boundaries are sometimes blurred and not easily recognizable. While the Web 1.0 was conceived to connect static documents, using static websites and without any possibility of interaction for the user, except surfing across webpages, sending emails and using search engines, a further step in the evolution of the web, sometimes called web 1.5, proposed the first dynamic sites, with online dashboards and forums, thanks to the introduction of databases and Content Management Systems (CMS).

As a matter of fact, considering the network infrastructure, the actual Web 2.0 is not different from the 1.0, because it is based on the same TCP/IP and HTTP protocols. The real difference is in the user approach to the web contents.

The greatest change in the perception of the web occurred when people started to *reverse the information flow*. While the write capability always existed, only with the advent of Web 2.0 technologies, as Social Networks, Peer to Peer networking and other tools that facilitated participation did users start to take advantage of read/write capabilities of the web on a large scale.

Tim O'Reilly, who coined the term Web 2.0, made an interesting observation about web applications and knowledge accumulation (O'Reilly, 2006):

A true Web 2.0 application is one that gets better the more people use it (as knowledge improve with its circulation process). Google gets smarter every time someone makes a link on the web. Google gets smarter every time someone makes a search. [...] And it immediately acts on that information to improve the experience for everyone else. It's for this reason that I argue that the real heart of Web 2.0 is harnessing collective intelligence. [...] The world of Web 2.0 can be one in which we share our knowledge and insights, filter the news for each other, find out obscure facts, and make each other smarter and more responsive. We can instrument the world so it becomes something like a giant, responsive organism.

This remarks underlines the difference from the Web 1.0, that is the web of information, from the Web 2.0, the web of people: like never before every Internet user can participate in a global knowledge gathering process.

There is a broad consensus that the web is moving more and more in the direction of becoming a platform for global knowledge and intelligence accumulation.

However, even applications such as Google are predominantly read-only, where an algorithm takes advantage of the structure of the web and of human interaction to reflect this insight in its search results.

Despite the advances in computational algorithms, artificial intelligence and processing speed, many problems remain unsolved and may be computationally unsolvable. Limited by Turing-computability²² and complexity of both the algorithm and the necessary background knowledge, truly intelligent machines seem out of reach.

The types of problems that can be mastered algorithmically are quite different from those that require extensive world-knowledge, creativity and the ability to purposefully abstract and intuit. Tasks that humans perform without even thinking about them.

Intuitively, *humans* and *computers* excel at orthogonal tasks. While computers are efficient and effective in logical and mathematical analysis, humans are strong in conceptual tasks, for instance, tasks that require perception, intuition or creative thinking.

The Web 2.0 paradigm allows us to solve these kinds of tasks on a larger scale with many participants making judgments, decisions or contributing information.

In the next future we will have systems that, even if not intelligent enough to answer our question directly, know who can answer to specific questions, choosing among a machine, an individual or a community. These kind of services can be considered black boxes, completely transparent to the end-user: we might not always know whether humans, computers or both are behind the offered service. The outcome matters, so we could care only about quality and time constraints.

Recently the areas of human computation and social computation have attracted much interest. There is a growing tendency towards directly employing web users to solve small problems: the Grid, which is based on a “super virtual computer” composed of many networked computers acting together to perform large tasks; SETI@Home²³ (Search for Extra-Terrestrial Intelligence), which is an Internet-based public volunteer computing project; Amazon.com’s Mechanical Turk²⁴, that is probably the largest-scale implementation of the human-centric view. That is why we are going to describe it shortly.

The Mechanical Turk is a marketplace for services, where the incentive to participate is monetary compensation. Service seekers can post problems, using web forms or an API, called Human Intelligence Tasks (HITs). The HITs are described using tags, a natural language description and formal descriptions, such as allotted time, reward and expiration date. Problem solvers are given reputation points based on reliability/accuracy and can take qualification tests that make them eligible for specific tasks.

This kind of problems are AI-interesting (Artificial Intelligence) if there is no algorithmic procedure that solves it efficiently, but humans can solve it with sufficient success in a reasonable amount of time, or if it is currently perceived to be more accurately solvable by humans.

So, many human-computation tasks are thus not restricted to humans, but enforce or promote interaction between man and machine. Or better between men and machines.

²² A numeric function f is Turing-computable when exists a Turing machine which calculate the valor of the function f for each possible choice of arguments.

²³ <http://setiathome.berkeley.edu/>.

²⁴ <http://aws.amazon.com/mturk/>.

The underlying assumption here is thus that knowledge discovery and aggregation is (almost) always a social activity. All the above mentioned technologies exploit and are exploited by communities of people.

Alvin Ira Goldman (1999) identifies four stage of social distribution of knowledge²⁵: discovery, production and transmission of messages, message reception, message acceptance. These four stages are still all focused on individual choices, but are quite helpful, since the individual is at the first and last stage of knowledge accumulation.

The journalist James Surowiecki (2005) identifies complementary social knowledge aggregation techniques that promise to be successful²⁶. It is possible to substitute the individual in Goldman's four stages with an entire community. Three categories of problems are identified:

1. cognition problems: questions with one answer or questions with a preferred answer.
2. coordination problems that require coordination of actions between members of a community.
3. cooperation problems involve the challenge of getting members of a group involved in tasks or duties that seem contrary to their self-interest, such as paying taxes.

According to Surowiecki, the requirements for good precision in answering questions, making predictions or making decisions are:

- diversity of opinion
- independence
- decentralization
- mechanisms for aggregation of individual results.

On the web, the first three are, for the most part, given by definition.

However, the last point, while theoretically independent of the others, can in practice impede them, because a tighter community will likely have aggregation mechanisms more easily in place than a more loosely coupled community, thus diminishing the value of the first three requirements. In some instances, tight communities can easily sabotage the outcome of a distributed decision making process by infusing it with pre-decided answers (see chap. 4 for a comparison with effects of bonding/strong ties).

In general, it seems that crowds are quite good at solving problems that can be answered in a single sentence, an estimate or a thumbs up. The more difficult problem is how to map this to more complex problems that require a chain of associations that defy immediate intuition. Common sense versus the scientific method: it turns out that both have their place.

It is not enough to know that some social entity is capable of solving problems. We need to know whether there is a good chance that it will solve the problem and that the solution is correct, at least to the best of the participants' knowledge. Goldman asserts that there is a "propensity towards truth."

²⁵ In "Knowledge in a Social World", Oxford University Press.

²⁶ In "The wisdom of crowds", Knopf Doubleday Publishing Group.

From an epistemological point of view, the larger the body of participants gets the more likely it is that the answer received from a crowd is at least not a maliciously invented lie.

The problem solver can potentially be anyone or anything on the web. In the approach taken by Amazon.com with its Mechanical Turk project, users are paid small amounts of money to solve problems on the web. Looking at these approaches, the old “bread and circuses” saying comes to mind. But contributors to Wikipedia or to Sourceforge devote substantial amounts of their time to improving articles or algorithms without reimbursement (see chap. 4). Overall, to explain the motivation for participating in problem solving tasks on the web, moralistic approaches seem to fail.

At first glimpse it seems that there are many factors which play a role in this decision: this can range from aesthetic appeal of the site or interest in the problem to the draw by members of other networks who are already participating. We can assume that people are willing to engage in problem solving activities provided that the incentive is, analogous to Freudian categories: fun, monetary benefit, or the prospect of contributing to something sensible and bigger than the individual’s contribution.

A few years into the existence of the web, its spiritual father Tim Berners Lee introduced a vision of a Web not only for humans to use, but also for machines: a more meaningful, a Semantic Web, or Web 3.0 or Web of data (Rubin, 2009):

The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.

How can semantics improve the mechanisms that we have seen that are already in place for collaborative strategies towards more reliable problem solving?

The Semantic Web is a vast collection of formalized knowledge and agents that are capable of understanding these formalizations and acting upon them. The formalized knowledge is available in ontologies that use logic or graph-based formalisms on top of unambiguous pointers to web resources in order to represent knowledge in a computer accessible manner. The Web 3.0 paradigm is in some sense perpendicular to that of the Web 2.0, characterized by collections of human-generated networks and tags (e.g. folksonomies) that are ambiguous, arbitrary and chaotic.

They differ in a top-down approach to content of the Web 3.0, in contrast to a bottom-up one of Web 2.0. The most relevant issue is how to combine these two paradigms to achieve the kind of man-machine-hybrid computing power that the web has the potential of providing. Even if they seem so close intuitively, they are so far ideologically and technically, because the first is meant for machine consumption, the other for humans.

We can take “a little semantics” and gradually improve it. We can relate tags to concepts in ontologies. We can take informal assertions and convert them into formal ones. Many communities might have a strong interest in simply tagging resources. So, we have to let them tag, while others need rigorous formal representations, and they will develop them out of their needs. Given these semantic bottom and top layers, other communities will have an incentive to relate them.

In addition to manual creation of references to formal concepts, computational algorithms can find commonalities between similar pages and similar tags.

The Semantic Web must provide platforms that facilitate the use of semantics, that hide the formalisms from those who do not want and do not need to see them, that connect the things that are interesting to everyone to those that are interesting only to Semantic Web visionaries. Nowadays we live in an established Web of documents, but the Semantic Web, would be seen as just starting to take off. We have the standards but still just a small community of true believers who recognize the value of putting data on the Web for people to share and to mash up and use at will.

Tim Berners-Lee states that “his invention” has changed in the last few years faster than it changed before, and it is crazy for us to imagine this acceleration will suddenly stop (Rubin, 2009). When the WWW started, there was a paradigm shift, that is when you do not have in your vocabulary the concepts and the ideas with which to understand the new world. The idea that in the next future you could access and combine data anywhere in the world and immediately make it part of your spreadsheet is another paradigm shift.

After a brief look to Collaborative and Semantic Web opportunities, it is interesting to focus on what are these “big data” being widespread worldwide and what are the main issues of having this availability of 10 zettabytes (10^{21} bytes) of data on the internet, with more than 2 billion people connected to the net. It is not clear if big data encompass also that portion of the web which is invisible and inaccessible to research engine: the “deep web”, which is reached only with a precise web address in the browser address bar. This unknown web collect password protected information, encrypted documents of foreign governments, or pirate material.

The American federal government is beginning a major research initiative in big data computing: this effort involves several government agencies and departments, and commitments for the programs total \$200 million (Lohr, 2012).

Administration officials compare the initiative to past government research support for high-speed networking and supercomputing centers, which have had an impact in areas like climate science and web browsing software.

Big data refers to the rising flood of digital data from many sources, including the web, biological and industrial sensors, video, e-mail and social network communications (for implication within the research field see chap. 4). The emerging opportunity arises from combining these diverse data sources with improving computing tools to pinpoint profit-making opportunities, make scientific discoveries and predict crime waves, for example.

The private sector is the leader in many applications of big data computing. Internet powers like Google and Facebook are masters at instantaneously mining Web data, click streams, search queries and messages to finely target users for online advertisements. Many major software companies, including I.B.M., Microsoft, Oracle, SAP and SAS Institute, and a growing band of start-ups, are focused on the opportunity in big data computing.

Farnam Jahanian, the head of the National Science Foundation’s computer and information science and engineering directorate states that (Lohr, 2012):

Data, in my view, is a transformative new currency for science, engineering, education, commerce and government. Foundational research in data management and data analytics promises breakthrough discoveries and innovations across all disciplines.

We hope that this hypothesis could come true, considering our previous remarks on the asymmetry in diffusing innovations and knowledge (e.g. education).

Regarding the educational sector, at Stanford University, an intriguing big-data experiment in online education is under way. Last year, three computer science courses, including videos and assignments, were put online²⁷. Hundreds of thousands of students have registered and participated in the courses. The courses generate huge amounts of data on how students learn, what teaching strategies work best and what models do not, says Daphne Koller, a professor at the Stanford Artificial Intelligence Laboratory.

In most education research, teaching methods are tested in small groups, comparing results in different classrooms, Ms. Koller explains. With small sample groups, research conclusions tend to be uncertain and results are often not available until tests at the end of school semesters.

But in an online class of 20.000 students, whose every mouse click is tracked in real time, the research can be more definitive and more immediate; Ms. Koller underlines that “if 5.000 people had the same wrong answer, it’s obvious a concept is not getting through, and you have a clear path that shows where students went wrong”. That kind of data tracking in education, she said, provides “an opportunity no one has exploited yet”.

In each of the above mentioned sector, the other side of the medal is that systems have to be aware of social aspects of data. We need to focus on what are the purposes for accessing different kinds of data. Accountable systems are aware of the appropriate use of data, and they allow you to make sure that certain kinds of information that you are comfortable sharing with people in a social context, for example, are not able to be accessed and considered by people looking to hire you. How you wish to use the data will be the difference in whether you can use it.

Another thing we’ll be able to do is to write intelligent programs that run across the Web of data, looking for patterns when something went wrong: when a company failed, or when a product turned out to be dangerous, or when an ecological catastrophe happened. We can then identify patterns in a broad range of data types that resulted in something serious happening, and that will allow us to identify when these patterns recur, and we’ll be better able to prepare for or prevent the situation.

For example, in the last years we have a really bad grasp of the financial system. Part of the reason for that might be that we have insufficient data from which to draw conclusions, or that the experts are too selective in which data they use. The more data we have, the more accurate our models will be. Actually, we hope so.

One of the most exciting things of this new scenario are the mash-ups, where there’s one market of people providing data and there’s a second layer of people mashing up the data, picking from a rich variety of data sources to create a useful new application or service. A classic example of a mash-up is when I find a seminar I want to go to, and the web page has information about the sponsor, the presenter, the topic, and the logistics (Rubin, 2009).

At present, I have to write all that down on the back of an envelope and then go and put it in my address book; I have to put it in my calendar; I have to enter the address in my GPS.

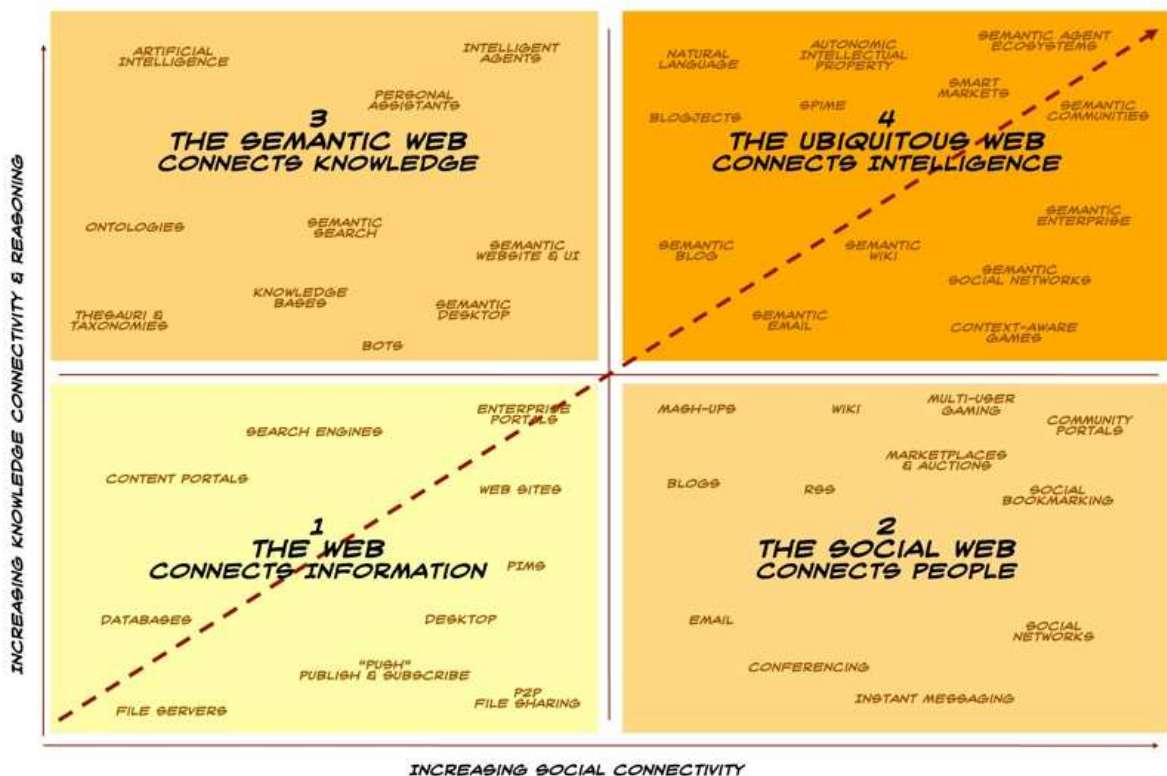
²⁷ http://news.bbc.co.uk/2/hi/programmes/click_online/9720231.stm.

Basically, I have to copy this information into every device I use to manage my life, which is inefficient and time-consuming. This is because there is no common format for this data to become integrated into my devices.

Now, the vision of the Web of data, or Semantic Web, is that the seminar's web page has information pointed at data about the event. So I just tell my computer I'm going to be attending that seminar and then, automatically, there is a calendar that shows things that I'm attending. And automatically, an address book I define as having in it the people who have given seminars that I've attended within the last six months appears, with a link to the presenter's public profile. And automatically, my PDA starts pointing towards somewhere I need to be at an appropriate time to get me there. All I need to do is say, "I'm going to that seminar," and then the rest should follow.

We do not know if all these novelties should really follow within the research field of Web 3.0, starting now, or will be really available only with next generation web, which should be the 4.0, the "ubiquitous web" (see picture²⁸ 2.2).

We can foresee that in the future technologies and human beings will become one, ubiquitous web of objects always-on where RFID tags will be widespread, as augmented layers and 3D holograms will be used instead of our TVs. Otherwise, we are sure that all we have said in this chapter offers the premises for an exponential growth of information transfers, people networks, data processing, to build and share a collective intelligence²⁹ on the web within a real Knowledge Society within the world (Levy, 1997).



Picture 2.2 The evolution of the Web till 2020

²⁸ <http://www.trigent.com/technology/web20/web20-overview.htm>.

²⁹ In "Collective intelligence: mankind's emerging world in cyberspace", Cambridge, MA Perseus.

Chapter 3. Emerging technologies and paradigms

To understand the complexity of the technological landscape in which the Knowledge Society will develop in the next years, this chapter will offer an overview of some emerging fields of research within computer science: ubiquitous computing and its “embodied virtuality” approach, the evolution in interface design, from graphic, to tangible, natural or even organic interfaces. The description of the “continuum” between real and virtual worlds will foresee the possibility offered to our everyday life by a mediated-reality framework.

3.1 Ubiquitous Computing

Computers have always been considered primary objects of our attention, resulting in an area called “Human-Computer Interaction” (HCI). Considering the evolution of the Web during the last decade and the possibilities of connecting communities and data (see chap. 2), are we actually interested in interacting with computers? Isn’t our goal rather to interact with information, to communicate and to collaborate with people? Shouldn’t computer move into the background and disappear? (Streitz & Nixon, 2005).

In the 90s, only foreseeing the third era of computers, after mainframes and personal PCs, Mark Weiser argued (Weiser, 1991):

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

With this sentence started the age of Ubiquitous Computing.

Speaking of Personal Computers, Weiser suggests that we “cannot truly make computing an integral, invisible part of people’s lives.” So researchers and developers had to conceive a new way of thinking about computers, taking into account the human world and making PCs to vanish into the background.

The most intriguing aspects of Ubiquitous Computing is this “disappearance”, which can take different forms: a *physical and mental disappearance*. The physical refers to the miniaturization of devices and their integration, in other everyday artifacts (e.g. clothes).

With the mental disappearance, the artifacts can still be perfectly visible or even very large, but they are not perceived as computers, because people discern them as interactive walls or interactive tables.

Underlining that such a disappearance is a consequence of human psychology, Weiser explains that whenever people learn something sufficiently well, they cease to be aware of it, and it can be added that if such technologies have been smartly designed, the interaction can be a real pleasure.

Only when things disappear in this way, we are free to use them without thinking, focusing beyond them on new goals. Considering this approach, ubiquitous computing does not mean just computers that can be carried everywhere.

Ubiquitous Computing will help to overcome the problem of information overload, allowing users to make everything faster and easier to do, with less strain and fewer mental gymnastics. Within this perspective machines should fit the human environment instead of forcing humans to enter theirs, and this will make using a computer “as refreshing as taking a walk in the woods” (Weiser, 1991).

If we look at the past, writing can be considered as the first information technology available to people, which is ubiquitous in industrialized countries: the constant background presence of this “literacy technology” does not require active attention, but the information is ready to use at a glance. Nowadays, the same is happening with computers: researches in Ambient Devices are actually exploring such “glanceable interfaces” (Ishii, 2008). By glanceable, we mean enabling users to understand information quickly and easily. Glanceability is critical to peripheral display design because users need to quickly glance at and read displayed information, with minimal interruption to their primary task³⁰.

The purpose of designing technological devices that require the less cognitive effort and the perspective that in the very next future hour homes and offices will be pervaded by smart artifacts, embedded into familiar objects, seem a paradoxical situation.

The research area of Ubiquitous Computing, also known as calm technology, proactive computing, ambient intelligence, is tackling this challenge, to offer a next generation of “computers”, which should tell who needs what, when, where and why.

At this point, there are two issues of crucial importance to be considered: location and scale. The first, location, is related to the fact that ubiquitous computers must know where they are, being aware of the room where they are in, adapting their behavior. The second, scale, is related to the fact that ubiquitous computers will also come in different sizes, each suited to a particular task: tabs, pads and boards.

Collections of interacting artifacts will create new people-friendly environments, where the computer-as-we-know-it has no role, reconsidering the complex interplay between technology and the human being.

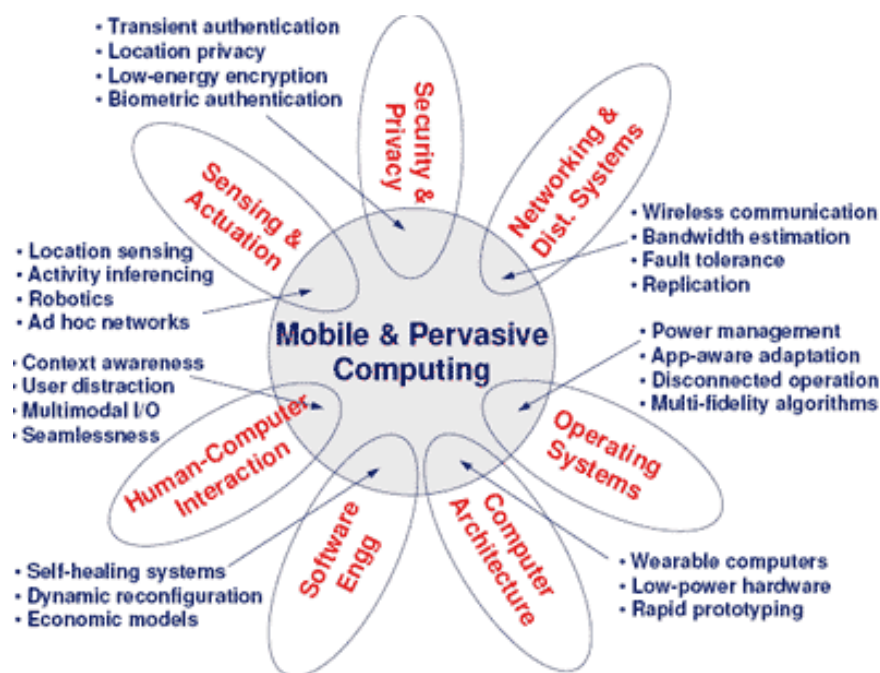
People will simply use these smart objects to accomplish everyday tasks, without being aware of the “intelligence” embedded. In Weiser’s vision, pads are intended to be “scrap computers”, that can be grabbed and used everywhere, without an individualized identity or importance. You can spread many electronic pads around on the desk, just as you spread out papers.

³⁰ <http://techreports.lib.berkeley.edu/accessPages/EECS-2006-113.html>.

Another interesting point, that is necessary to understand the next paragraphs of the chapter, is that the vision of Ubiquitous Computing research field is most diametrically opposed to the notion of virtual reality, which attempts to make a world inside the computer. Virtual reality focuses an enormous apparatus on simulating the world rather than on invisibly enhancing the world that already exists. Invisible computing is so strong that some researchers use the term “embodied virtuality” to refer to the process of drawing computers out of their electronic shells.

Ubiquitous computing, in contrast with virtual reality, resides in the human world and pose no barrier to personal interactions. The goals of deploying the hardware of embodied virtuality is near to hundreds of computers per room (e.g. post-it notes, books and magazines, blackboards). Computers are becoming invisible to our common awareness, and this is already happening, if we think to technology enhanced classrooms, equipped with smartphones, e-readers, netbooks, desktop computers, Interactive WhiteBoards, Interactive Tables, electronic badges, or even RFID Tags.

Within different contexts of application, the disappearing or embodied virtuality process needs to consider some guiding themes of two collateral research areas, which for some aspects overlap with the Ubiquitous Computing vision: Mobile Computing and Pervasive Computing³¹.



Picture 3.1 Mobile & Pervasive Computing related to other research areas

For instance, referring to picture 3.1, Human-Computer Interaction is helpful to understand how people can interact with invisible devices, and how can migrate from traditional explicit to future implicit interaction, offering the proper context-awareness. A major approach in this domain is and will be to combine the best of real and virtual worlds, resulting in hybrid worlds (see par. 3.4).

³¹ <http://www.csd.cs.cmu.edu/research/areas/mopercomp/>.

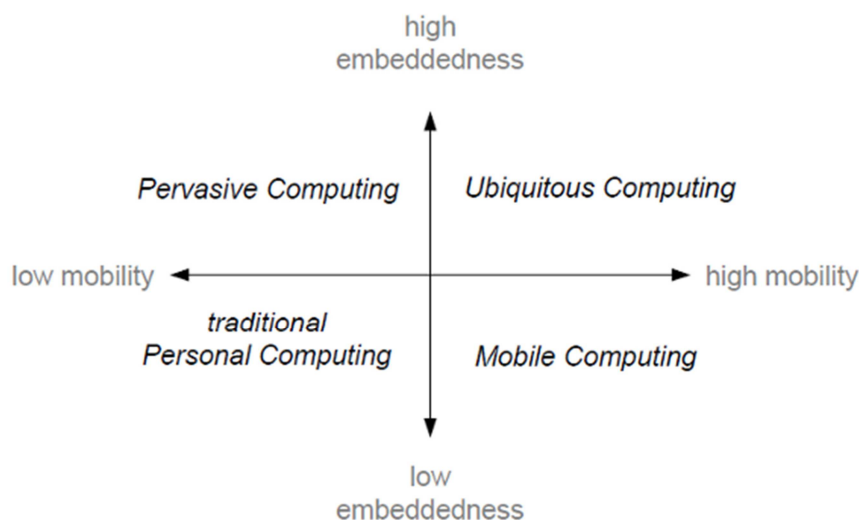
Also Sensing and Actuation are necessary to discern what are the relevant parameters that can be used by the systems to support us in our activities through sensor networks. All these data should be gathered by an infrastructure, deployed to support ambient and ubiquitous computing, being, by definition, long lived and robust.

Summarizing, the technology required for ubiquitous computing comes in three parts: cheap, lower-power computers that include equally convenient displays, software for ubiquitous applications and a network that ties them all together. Moreover, the most common issue of having hundreds of computers in the same room is Security and Privacy, but a well-implemented version of ubiquitous computing could even afford better privacy protection than exists today.

Although 20 years have passed since those early visions and implementations in Ubiquitous Computing, there is still a long way to go to achieve the complete vision. Today, we have islands of results providing dedicated services and serving specific applications. They provide a test bed for the approaches that have been proposed and constitute milestones on our way toward a people-centered vision addressed by Ubiquitous Computing, starting from the contribution of *Mobile* and *Pervasive Computing*.

In the next section we will try to clarify the relations among these three research fields, but it is not really clear for which aspects the areas of Pervasive Computing, Ubiquitous Computing and Mobile Computing differ.

The term Pervasive Computing stands for the philosophy to embed limited intelligence into objects that surround us, so digital technology diffuses through every part which implies high embeddedness. Mobile Computing describes environments in which the user is able to use mobile devices and wireless networks but does not imply any use of embedded devices. Ubiquitous Computing means that digital services and applications are mobile and can be consumed everywhere. Most of the modern applications that are running in smart environments include aspects of all three computing philosophies. Therefore, it is hard to identify which part of the hardware or software is associated to one philosophy. Picture 3.2 shows how these computing philosophies can be distinguished according to the axes of embeddedness and mobility (Beer, 2004).



Picture 3.2 Differences between Personal, Pervasive, Ubiquitous, and Mobile Computing

In the following section will be addressed some other features and examples of pervasive systems, to complete the vision of ubiquitous computing opportunities.

Taking into account Weiser's vision, nowadays users can already access the same point in the Web from several different devices: office or home PCs, cell phones, personal digital assistants, and so forth (Saha & Mukherjee, 2003).

In addition to mobility, pervasive systems require support for interoperability, scalability, smartness, and invisibility to ensure that users have seamless access to computing whenever they need it. Global networks like the Internet also must modify existing applications to completely integrate these pervasive devices into existing social systems (e.g. Internet of Things).

Pervasive Computing implies that everyday objects can get the possibility to communicate and to discover the environment. The idea is that the technology should not visibly change an environment but should improve common objects below the visible surface, preserving their original appearance, purpose, and use.

Examples for such changes can already be found in our daily life. One of the first applications of wireless object identification was implemented for supermarkets to prevent the customers to take products without paying them. A primitive mechanism changes the state of the product from "not paid" to "paid" when the customer visits the cash box. For the customer it seems as if the system did not change at all.

Pervasive systems differ from traditional systems by the fact that the user does not have to be in front of an input/output interface and does not have to focus his attention. These systems are meant to function with a minimum of supervising by the user, which means that they demand less concentration. To solve problems without the user's attention such systems need information about their environment (context information) and the possibility to communicate and to share this information.

One of the most important aspects of pervasive computing was not mentioned so far. The fact that many objects of our daily life get some sort of specific intelligence to perform operational tasks leads to the question of who controls an environment, or more general, of how the need for security and safety should be solved in pervasive environments. As security targets the issue of not sharing critical information with the wrong people or devices, safety asks the question of how such systems may change the user's situation. How smart devices and environments will change the human's safety is hard to discover, due to the fact that the systems are steadily growing and are already taking control over some areas of our daily life. Most people already depend on smart devices embedded in their cars that take control when the car is in a critical situation (e.g. ABS, ESP, air bags). Other components support the user to control the vehicle (drive by wire). So it is quite evident that today smart components have already taken over the control in everyday life and that embedded intelligence is actually a reality.

In the following, I'm going to describe some challenges of pervasive computing environments (and of Ubiquitous Computing).

If we consider Scalability, as the environmental smartness grows, so will the number of devices connected to the environment and the intensity of human-machine interactions. The growth in the number and variety of devices triggers Heterogeneity issues: pervasive computing must find ways to mask this heterogeneity from users.

Moreover, the Integration of pervasive computing components has severe reliability, quality of service, invisibility, and security implications for pervasive networking.

If a system requires minimal human intervention, it offers a reasonable approximation of invisibility. Automated techniques to dynamically reconfigure the network when required are also crucial to realizing the pervasive computing vision.

Perception aspects, or context-awareness, are an intrinsic characteristic of intelligent environments. Implementing perception introduces significant complications: location monitoring, uncertainty modeling, real-time information processing, and merging data from multiple and possibly disagreeing sensors.

Smartness issue, related to Context Management, involves accurate sensing (input) followed by intelligent control or action (output) between two worlds: machine and human.

Pervasive computing is about making our lives simpler through digital environments that are sensitive, adaptive, and responsive to human needs. Far more than mobile computing, this technology will fundamentally change the nature of computing, allowing most objects we encounter in daily life to be “aware”, interacting with users in both the physical and virtual worlds. While research challenges remain in all areas of pervasive computing, all the basic component technologies exist today.

3.2 Tangible User Interfaces and beyond

With the pervasive diffusion of technologies, we are continuing facing the challenge of reconciling our dual citizenships in the physical and digital worlds (Ishii, 2008):

Our visual and auditory sense organs are steeped in the sea of digital information, but our bodies remain imprisoned in the physical world. Windows to the digital world are confined to flat, square screens and pixels, or ‘painted bits’.

Nowadays, interactions with digital information are now largely confined to Graphical User Interfaces (GUIs). GUIs represent information (bits) with pixels on a bit-mapped display and with a “see, point and click representation” represent a significant improvement over CUIs (Command User Interfaces), which required the user to “remember and type” characters. We are surrounded by a variety of ubiquitous GUI devices such as personal computers, handheld computers, and cellular phones.

Graphical User Interfaces have been in existence since the 70’s and first appeared commercially in the Xerox 8010 Star System in 1981. With the commercial success of the Apple Macintosh and Microsoft Windows, the GUI has become the standard paradigm for Human Computer Interaction (HCI) today. When we interact with the GUI world we cannot take advantage of our dexterity, or utilize our skills for manipulating various physical objects.

Tangible User Interfaces (TUIs) aim to take advantage of these haptic interaction skills, which is a significantly different approach from GUIs. An iceberg is the metaphor of Tangible User Interfaces: they give physical form to digital information and computation, making bits directly handled by human hands.

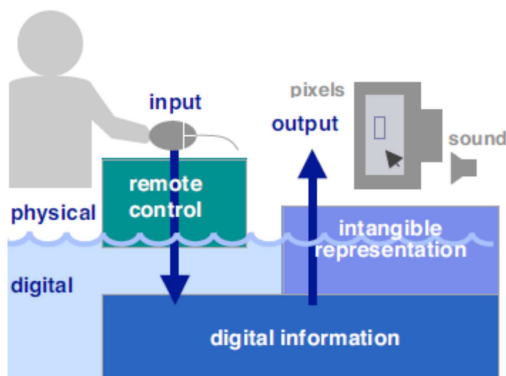
TUIs empower human collaboration, learning and design using digital technologies and taking advantage of human abilities to grasp and manipulate physical objects and materials (V. Ha, Inkpen, Mandryk, & Whalen, 2006).

The physical forms serve as both representations and controls for their digital counterparts. TUI makes digital information directly manageable with our hands, and perceptible through our peripheral senses by physically embodying it (Ishii & Ullmer, 1997). A Tangible User Interface serves as a special purpose interface for a specific application using explicit physical forms, while GUI serves as a general purpose interface by emulating various tools using pixels on a screen (Ishii, 2008).

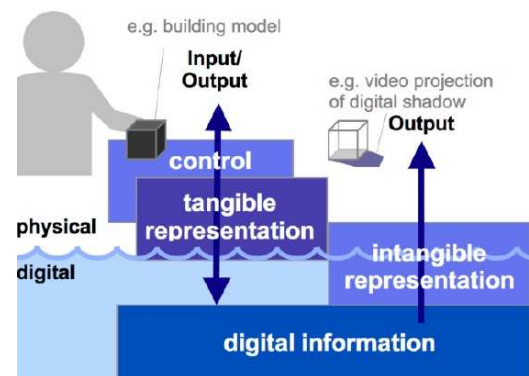
As a matter of fact, TUI is an alternative to the current GUI paradigm, demonstrating a new way to materialize Mark Weiser’s vision of Ubiquitous Computing, of weaving digital technology into the fabric of a physical environment and making it invisible.

In the GUI paradigm (see Picture 3.3) the metaphor of a seashore separates the sea of bits from the land of atoms. While in the TUI paradigm (see Picture 3.4) information is represented in both tangible and intangible forms, so users can more directly control the underlying digital representation using their hands.

The tangible representation helps bridge the boundary between the physical and the digital worlds and functions as an interactive physical control. TUI attempts to embody the digital information in the physical form, maximizing the directness of information by coupling manipulation to the underlying computation.



Picture 3.3 Graphical User Interface



Picture 3.4 Tangible User Interface

Unlike malleable pixels on the computer screen, it is very hard to change a physical object in its form, position or properties (e.g. color, size) in real-time (Ishii, 2008):

In comparison with malleable ‘bits’, ‘atoms’ are extremely rigid, taking up mass and space. To complement this limitation of rigid ‘atoms’, TUI also utilizes malleable representations such as video projections and sounds, to accompany the tangible representations in the same space and to give dynamic expression of the underlying digital information and computation.

One of the most critical aspects is that both tangible and intangible representations must be perceptually coupled to achieve a seamless interface, which is the interactive mediator with the underlying digital information.

This is necessary to blur the boundary between physical and digital. Coincidence of input and output spaces and real time response are important requirements to accomplish this goal. One of the challenges of TUI design is how to map physical objects and their manipulation to digital computation and feedback in a meaningful and comprehensive manner.

In order to make interaction simple and easy to learn, TUI designers need to utilize the physical constraints of the chosen physical embodiment. This understanding of the culturally common manipulation techniques helps disambiguate the users' interpretation of how to interact with the object. The real time feedback of the intangible representation (bits) corresponding to the manipulation of the tangible representation (atoms) is critical to insure perceptual coupling.

In the following paragraph I'm presenting some genres of TUI applications, sometimes considered post-WIMP interfaces.

In Tangible Tele-presence, the effect is to give a remote user the sense of ghostly presence, as if an invisible person was manipulating a shared object. Also a system called Tangibles with Kinetic Memory, using kinesthetic gestures and movements to promote learning concepts is another promising domain, for example, to teach children concepts relevant to programming or storytelling.

Another example, Constructive Assembly, draws inspiration from LEGO and building blocks, building upon the interconnection of modular physical elements.

In a Tokens and Constraints system, tokens are discrete, spatially reconfigurable physical objects representing information or operations and constraints are confining regions within place tokens. In Interactive Surfaces-Tabletop TUI, on an augmented workbench discrete tangible objects are manipulated and their movements are sensed by the workbench.

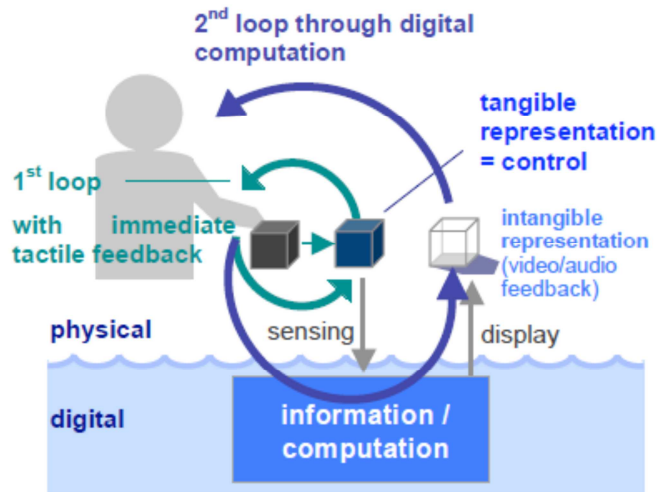
In Continuous Plastic TUI, instead of using predefined discrete objects with fixed forms, a new type of TUI systems utilize continuous tangible material such as clay and sand.

For Augmented Everyday Objects, the augmentation of familiar everyday objects is an important design approach of TUI.

Last of the series, Ambient Media describes the class of interfaces that is designed to smooth the transition of the users' focus of attention between background and foreground. Ambient media serves as background information displays that complement tangible/graspable media that users manipulate in their foreground (Saha & Mukherjee, 2003).

Definitively, one important advantage of TUI is that users receive passive haptic feedback from the physical objects as they grasp and manipulate them, without waiting for the digital feedback.

Typically, there are two feedback loops in TUIs, as shown in the picture 3.5. The 1st loop exists within a physical domain and it does not require any sensing or processing by a computer, so there is no computational delay. The 2nd loop is a digital feedback loop that requires sensing of physical objects moved by users, computation based on the sensed data, and displaying the results as visual (and auditory) feedback.



Picture 3.5 TUI's double feedback loops

As physical artifacts, TUIs are persistent. Tangibles also carry physical state, with their physical configurations tightly coupled to the digital state of the systems they represent. TUIs try to coincide inputs space and output space as much as possible to realize seamless coupling of physical and digital worlds.

As said before, GUIs are fundamentally general purpose interfaces that are supposed to emulate a variety of applications. On the other hand, TUIs are relatively specific interfaces tailored to certain type of applications in order to increase the directness and intuitiveness of interactions. In the design of TUIs, it is important to give an appropriate form to each tangible tool and object so that the form will give an indication of the function available to the users.

Another distinct feature of TUIs is space-multiplexed input and encourages two-handed and multi-user simultaneous interaction: for instance, multi-touch input may be a more appealing and natural means of input as users manipulate objects directly and easily with their fingers (Harris et al., 2009). GUIs, in contrast, provide time-multiplexed input that allows users to use one generic device, to control different computational functions.

TUI pursues these features further into the digital domain by giving physical form to digital information and computation, employing physical artifacts both as representations and controls for computational media. Its design challenge is a seamless extension of the physical affordances of the objects into the digital domain.

After TUIs, Natural User Interfaces (NUIs) are beginning to populate our desks and desktops with multi-touch tabs and pads, our schools and offices with multi-touch tables and boards. NUIs are extremely natural and intuitive to use, so they are more than “user-friendly” (Peltonen et al., 2008).

August de los Reyes, principal director of user experience for Microsoft Surface, argues:

The goal of NUI is not to make the keyboard and mouse obsolete. Instead, NUI is meant to remove mental and physical barriers to technology, to make computing feel more intuitive, and to expand the palette of ways users can experience technology.

Researchers (not only at Microsoft) have released, and are continually developing, a number of products that incorporate touch, gestures, speech, and more to make user-computer interaction more natural, more like the way humans interact with each other.

But creating a more natural relationship between user and technology is not merely a matter of simply removing mice, keyboards, buttons, and knobs, or adding new input methods such as speech, touch, and in-air gestures³².

For instance, with MS Kinect, you are the controller³³. The senior vice president of Interactive Entertainment at Microsoft, Don Matrick, underlines that “all you have to do is step in front of the sensor and it instantly recognizes you and tracks your movements with no experience required.”

So, “if you’re simply walking through the game” means that Weiser’s interacting with PCs like a “refreshing walk in the woods” is nearer than we can imagine.

Nowadays, significant researches are going towards Organic User Interfaces (OUIs): the term “organic” refers not only to technologies that underpin some of the most important developments in this area, that is, organic electronics, but also to the inspiration provided by millions of organic shapes that we can observe in nature, often transformable and flexible, naturally adaptable and evolvable, while extremely resilient and reliable at the same time.

Actually, with this kind of interfaces, the shift is from “stone” “to skin” (Rekimoto, 2008):

I use the terms ‘organic’ and ‘organic interaction’ for such interfaces, because they more closely resemble natural human-physical and human-human interaction (such as shaking hands and gesturing).

In the foreseeable future, the physical shape of computing devices will no longer necessarily be static.

On the one hand, we will be able to bend, twist, pull, and tear apart digital devices just like a piece of paper or plastic. We will be able to fold displays like origami, allowing the construction of complex 3D structures with continuous display surfaces.

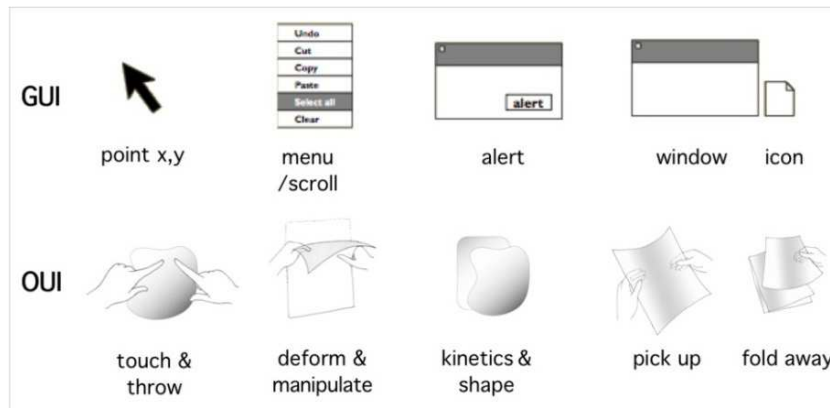
On the other hand, augmented with new actuating devices and materials, future computing devices will be able to actively alter their shape.

Form will be able to follow the flow of user interactions when the display, or entire device, is able to dynamically reconfigure, move, or transform itself to reflect data in physical shapes (Vertegaal & Poupyrev, 2008). The 3D physical shape itself will be a form of display, and its kinetic motion will become an important variable in future interactions.

In picture 3.6 the most significant features of OUIs are compared with the traditional GUIs’ ones (Vertegaal & Poupyrev, 2008), while additional comparisons are listed within table 3.1 (Rekimoto, 2008).

³² <http://www.microsoft.com/en-us/news/features/2010/jan10/01-06cesnui.aspx>.

³³ <http://www.microsoft.com/en-us/news/features/2010/nov10/11-03kinect.aspx>.



Picture 3.6 Kinetic Features of OUIs

We should note that the diffusion of next-generation flexible displays will be strongly influenced by highly related areas of user interface research, most notably Ubiquitous Computing, Augmented Reality, Tangible User Interfaces, and Multi-touch Input.

Table 3.1 Additional comparison between GUIs and OUIs

	Traditional UI	Organic UI
Metaphor	Tools/Stone	Skin/Membrane
Number of interaction points	single	plural or infinite
State	discrete (button ON/OFF)	analog (continuous)
Input	position (x, y)	shape
Output (Feedback)	visual	tactile and others
I/O coupling	separated	unified
Distance to target	contact	proximity
Purpose	perform commands	communication
Place of interaction	computer screen	anywhere

3.3 Reality and Virtuality along the “continuum”

Diametrically opposed to the vision of embodied virtuality proposed by Ubiquitous Computing, Virtual Reality (VR) has been matter of discussion for 50 years: the first experiment dates from 1962 in the US, when Morton Heilig invented Sensorama Simulator.

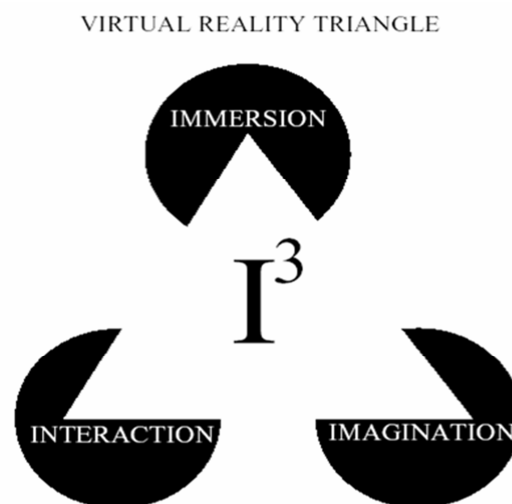
This was the first VR video arcade, where a workstation had a 3D video feedback, motion, color, stereo sounds, aromas, wind effects and a seat that vibrated (Burdea & Coiffet, 2003). So, you could simulate a motorcycle ride through New York, sensing the wind, the holes of the road and the smell food passing by a store.

Heilig, a cinematographer by profession, realized also the possibility of Head-Mounted Displays (HMD), imagining a new machine that would replace the classical cinematographic experience, that today is a common presence in our 3D movies and films. In the sixties nobody realized the revolutionary technological progress represented by these inventions.

Virtual Reality is commonly linked to an Immersion-Interaction paradigm (see picture 3.7), but there is a third feature (Burdea & Coiffet, 2003):

Virtual reality is not just a medium or a high-end user interface, it also has applications that involve solutions to real problems in engineering, medicine, the military etc. [...] The extent to which a simulation performs well, depends therefore very much on the human Imagination, the third “I” of VR.

Therefore, a VR environment triggers the human mind’s capacity to perceive, imagine in a creative sense, nonexistent things, which can be exploited in a wide range of situations (see par. 4.5).



Picture 3.7 The Immersion-Interaction-Imagination paradigm

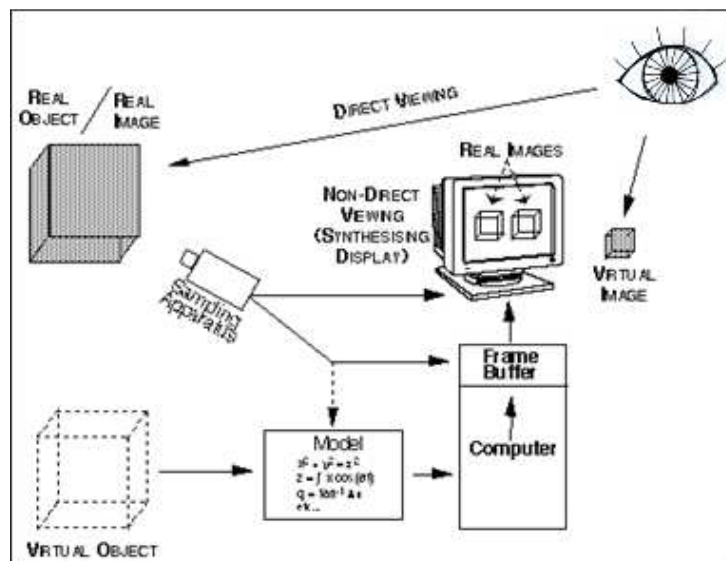
Nowadays the mental and physical (or sensory) immersion play an important part in creating a successful personal experience with VR world. Mental immersion refers to the state of being deeply engaged within a VR environment, while physical immersion occurs when the user interpret visual, auditory, and haptic cues to gather information and controlling objects in the synthetic environment (Huang, Rauch, & Liaw, 2010).

In short, VR technology is well suited to convey difficult abstract concepts due to the visualization abilities (Burdea & Coiffet, 2003), and this can be really useful not only for educational purposes, but also for research activities or science communication, involving the public in new cultural immersive experience.

As a first step dealing with real and virtual environments, we propose the distinction between the concept of *real* and the concept of *virtual*, according to Milgram and Kishino (1994).

The need to take this as a starting point derives from the simple fact that these two terms comprise the foundation of the now ubiquitous term Virtual Reality. Considering the conventional sense of VR (e.g. for completely Immersive Virtual Reality Environments, IVRE), the basic intention in interpreting the two terms is the following (Milgram & Kishino, 1994):

A virtual world synthesized, by computer, gives the participant the impression that that world is not actually artificial but is real, and that the participant is really present within that world.



Picture 3.8 Aspects of distinguishing reality from virtuality

The distinction between real and virtual is in fact treated according to three different aspects, all illustrated in picture 3.8: Real vs Virtual Object, Direct vs Non-direct viewing, Real vs Virtual Image.

The first distinction is between *real objects* and *virtual objects*: real objects are any objects that have an actual objective existence, while virtual objects are objects that exist in essence or effect, but not formally or actually. To view a real object, you can observe it directly or it can be sampled and then resynthesized through a display device. To view a virtual object, it must be simulated, since in essence it does not exist.

The second distinction is related to image quality as an aspect of reflecting reality. The standard of comparison for realism is taken as *direct viewing* (through air or glass) of a real object, or unmediated reality³⁴. On the contrary, *non-direct viewing* of a real object requires an imaging system first to sample data about the object (e.g. using a video camera, laser or ultrasound scanner) and then to resynthesize these data through a display medium (e.g. an analogue video or digital computer monitor). The point is that just because an image looks real does not mean that the object represented is real.

The third distinction is between real and virtual images. In optics a *real image* is defined as any image which has some luminosity at the location at which it appears to be located.

³⁴ Elements of Realspace Imaging: A Proposed Taxonomy, <http://www.naimark.net/writing/realspace.html>.

This definition therefore includes direct viewing of a real object, as well as the image on the display screen of a non-directly viewed object.

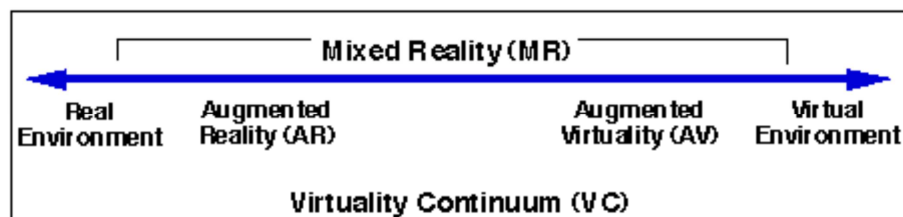
A *virtual image* can therefore be defined conversely as an image which has no luminosity at the location at which it appears, and includes such examples as holograms and mirror images. It also includes the interesting case of a stereoscopic display, for which each of the left and right eye images on the display screen is a real image, but the consequent fused percept in 3D space is virtual. With respect to “Mixed Reality” environments (explained further forward) we can define any virtual image of an object as one which appears transparent, in the sense that does not occlude other objects located behind it.

After some key definitions of the concepts of real and virtual, the following step is to understand what does it mean to have both virtual space and reality available within the same environment (e.g. a visual display).

Conventionally, a Virtual Reality environment can be defined as (Milgram & Kishino, 1994):

One in which the participant-observer is totally immersed in, and able to interact with, a completely synthetic world.

However, the VR label is frequently used in association with a variety of other environments, that are not completely immersive or synthetic (see picture 3.9), but can fall somewhere along a “Virtuality Continuum”.



Picture 3.9 The Virtuality Continuum concept

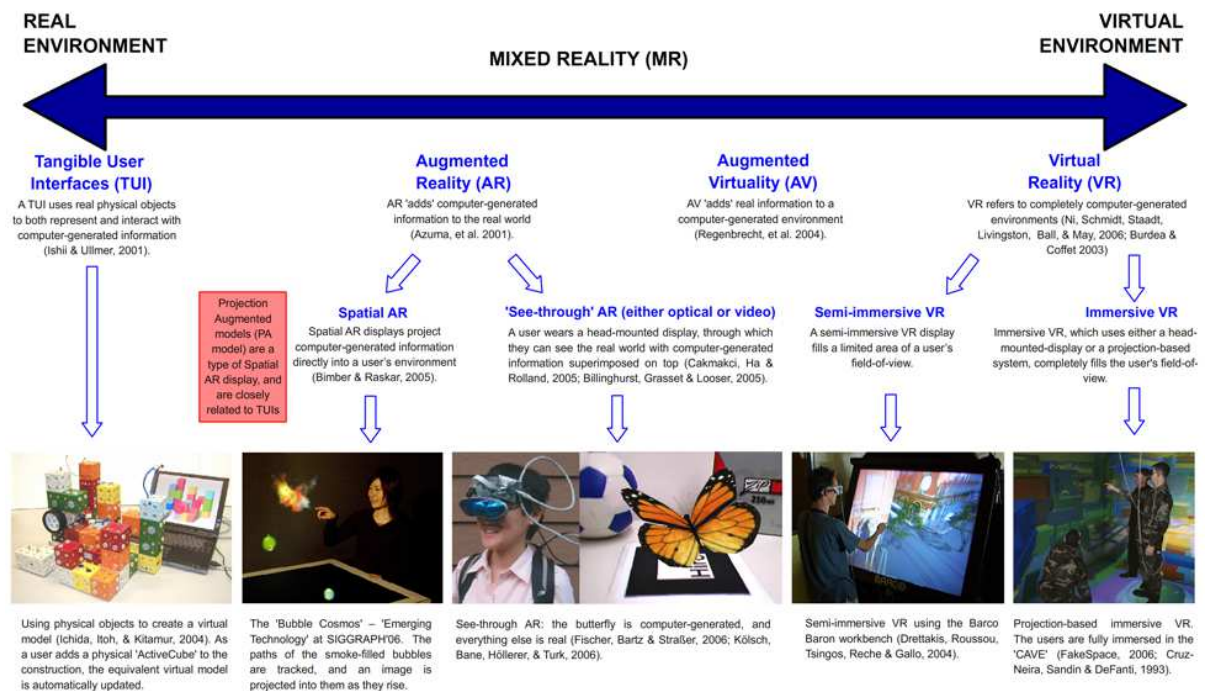
Mixed Reality (MR) covers a particular subclass of VR related technologies that involves the merging of real and virtual worlds. The concept of a Virtuality Continuum relates to the mixture of classes of objects presented in any particular display situation, where real environments are shown at one end of the “continuum” and virtual environments at the opposite extremum.

In this way, a Mixed Reality environment can be defined as (Milgram & Kishino, 1994):

One in which real world and virtual world objects are presented together within a single display, so anywhere between the two extrema of the ‘continuum’.

Of course, as technology progresses, it may eventually become less straightforward to perceive whether the primary world being experienced is in fact predominantly real or predominantly virtual, but should not affect the validity of the more general MR term to cover the “grey area” in the center of the Virtuality Continuum.

The following continuum is an adaptation of the one by Milgram and Kishino, considering recent Mixed Reality displays technologies (see picture³⁵ 3.10), starting from Tangible User Interfaces (see par. 3.2), till Spatial AR Displays, Head Mounted Displays, Semi-immersive VR Displays, and Immersive VR, like Cave Automatic Virtual Environment (see par. 4.5). It is now quite clear how Ubiquitous Computing issues, User Interfaces challenges and Virtual Reality opportunities are tightly connected.



Picture 3.10 Mixed Reality Displays Technologies

At this point, considering the different kinds of Mixed Reality displays, it is necessary to distinguish among the various technological requirements necessary for realizing them, with no restrictions on whether the environment is supposedly immersive (using Head Mounted Displays) or not. We can attempt to address the following questions:

- How much do we know about the world being displayed?
- How realistically are we able to display it?
- What is the extent of the illusion that the observer is present within that world?

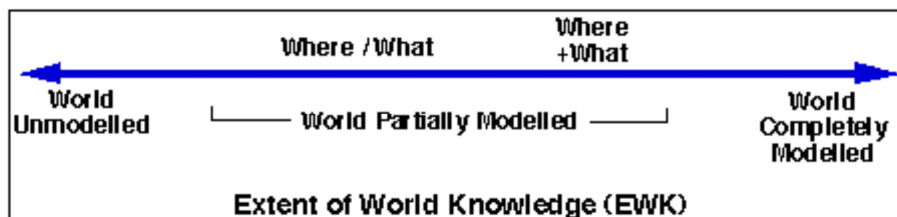
The dimensions proposed for addressing these questions include respectively Extent of World Knowledge, Reproduction Fidelity, and Extent of Presence Metaphor (Milgram & Kishino, 1994).

In the Extent of World Knowledge dimension, at one extreme, on the left, is the case in which nothing is known about the world being displayed, so the world is *unmodelled* (see picture 3.11). This end of the continuum encompasses images of objects that have been “blindly” scanned and synthesized for non-direct viewing, as well as for directly viewed real objects.

³⁵ http://en.wikipedia.org/wiki/File:Adapted_milgrams_VR-AR_continuum.png.

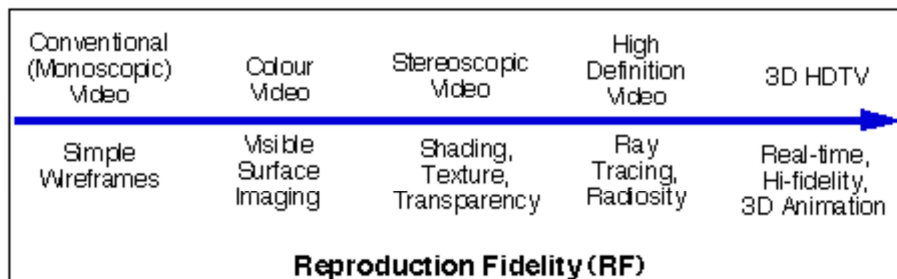
Even though such an image might be displayed by means of a computer, no information is present within the knowledge base about the contents of that image.

The other extreme defines the world in the conventional sense of VR, for which the world is *completely modelled*. This can be created only when the computer has complete knowledge about each object in that world, its location within that world, the location and viewpoint of the observer and, when relevant, the viewer's attempts to change that world by manipulating objects within it. The first “Where” refers to cases in which some quantitative data about locations in the remote world are available. The “What” label refers to cases in which the control software does have some knowledge about objects in the image, but has no idea where they are.



Picture 3.11 Extent of World Knowledge dimension

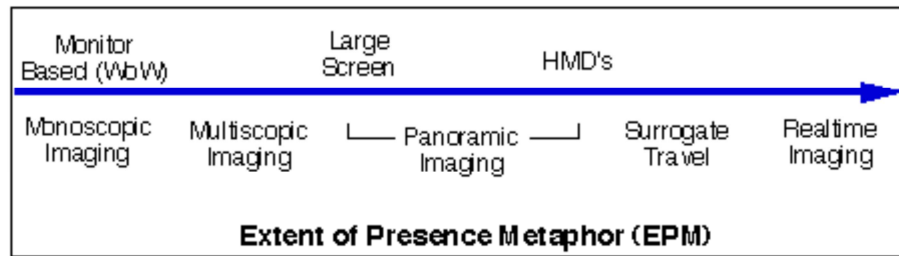
The remaining two dimensions both attempt to deal with the issue of *realism* in MR displays, but in different ways: in terms of image quality and in terms of immersion, or presence, within the display.



Picture 3.12 Reproduction Fidelity dimension

Related to image quality, the elements of the Reproduction Fidelity (RF) dimension are illustrated in picture 3.12, where we follow the approach introduced for classifying non-direct viewing, of either real objects or virtual objects. It is important to point out that this picture is actually a gross simplification of a complex topic, and in fact lumps together several different factors, such as display hardware, signal processing, graphic rendering techniques, etc.

The third dimension, outlined in picture 3.13, is the Extent of Presence Metaphor (EPM) axis, that is, the extent to which the observer is intended to feel “present” within the displayed scene.



Picture 3.13 Extent of Presence Metaphor dimension

In the case of EPM, the axis spans a range of cases extending from the metaphor by which the observer can access the world from a single fixed monoscopic viewpoint, up to the metaphor of “realtime imaging”, by which the observer’s sensations are ideally no different from those of unmediated reality. For instance, in order to accomplish multiscopic viewpoint dependent imaging, the observer’s head position must normally be tracked, while surrogate travel refers to the ability to move about within the world being viewed. Finally, realtime imaging refers to the solution of temporally related issues, such as sufficiently rapid update rates, simulation of dynamics, as within a CAVE.

So, after some basic definitions about what is *real* and *virtual* along the Virtuality Continuum and what dimensions allow to distinguish among different kinds of Mixed Displays, in the following we are going to deepen the infinite degrees of the “continuum”, introducing the concepts of “Augmented Reality” and “Augmented Virtuality”, till a more general definition of Mediated World.

3.4 Nor Augmented nor Mixed: a Mediated World

Even if the term Mixed Reality is not in common use, the related term “Augmented Reality” (AR) has in fact started to appear in the literature with increasing regularity and is now widespread in many contexts (Milgram & Kishino, 1994):

As an operational definition of Augmented Reality, we take the term to refer to any case in which an otherwise real environment is ‘augmented’ by means of virtual (computer graphic) objects.

The most common definition of Augmented Reality is that AR refers narrowly to the class of display systems comprising some kind of Head-Mounted Display (HMD) or Head-Up Display (HUD).

HUDs have existed in primarily military aviation environments for several years, have been substituted by HMDs, because the viewer observes a direct see-through view of the real world. Some of these displays are used in manufacturing and medicine and this concept has been proposed also for combat soldiers on the ground (Milgram & Colquhoun, 1999). A broader class of definitions covers any case in which an otherwise real environment is “augmented” by means of virtual, that is computer graphic, objects, encompassing large screens and monitor-based displays as well.

An even broader class of AR displays has been proposed by some in the literature, encompassing those cases involving any mixture of real and virtual environments. AR can be referred³⁶ as “a variation on Virtual Environments that combines virtual and real” (Azuma, 1997), considering any system that:

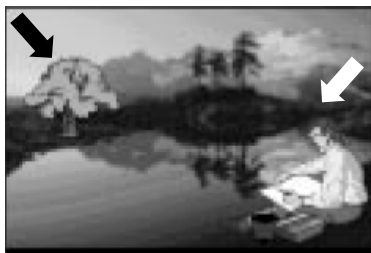
- combines real and virtual;
- is interactive in real time;
- is registered in three dimensions.

The most significant issue is to understand whether it is reality or virtuality which is being enhanced.

If we go back to the Extent of World Knowledge concept (see par. 3.3), we remember that virtual environments (at the right extremum) must be necessarily be completely modeled, in order to be rendered. At the opposite extremum we have real environments as a representation of a world, or a region, which are completely unmodeled. In this latter case, the computer does not possess, or does not attribute meaning to any information about the content of an image.

In order to understand some of the possible mixture of real and virtual elements we can consider the four following examples (Milgram & Colquhoun, 1999).

Picture 3.14 is an example of Augmented Reality: on a real image of a mountain lake, have been superimposed computer generated (virtual) images of an artist sketching a tree.



Picture 3.14 Augmented Reality



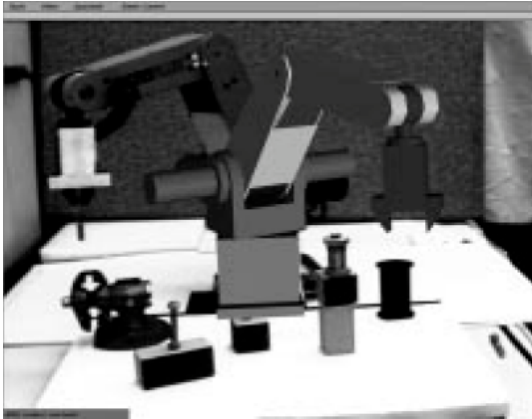
Picture 3.15 Augmented Virtuality

In picture 3.15 it is shown an example of Augmented Virtuality: a completely modeled (3D) world, comprising a series of virtual 3D blocks located on a virtual plane. The computer must have a model of all of their dimensions and locations to draw these objects. In the middle of the picture, in a specific location, has been added a photograph of a group of people; we can assume that the computer knows where the photograph has been placed, but this is not true about the content of the photograph.

In picture 3.16 a real robot (ARTEMIS, Augmented Reality TELeManipulation Interface System) is situated within a real environment, which is completely unmodelled. On the contrary we possess a model of the real robot, registered to real-world coordinates. In this way we can superimpose a modeled stereoscopically presented virtual robot on the top of the real robot. This set up enables an operator to pick up and deposit real objects depicted in the image aligning the virtual end effector with the object to be manipulated, and then transmitting the robot joint coordinates to the remote site at the appropriate moment.

³⁶ In “A survey of augmented reality”, Presence, 6(4), pp.355-385.

In picture 3.17, a screen dump of a Christmas scene produced with Cyberworld, a commercial software for creating 3D web pages, shows an example of Augmented Virtuality. A 3D virtual world has been created, comprising a large public square. A miniature plan view of the square is shown at the bottom right corner. However, the buildings, the Christmas tree, Santa Claus and all of the other objects in the picture are superimposed 2D photographic images, but with known locations in the 3D virtual world.



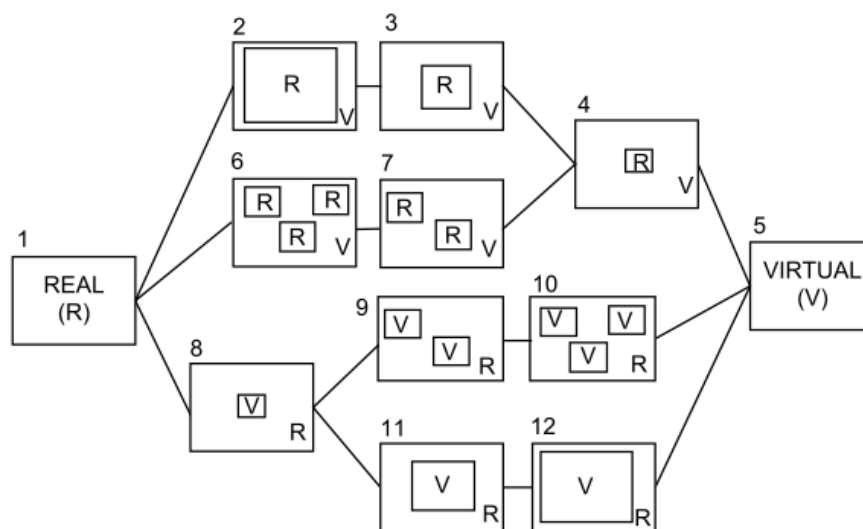
Picture 3.16 ARTEMIS, Augmented Reality System



Picture 3.17 Cyberworld for Augmented Virtuality

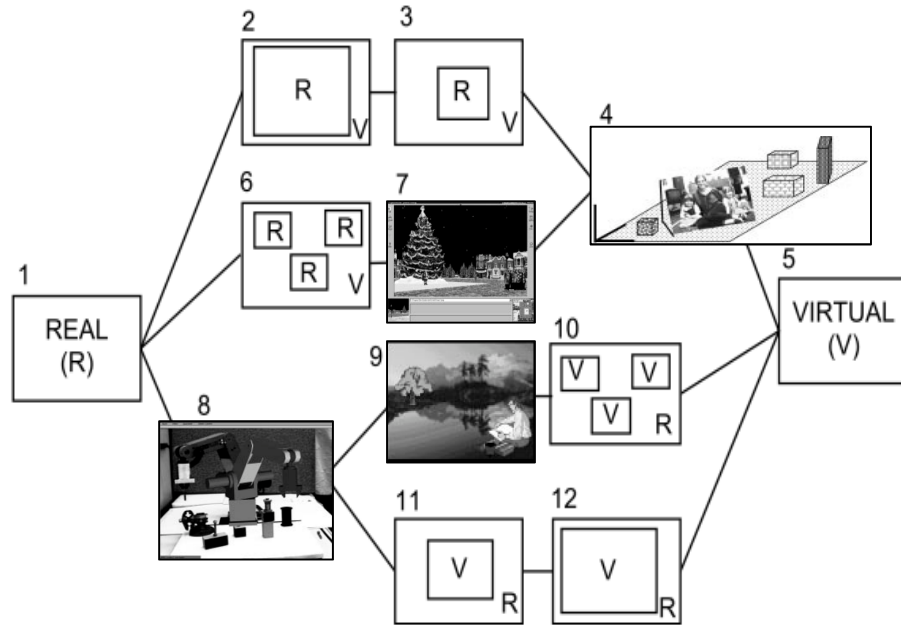
After opposing Reality-Virtuality mixtures with the previous examples, we can underline that it is not always so simple to distinguish between AR and AV. The term Mixed Reality (see par. 3.4) becomes necessary, to encompass in a less constrained way all mixtures between the poles of the “continuum”.

The following combination space (see picture 3.18) highlights the variety of ways in which the real components (R) and the virtual components (V) of an image may be mixed. Reconsidering the four earlier examples it is possible the following combination space.



Picture 3.18 Mixed Reality combination space model

While, within picture 3.19, the previous four examples have been mapped on the combination space model: the robot and the lake photograph could correspond to blocks n°8 and 9, because of the predominance of the real environment or background, with a few of virtual objects; the Christmas scene can be placed in the block n°7, while the completely model 3D world, with the virtual 3D blocks and only one “real” image, is the most “virtual” among the proposed examples, and could be placed in the block n°4.



Picture 3.19 The previous 4 examples mapped on the combination model

One relevant aspect is the circularity nature of the Reality-Virtuality continuum.

It is possible to traverse the continuum from right to left (corresponding to a transition from a completely virtual environment to a completely real one) and from left to right (from a completely real environment to a completely virtual one).

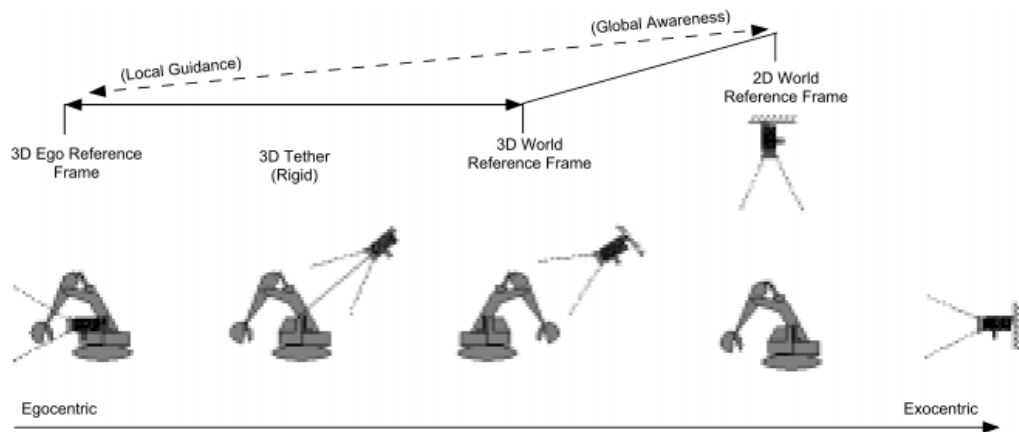
The Augmented Reality segment of the continuum covers a portion of the Reality-Virtuality continuum adjacent to, but excluding the real environment, and this happens similarly for the other segment.

Unfortunately, in practice the distinctions are often not always easily recognized.

After understanding the Reality-Virtuality Continuum, other two dimensions are relevant for the global taxonomy described by Milgram and Colquhoun (1999), in order to define a “single unified framework” for mixed displays: Centricity and Control-Display Congruence.

The first factor, the Centricity Continuum, illustrates a transition from an Egocentric to an Exocentric view-points and we can take into account the following excavator example (see picture 3.20).

In the Egocentric case, the nominal viewpoint of the excavator system is at the driver’s seat inside the cab of the excavator and looking out, so the egocentric case correspond to the view, which would be seen by that operator; in the picture this is represented by the camera mounted within the cab and looking out the window.



Picture 3.20 Centricity Continuum

In the Exocentric case, the cameras are fixed with respect to the external world: the prefix “exo” refers to the state of being outside, looking at the nominal viewing position.

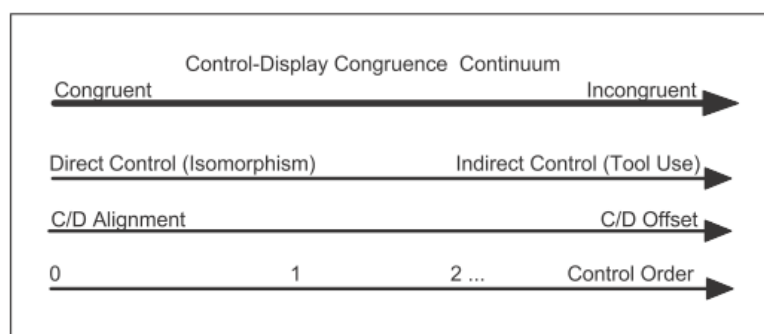
The second factor explains the congruence of mapping a user’s input actions to responses in the display space: the Control-Display Congruence Continuum (see picture 3.21). Depending on the circumstances, a user can effect changes in the observed scene, either congruently with or incongruently with respect to the form, position and orientation of the device(s) provided.

A highly congruent control-display relationship will correspond with a natural, or intuitive, control scheme, whereas an incongruent relationship will compel the user to perform a number of mental transformations in order to use it. Three different aspects allow an intuitive control of the display: directness, alignment and control order.

Directness is easily understandable thinking to see-through AR display environments, in which the user can interact with the environment with maximal directness, by using her/his own hands or feet.

Alignment explains the relative location and/or orientation of the control device relative to the display space.

Control order refers to the transformation between input commands to the control device and the resulting responses of the system being controlled.



Picture 3.21 Control-Display Congruence Continuum

At this point it is possible to build the *global taxonomy* using the three following axes: Real-Virtual Continuum, Centricity Continuum and Control-Display Congruence Continuum (see picture 3.22). Some practical examples of MR displays are inserted in the taxonomy to discuss some issues.

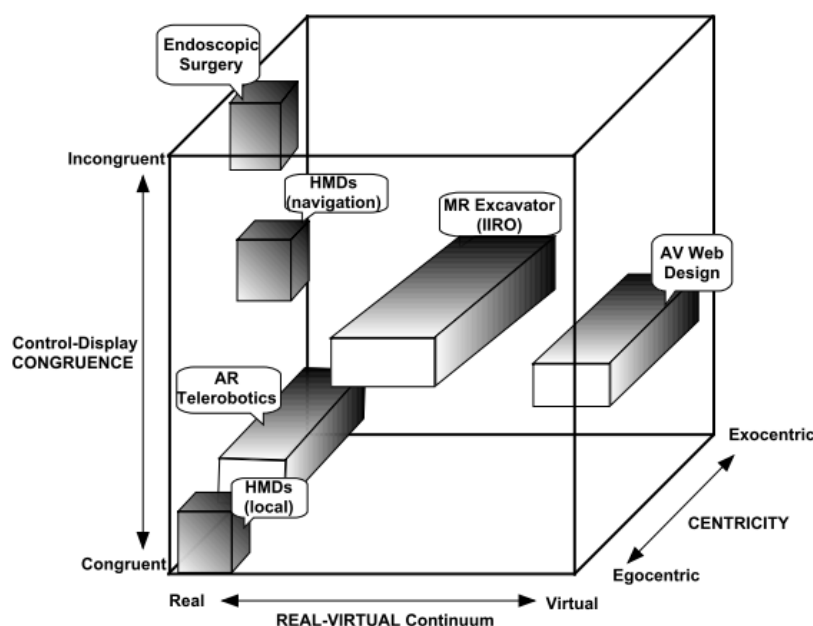
We can start the analysis considering Head Mounted Displays, that is HMDs (local), the more conventional AR displays for local task execution. This class lies very close to the real end of the RV continuum and very close to the Egocentric end of the Centricity axis, with also a good Control-Display congruence. In case of HMDs (navigation), such displays lie very close to the real end of the continuum, closer to the middle of the Centricity axis for the top-down nature of the graphic information and with low congruence between the outside world display and the superimposed control related navigation information.

Considering another example, such as the endoscopic surgery, we can observe that this promising area is at the Real end of the RV Continuum, in the middle of the Centricity continuum and close to the maximum level of incongruence along the C-D Congruence dimension. The latter position is explained by the difficult in providing the means to map control movements unambiguously onto the corresponding displayed responses.

Taking into account AR Telerobotics, this block lies at the Real end of the RV Continuum, is stretched across most of the Centricity axis and is close to the highly congruent end of the Congruence axis.

The previous example of the MR Excavator covers the center of the RV Continuum, is stretched across the Centricity dimension and is in the middle of the Congruence axis. Only the AV Web Design block is located at the Virtual end of the RV Continuum, covers the whole Centricity continuum, while the C-D Congruence is considered neutral here.

In conclusion, the blocks tend to spread out across the Centricity axis as the different systems vary from mostly real (AR) to mostly virtual (AV). This shows the great flexibility of MR displays, where users are able to exploit the advantages of both the real components and the virtual ones. Moreover, current application of Mixed Reality spread out over most the taxonomy space.



Picture 3.22 Global Taxonomy of MR Display Integration

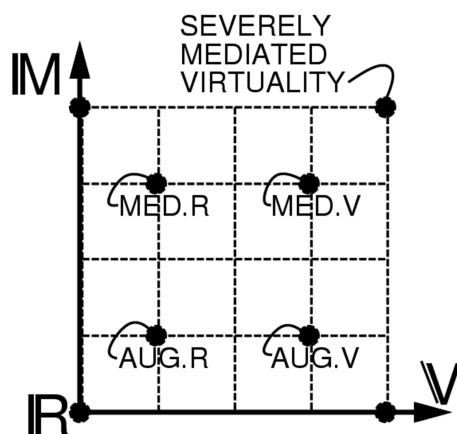
As a matter of fact, the concept of mixing real and virtual world exists in a wide variety of situations in the broadcast, entertainment, audiovisual and computer graphics industries, but unfortunately there are important categories of visual information processors that do not fit within the taxonomy by Milgram & Colquhoun and have other problems with existing distinctions (e.g., optical versus video see-through), that arise when we consider reality-modifying devices.

For instance, the pair of eyeglasses built by G. Stratton in the '90s to diminish his perception of reality is an example of optical see-through, that is not an example of registered illusory transparency³⁷ (Mann, 2002).

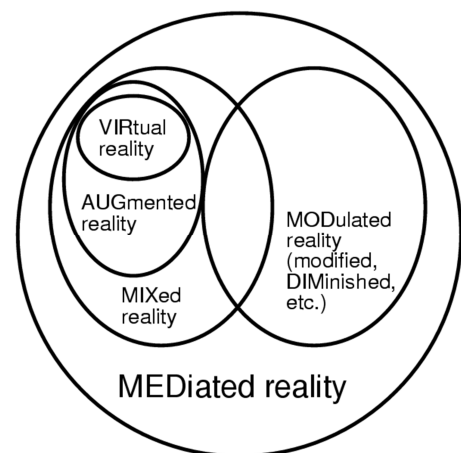
Other similar devices are neither examples of Augmented Reality nor of Augmented Virtuality.

The concept of “Mediated Reality”, introduced by Stratton more than 100 years ago, considers a broad range of devices that modify human perception, mixing these various aspects of Reality and Virtuality.

Mediated Reality refers to a general framework for artificial modification of human perception by way of devices for augmenting, deliberately diminishing and, more generally, altering sensory input (Mann, 2002).



Picture 3.23 Taxonomy of Mediality



Picture 3.24 Mediated reality

Within this new taxonomy (see picture 3.23) the origin “R” denotes unmodified Reality. A continuum across the Virtuality axis “V” includes reality augmented with graphics (Augmented Reality), as well as graphics augmented by reality (Augmented Virtuality). However, the taxonomy also includes modification of reality, or virtuality, or any combination of these.

The modification is denoted by moving up the Mediality axis “M”. Further up this axis, for example, we can find Mediated Reality, Mediated Virtuality, or any combination of these. Further up and to the right we have virtual worlds that are responsive to a severely modified version of reality.

³⁷ The older concept of illusory transparency is a generalization of video see-through applied to systems that do not involve video (e.g. laser EyeTap devices).

In this way Mediated Reality generalizes the concepts of Mixed Reality (see picture 3.24), including the Virtuality-Reality continuum (Mixed reality) and the possibility of diminished reality (Modulated reality).

Reality may be modified in various ways: for instance, some systems allow to diminish reality, filtering out advertisements, or allow to see in different spectral bands, wearing a thermal EyeTap wearable computer system for seeing heat (Mann, 2002).

Mediated Reality can be summarized as follows: if virtual reality aims to replace the real world, augmented reality supplements it, whereas Mediated Reality modifies it.

After the overview of this chapter, it results that technology is disappearing and becoming more and more malleable, passing from “bits” to “atoms” and from “stones” to “skins”.

Moreover, it is more and more easy to use, pervading objects and habits, augmenting or deliberately diminishing our perception of the real. Maybe, we are not even aware of how technology influences the way knowledge is created and communicated, within everyday environments.

Within the following three chapters, research, culture and educational contexts will be deepened considering technology changing behaviors and roles of individuals, taking into account these critical relationships: research-research community, writer-publisher-reader and student-teacher.

Chapter 4. Towards Mixed Reality research

New scenarios are influencing the way we do research. One of the most significant factor is surely the networking opportunity offered to research communities, through the use of new technologies, together with new forces within science field: OpenAccess and the digital data deluge. This chapter will describe present and future research instruments, starting from the importance of social capital, enhanced by academic social networks, showing tools of Virtual Research Environments and a personal experience within a CAVE (Cave Automatic Virtual Environment), towards a Mixed Reality Research Environment, integrating real and virtual worlds.

4.1 Social and Sociotechnical Capital

Dealing with the issue of Academic Social Networks needs a step backward to reflect upon what kind of ties and relationships can be built within a network of researchers (of people). Without considering for a while technological issues, the American sociologist Mark Granovetter, explains that the “strength” of an interpersonal tie should be satisfied by the following definition (Granovetter, 1973):

The strength of a tie is a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie.

In particular, among all possible forms of ties (strong, weak, even absent), weak ties are more likely to link members of different small groups than are strong ones, which tend to be concentrated within particular groups. In this way, weak ties act as “local bridges”, which allow the diffusion of whatever piece of information, reaching a larger number of people, when passing through weak ties rather than strong.

“The significance of weak ties, then, would be that those which are local bridges create more, and shorter, paths.” So, weak ties are indispensable to individuals’ opportunities and to their integration into communities.

Especially within professional and technical specialties, which are well defined and limited in size, this mobility sets up elaborate structures of bridging weak ties between the

more coherent clusters that constitute operative networks in particular locations. Information and ideas thus flow more easily through the specialty, giving it some “sense of community”, activated also at meetings and conventions.

All the ties (strong or weak) which are created and reinforced within a network of connections, represent the social capital of each participant to the network.

Another scientist who investigates deeply social capital is Robert Putnam. He similarly discusses two kinds of social capital (Putnam, 2000): bonding and bridging social capital. Bonding social capital comes from close friends and family in the form of emotional support and tangible resources, while bridging one, conversely, is associated with our “weak ties”: friends of friends, past colleagues, or other acquaintances. Also for Putnam our weak ties are valuable conduits to diverse perspectives and new information; research has shown that we are more likely to receive information about an employment opportunity from someone we see rarely. While bonding social capital close group members in respect to the wider net of social relationships, bridging one opens and expands the area of relationships.

The most interesting aspect of Putnam’s theory, in respect to this work, is when he gives space to the “virtual social capital”, underlining possible obstacles to be overcome within computer-based groups, which are also studied within Computer-Supported Cooperative Work (CSCW) research field.

The author identifies a series of issues affecting Internet communities (Putnam, 2000), starting from depersonalization and difficulties in building a sense of trust and reciprocity among participants:

[...]Participants in computer-based groups find it harder to reach consensus [...]. They develop a sense of ‘depersonalization’ and are less satisfied with the group’s accomplishments. Computer-based groups are quicker to reach an intellectual understanding of their shared problems – but they are much worse at generating the trust and reciprocity necessary to implement that understanding.

Moreover, the fluidity within online relationships does not help to overcome the previous problems, and also a virtual environment enriched by audio-video possibilities seems not to be enough:

Anonymity and fluidity in the virtual world encourage ‘easy-in and easy-out’ relationships.[...]Video and audio enhancements of computer-mediated communication may in time reduce these difficulties, but that is unlikely to happen soon.

Actually, other critical points may reduce the basis for creating wide social capital within networked communities, such as the risk of “cyberbalkanization” and the related risk of narrowing our interests and number of connections:

The Internet enables us to confine our communication to people who share precisely our interests (cyberbalkanization). [...]That powerful specialization is one of the medium’s great attractions, but also one of its subtler threats to bridging social capital. [...]Serendipitous connections become less likely as increased communication narrows our tastes and interests – knowing and caring more and more about less and less.

Only overcoming these challenges we could demonstrate that online communication is “complementary and not as an alternative to real communities”. As a matter of fact, we do not know how these Internet communities will evolve in the future, tackling these challenges. Paul Resnick, a computer scientist has pointed out that (Putnam, 2000):

[...] Perhaps what will evolve are neither all-encompassing ‘cybercommunities’, nor watertight ‘cyberghettos’, but multiple ‘cyberclubs’ with partially overlapping memberships. In this sort of world, weak ties that bridge among distinct groups might create an interwoven community of communities.

We have seen that productive social structures and dynamics emerge as a by-product of interactions that occur (or not) naturally in the course of work. If we try to conceptualize such resources as social capital suggests, it is also possible to make conscious investments to develop resources that inhere in social relations (Resnick, 2002).

Social capital is a residual or side effect of social interactions, and an enabler of future interactions. If social capital, like many other aspects of social life, is not only produced but also reproduced, it is important to understand if some social practices might be productive only in the presence of particular communication and computational tools.

The term “sociotechnical capital” is used by Paul Resnick, to refer to productive combinations of social relations and information and communication technology (Resnick, 2002):

The resources are sociotechnical in nature if their production or use requires a combination of social relations and information and communications technologies.

Actually, it will be significant to understand if academic social networks and other actual Virtual Research Environments are really useful and adequate in building social capital and research opportunities within the research world and how these networks affect the role of the researcher.

To better analyze sociotechnical capital, we are going to consider how social capital usually works and which opportunities sociotechnical capital can offer.

We have seen that social capital facilitates information routing, exploiting communication paths: instead of bonding social capital, Granovetter and Putnam have noted that information flows better when there are weak or bridging ties. In contrast, if a clique is very tight, then members of the clique are less likely to have access to information or resources from outside the clique. Recent research has suggested that graphs that have significant closure (e.g. mostly cliques) with just a few bridging links can still exhibit a phenomenon where everyone is only a few links away from everyone else.

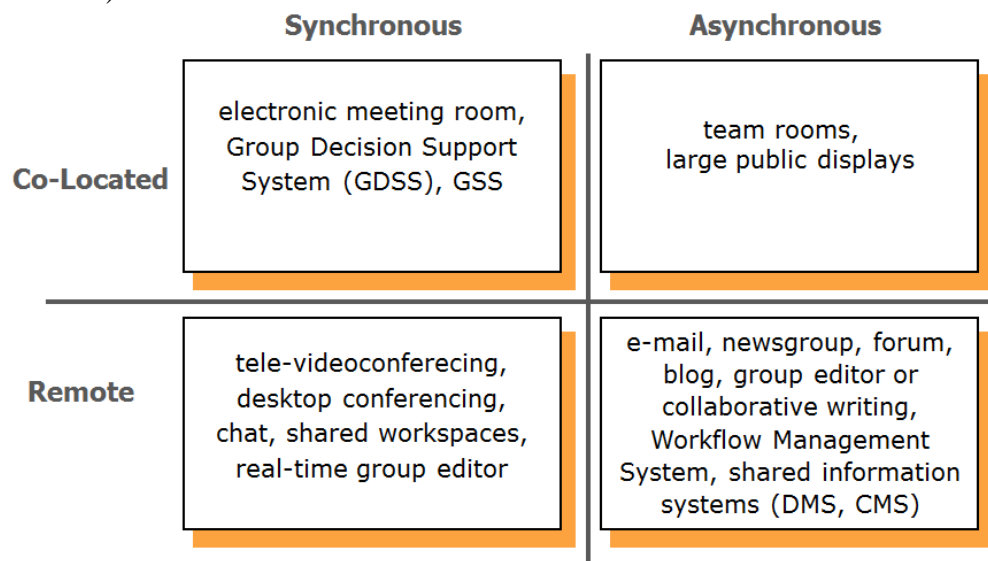
Moreover, social capital helps people to exchange other resources besides information: the shared knowledge can include not only knowledge of facts, events, or stories, but also a shared vocabulary and repertoire of ways of interacting (Wenger, 2006).

In summary, social capital is both a residual of previous interactions and an enabler of future interactions. The residuals can include: communication paths, shared knowledge and values, identities, obligations, norms that people take on, and expectations that people form about others’ behavior.

These residuals are a resource that help people route information, exchange resources, provide emotional support, coordinate activity, and overcome dilemmas of collective action (Resnick, 2002).

Two aspects of social capital are clear: the shadow of the future created by repeated interaction is a necessary condition, and the generation and use of social capital act in a virtuous or vicious cycle. We constantly experiment that successful collective action typically generates social capital while inaction or failed attempts to act together make it even harder to do so in the future.

At this point we should evaluate which are the opportunities offered by sociotechnical capital. Past researches within CSCW field study common practices and tools through which computer-mediated communication enables communication at a distance and across time (see picture 4.1).



Picture 4.1 CSCW Space-Time Communication Possibilities

In addition, technology can present information in unobtrusive ways (e.g. recent developments in ‘calm technology’ such as for glanceable interfaces).

ICTs allow people interact with much larger social networks, but also to restrict information flows (e.g. the division of netnews into a hierarchy of topics); technology can be incorporated into routines for managing dependencies (e.g. Workflow Management Systems) or are useful in maintaining history, making the residuals of previous interactions visible in some way. Finally, ICTs can contribute to social capital through indirection in naming (e.g. e-mail addresses).

Summarizing, the possible sociotechnical relations involve constant awareness, short interaction, maintaining ties while effectively using less time (with multitasking), giving support to large groups of people (recommender systems). We have just seen the success of open-source projects (see par. 2.2): here the interesting feature from the sociotechnical capital perspective is the ability of a large group of people, most of whom will never meet each other, to together create really good software.

It is clear that society is changing, and that older forms of togetherness that generated social capital, within the American society and also all over the world, no longer draw people in the way they once did.

The future needs us to succeed in identifying and promoting new forms of sociotechnical capital, in the workplace, in learning environments, and especially in civic life. Antonio Casilli³⁸ argues that (Gambaro, 2012):

Internet does not de-socialize individuals, but produces new genres of sociality which allow us to better modulate the equilibrium between strong ties and weak ties, that is those potential ties we stimulate discontinuously.

The advantages for the individuals are manifold, especially in social capital terms, that is the whole social resource of each individual, available for realize one's potential on personal, professional, social and cultural level. Social media allow us to increment and better modulate our social capital, offering a richer sociality, which facilitate the access to environments, precluded in the past. In short, we are in the middle of glocal networks, in the sense that they are global and local at the same time (Gambaro, 2012).

4.2 Academic Social Networks

Before describing some widespread academic social networks, we have to introduce shortly which are the most relevant aspects of present Social Networking Sites (SNSs), related to the concept of sociotechnical capital. We believe it is important to consider the social changes that might accompany mainstream use of these sites (Facebook and the like), both for working activities and for leisure.

Most Social Networking Sites consist of the same ways to interact: chat, video chat, email, comments, messaging, blogs, discussion groups, forums, and file sharing. A Social Network is a social structure made up of individuals (or organizations) called "nodes", which are tied by one or more specific types of interdependency, such as friendship, kinship, common interest, financial exchange, likes/dislikes, relationships of beliefs, knowledge or prestige (Chakraborty, 2012).

The most significant features of SNSs are the Web 2.0 opportunities of findability and participation.

The concept of *findability* pertains to information architecture and it is usually applied to digital resources available in the web, but with social networks, this concept has been applied to persons: in this way people become resources, that is social capital. People do not search only documents and contents but they look for other persons, tearing down distance problems and cultural differences. On a community level, the organizing features of social networking sites lower the transaction costs for finding and connecting with others who may share one interest or concern (Ellison, Lampe, & Steinfield, 2009).

What truly distinguishes SNSs from earlier technologies is the articulated social network, which is at the heart of these systems: Social Network Sites allow us to digitally represent our connections with other users. But in the very next future, the boundaries among digital and physical connections will not be so clear as in the past.

³⁸ <http://www.liaisonsnumeriques.fr/?p=2609>.

Actually, social network sites might influence public and community life through the combined forces of mobility and place awareness. As mobile phones increasingly include GPS services, users can create hyper-local, ad-hoc networks. For instance, recent iPhone release includes connections to location-based SNSs, which alert users to nearby friends, blurring the line between online and offline interaction, which is the second challenge underlined by Putnam (see par. 4.1). Adding proximity information to one's digital presence may provide additional connection opportunities that would otherwise be missed. For designers and creators of these systems, these questions highlight the need to better understand how they must adapt in order to support diverse populations and goals.

The concept of *participation* is more controversial. Even if the Web 2.0 is a work in progress, the growth of users participation is quite evident, making arise a collective intelligence, remixing data and producing user-generated content (see par. 2.4). Web 2.0 expresses technologies that can increment participation and deepening possibilities, being a new point of view, to become aware entrepreneur of our opportunities, communities aware of our power and potential (see par. 2.2).

In spite of these possibilities, we have to underline the fact that not all individuals participate in first person to collective processes: most of the time only a small minority contributes in the creation of something, that is then exploited by the rest of the users.

Jacob Nielsen summarizes this concept with the 90-9-1 rule (Nielsen, 2006):

In most online communities, 90% of users are lurkers who never contribute, 9% of users contribute a little, and 1% of users account for almost all the action.

The famous usability consultant refers to his rule as “Participation Inequality”, highlighting that intelligence is not so collective, but more connective. With the exponential growth of social media, subgroups of users consolidate their position participating more actively than others, exploiting the service.

To explicit this behavior, Michael Arrington opposes to the “wisdom of crowds” the perspective of a “wisdom of the few”: with this expression, the founder of TechCrunch³⁹, a blog covering the Silicon Valley technology start-up communities, synthetizes the participative fracture, which can be explained by the 1-10-89 rule (Bruno, 2006):

Out of 100 users of a participation platform, only 1 user contribute actively with personal contents, 10 participate rarely to minimal activities within the community (comments, ranking, tagging), the other 89 are passive users.

As a matter of fact, this is completely in opposition with the view of a real collective intelligence, as proposed by Pierre Levy, that is the capacity of virtual communities of use combined competences of their members to exercise more power.

Collective intelligence seems to be in discussion at every change in the internet history; if you think only to YouTube and Wikipedia the participation asymmetry is extremely evident: for each YouTube upload there are 1538 download (active users are only 0.07%) and the 50% of Wikipedia articles are produced by 0.7% of wikipedians.

³⁹ <http://techcrunch.com/>.

For Jacob Nielsen the only solution is to reduce the actual divide, involving more than 10% of users, trying to reduce barriers to collaboration, enforcing usability, automatize mechanisms (better recommendation systems), allowing more changes than creating contents ex-novo, promoting quality with compensations (reputation, discounts).

The Web 2.0 logics are actually changing also the way scientists connect, share and collaborate: *findability* and *participation* are two common keywords also in this context, thanks, for instance to Wikis and social networks, as new means for connecting researchers. On this path, some social networks have been created and tailored to scientists' needs, in order to make them find researchers with similar interests or expertise, to keep in touch with their peers, to share their information.

If communication between scientists will accelerate the creation and distribution of new knowledge, we will pose the basis of a successful research, also towards a promising vision of a "Science 2.0", when the possibility of building connections among researchers will join completely Open Access Logics, allowing researchers also to search, access and disseminate their scientific work (see par. 3.4).

There are some effective examples of academic social networks which encompass these logics (Giglia, 2011).

ResearchGate, founded in 2008, is a free social networking site for scientists and researchers and has reached 1.4 million of users, in 192 countries. Web 2.0 tools are available to enhance scientific collaboration, creating professional profiles, discussing in forums and sharing papers, jobs opportunity or conferences of interest. One of the powerful tool of this platform is the semantic search engine, which allows to search simultaneously abstracts or full-texts through the largest literature databases: PubMed, IEEE, CiteSeer, arXiv, RePEc, NASA Library and the Open Archive Initiative (OAI).

According to the Open Access paradigms, if copyright policies allow, it is possible to upload the full text of published works in the Publications section and also to sign in into virtual Groups in different topics, or create proprietary subject group. In the Event section users can find conference, meetings and workshops clustered by topics, while in the Job section there are research job applications: jobs can be filtered by keyword, position, field and country.

In 2009, as a sort of spin-off, ResearchGate Blog was launched. Members of the scientific network can submit postings from their individual ResearchGate profile: the highest-quality submissions are then selected and published. Made up of these quality postings, ResearchGate Blog is a reputable source for science news, commentary, research and innovation from all academic disciplines.

Another free platform launched in 2008 is *Academia.edu*, with more than 1.2 million of registered users, which can be used to share papers, monitor their impact, and follow the research in a particular field. An important tool that Academia.edu offers is the statistic of personal downloads and page views; it also allows to know what keywords people use to search for you on Google.

Academia.edu is a participant in the Open Science or Open access movements, responding to a perceived need in science for instant distribution of research, providing unrestricted access via the Internet to peer-reviewed scholarly journal articles, but also to theses, scholarly monographs and book chapters.

Moreover, Academia.edu is in opposition with the Research Works Act⁴⁰, which would prohibit open access mandates for federally funded research and, if enacted, it would also severely restrict the sharing of scientific data.

Mendeley is another free tool founded in 2008, that combines a reference management application, Mendeley Desktop, with an online social network for researchers, Mendeley Web.

As reference management application, Mendeley can import or export citations to other similar tools (Zotero, CiteULike, EndNote) in various formats, and, more important, can then synchronize with them. Moreover, it helps to turn pdf files into a bibliography database without manual data entry, just by dragging and dropping the pdf into the Mendeley Desktop. Mendeley can also import citations from the results page of Google Scholar, PubMed, Web of Science, EBSCO, ScienceDirect, Wiley Online Library, Amazon, from other 50 databases and from a common Web page (using a script). As other tools, this system generates bibliography and reference lists in more than 1.000 different styles and allows you to manage the bibliographic database, indexing it by keywords, reading, annotating and sharing the pdf files with peers.

As academic social network, Mendeley allow users to build their academic profile with areas of expertise to be discovered by others and to increase their visibility by sharing the profile as a CV. The Papers section, clustered into topics, is an archive in which you can upload your works, while the Group section can be both public and private, closed to a lab or a project group: it allows assigning tasks, or discussing research projects. As Academia.edu, Mendeley generates personal research impact data: users can find out about the readership of their own publications as it develops in real-time, with figures about readers, their country and affiliation, their academic status, and their academic field.

As a matter of fact, having a cross-platform operating system and offering also two apps for Iphone and Ipad, Mendeley is becoming one of the biggest research databases in the world and it has the added-value of a layer of social information about the readership demographics and user-generated tags for each research paper.

Other two academic networks, this time specific for social studies, are Social Science Research Network and Social science space.

The first website, *Social Science Research Network* (SSRN), was founded in 1994, and is not a social network, but still a 1.0 platform devoted to the rapid dissemination of scholarly research in the social sciences and the humanities.

Academic papers in pdf can be uploaded directly to the site by authors. Most papers are available for worldwide free downloading, but there are papers available only for a fee. Users can also subscribe to abstracting email journals covering a broad range of subject matters. These e-journals then periodically distribute emails containing abstracts (with links to the full text where applicable) of papers recently submitted to SSRN in the respective field. SSRN, like other preprint services, let circulate publications throughout the scholarly community at an early stage, permitting the author to incorporate comments into the final version of the paper before its publication in a journal.

⁴⁰ A bill introduced in the United States House Of Representatives at the 112th United States Congress on December 16, 2011; http://cyber.law.harvard.edu/hoap/Notes_on_the_Research_Works_Act.

Moreover, even if access to the published paper is restricted, access to the original working paper remains open through SSRN.

The second website, *Social science space*, has been recently launched by SAGE, one of the leading international publisher, and is fully integrated with 2.0 application, such as Twitter and FaceBook. Social science space brings social scientists together to explore, share and shape the big issues in social science, from funding to impact. This online social network offers blogs with the most current thinking from key players in social science, a forum for discussions, a resource center with free videos, reports and slides that support these discussions, as well as funding and job opportunity notices.

Other widespread networks are LinkedIn, considered most a professional network, Viadeo, a web 2.0 professional social network based in Paris competing with LinkedIn, while Twitter, at present, will not be considered as Academic Social Networks for its specificity of micro-blogging site, but could become one of the research instruments of the researcher's palette of the future (Priego, 2011).

4.3 Virtual Research Environments

The aim of this paragraph is to understand the use of academic social networks starting presenting two different case studies, in order to reflect upon and then list the desired features of a Virtual Research Environment.

The *first case study* focuses on the use of ResearchGate and Facebook by research scholars in the North Eastern Hill University (NEHU), India (Chakraborty, 2012). The research questions of this case study are, which are interesting for our research purposes are: What activities do researchers perform on SNSs? How SNSs are related with research? On a dataset composed by 100 research students, 69 respondents are from Arts stream and 31 are from Science stream; moreover, in case of research experience, 44 respondents fall under 1 to 2 years of experience, 31 fall under 2 to 3 years of experience, and 25 fall under 3 to 5 years of research experience.

It is found that 34% respondents have account only on Facebook. Similarly, 8% respondents have account only on ResearchGate. And pleasingly 58% have account on both of the SNSs. Moreover, the most majority of researchers spend so little time on SNSs: 36% of FB users and 60% of RG users spend less than one hour on the respective SNS.

When analyzing a comparison between the two social networks in respect to the reasons for using them, the research reveals that out of 92 Facebook users, the majority uses it "to be up to date". On the other hand, out of 66 ResearchGate users 24% use it "to know other's field of research", 31% use it "to be up to date" and 37% use it "to form study groups". Moreover, it is noticeable that no respondent uses ResearchGate for "entertainment", while if considering the activities performed, ResearchGate responders do not use this site for instant messaging, or to meet new people, or to share personal photos and videos or comment's to other posts.

Finally, research scholars are asked what they think about the importance of SNS in research. Here it is found that almost 70% respondent (majority are from social science background) claim SNS as a research tool; on the contrary remaining 30% respondent

(majority are from pure science background) think that SNS has no role in research and education. However, the majority of the researchers (59%) responds positively about the future of social network sites, while only 6% responds negatively and 35% have no idea about it.

This research confirms a certain specialization of actual SNSs, like Facebook, and Academic Social Networks, like ResearchGate. Even if both sites present some overlapping features, ResearchGate is definitively perceived as an academic site, for “serious” activities. But there is something more. This perception influences the amount of hours spent on this site, actually not “time-consuming” as Facebook, witnessing a particular habit in excluding certain type of social activities (chatting, commenting posts and meeting new people), which are actually not perceived as functional to “serious” research activities, as explained by sociotechnical capital (see par. 4.1).

The *second case study* illustrates the sociotechnical features of a new social networking site, Cloudworks⁴¹, which has been specifically developed to enable discussion and sharing of learning and teaching ideas/designs and to promote reflective academic practice (Conole, Galley, & Culver, 2012). This site aims to foster new forms of social and participatory practices: peer critiquing, sharing, user-generated content, aggregation, and personalization among different communities of users, within an educational context.

The core object in the site is a cloud, which can be aggregated into community spaces called “cloudscapes”. Clouds can belong to more than one cloudscape and they can be anything to do with learning and teaching (e.g. a description of a learning/teaching practice, an outline about a particular tool or resource, a discussion point).

Clouds combine a number of features of social and participatory technologies: they act like multiuser blogs with posts, links and resources, they are similar to social bookmarking sites⁴², enabling the aggregation of links and academic references, they have a range of other functionalities common to networking sites, such as tagging, RSS feeds, Twitter-like follow-and-be-followed options, and activity streams for different aspects of the site. The homepage of the site, in addition to providing standard navigation routes, such as browsing of clouds, cloudscapes, people, and searching, shows recent activities, currently active clouds, and featured cloudscapes.

A core principle of the site is that it is totally open: anyone can see anything in the site. Moreover, serendipity has been built into the site in a variety of ways, which enables individuals to cross community boundaries and to make unexpected connections. The site offers powerful mechanisms for supporting social networks in a range of ways and at different levels: for events, debates, open reviews, resource aggregation, courses, reading circles, learning design, expert elicitation and consultation.

From this last case study, it is undoubtedly clear the potential use of Web 2.0 tools as the basis for the creation of a complex and complete Virtual Research Environment or VRE (Myhill, Shoebridge, & Snook, 2009). However, desirable features of a VRE may have to wait until Web 3.0 tools become available (see par. 2.4), with the possibility of a reliable, consistent, secure, pervasive, scalable, efficient, interoperable, coherent context and data⁴³.

⁴¹ <http://cloudworks.ac.uk>.

⁴² <http://www.ebizmba.com/articles/social-bookmarking-websites>.

⁴³ http://www.youtube.com/watch?v=SUVIE-t_Y1c&feature=related

Moreover, there is very limited literature describing operational applications of a Web 2.0 approach to the development of a Virtual Research Environment, so what we are going to describe is conceptual, but integrated by recent available tools. Based on an earlier description by Michael Fraser, working at the University of Oxford, the JISC defines a *Virtual Research Environment* as (Joint Information Systems Committee, 2006):

[...] A set of online tools and other network resources and technologies interoperating with each other to support or enhance the processes of a wide range of research practitioners within and across disciplinary and institutional boundaries. A key characteristic of a VRE is that it facilitates collaboration amongst researchers and research teams providing them with more effective means of collaboratively collecting, manipulating and managing data, as well as collaborative knowledge creation.

There are many facets that a Virtual Research Environment could encapsulate. Many of these exist as stand-alone systems or processes, while others are less defined and subject to wide-ranging institutional or disciplinary practices. There is considerable evidence that many researchers are already using some of these tools in this way, but actually, a VRE, which stands isolated from existing infrastructure and the research way of life, will not be a widespread research environment, but probably only another underused web portal (Myhill et al., 2009).

At this point it is necessary an integrated infrastructure, including common components of existing VREs and new desirable additional features. If considering the fundamental phases of a research project and some of its most relevant activities, we can summarize some of the existing tools within table 4.1.

Identifying a research project	<ul style="list-style-type: none"> •federated research , commercial bibliographic indexes •RSS feeds, open access repositories
Identifying funding streams	<ul style="list-style-type: none"> •e-mail alerts •RSS feeds
Identifying project partners	<ul style="list-style-type: none"> •Facebook, ResearchGate, Google+ •Other Social Network Sites
Collaborating on a research proposal	<ul style="list-style-type: none"> •Google Drive, Dropbox •Skype, Google Hangout
Managing project expenditure and grant compliance	<ul style="list-style-type: none"> •Google Drive, Dropbox
Collaborating research info	<ul style="list-style-type: none"> •Google Drive, Dropbox •Wikis, Reference Management Application
Writing research reports and outputs	<ul style="list-style-type: none"> •Google Drive, Dropbox •Skype, Google Hangout
Disseminating Results	<ul style="list-style-type: none"> •Open access repositories •Webinars, virtual conferencing (Second Life)

Table 4.1 Web-based research tools which should be integrated within a VRE

First of all, a good *research project* is informed by the findings of other research. Researchers build on what has been done before and consequently rely on earlier research outputs, papers, and articles as the basis for formulating their own research hypotheses and questions. Unfortunately, the extent of subscribed or authentication-protected academic information available on the web, “the invisible web”, makes this very difficult to do.

Considerable content of the deep web consists of subscription-based bibliographic indexes, which are hidden from most search engines and require either individual interrogation – provided you have a subscription or are a member of an entity that does – or can be queried by the latest, federated library search engines such as ResearchPro⁴⁴ or MetaLib⁴⁵. However, the ability to trawl “hidden” sources can revolutionize the preliminary explorations required to formulate research questions.

Also RSS feeds are another opportunity of being updated about a specific content: this is a common approach adopted by the UK Research Funding Councils⁴⁶. Online newsletters are maintained by many *funding* bodies: the UK’s Medical Research Council⁴⁷, for example, provides a means of signing up to receive news daily, weekly, or monthly and then the ability to customize content received by a selection of headings including funding, research, publications, policy and press releases.

Last but not least, we should consider open access repositories, like open DOAR web site⁴⁸, maintained by SHERPA⁴⁹, the Centre for Research Communications at the University of Nottingham, which is investigating issues in the future of scholarly communication. It is developing open-access institutional repositories in universities to facilitate the rapid and efficient worldwide dissemination of research. The benefits of open access repositories for researchers are related, on one hand, to an increased visibility and access to research outputs, and on the other hand to an arising possibility of make their own work widely known.

For identifying project *partners*, we have seen that existent social and academic networks (Facebook, ResearchGate, Google+) are the most suitable for establishing and widening the social capital of researchers.

In the context of a VRE, Google Drive (born as Google Documents) can be a fundamental tool especially because it can work with a variety of file types and formats and is not solely limited to Microsoft applications. The ability to control who can view and edit documents and share updates in real time inserts Google Drive at the heart of virtual research collaboration, including the ability to manage research *inputs*, *outputs* and even project *administration*.

Today also Dropbox is widespread for cloud storage, file sharing among users and synchronization with a client, installed on a pc; also wikis can be a very powerful means of exchanging ideas and concepts within an academic community; finally every VRE should integrate a reference management application to store and share research papers and materials among all the participants.

⁴⁴ http://www.iii.com/products/research_pro.shtml.

⁴⁵ <http://www.exlibrisgroup.com/category/MetaLibOverview>.

⁴⁶ www.rcuk.ac.uk.

⁴⁷ <http://www.mrc.ac.uk/index.htm>.

⁴⁸ www.openoar.org.

⁴⁹ <http://www.sherpa.ac.uk/>.

For synchronous communication, calls between Skype users are free and with a standard broadband internet connection, it is a simple matter to run other Web 2.0 applications: this has been reached with Google Hangout, recently linked to Google+ social Network and Google Drive features, so that collaborators can talk to each other in real time and even work on the same documents simultaneously.

For the *dissemination* of research results, print and online conference papers and presentations have long been used to reach a wider audience, more than is possible through physical conference attendance. The advent of online webinar functionality and the creation of virtual conference facilities, such as the 50 events offered through Nature Publishing and Macmillan Publishers' Elucian Islands Conference Suite within Second Life⁵⁰, have introduced an interactive dimension to the relationship with the wider research audience.

The value of these types of services in the context of the VRE is that they are supportive of multidirectional communication, being particularly useful in question and answer type sessions and in facilitating discussions between participants. It is also thought that the adoption of an online avatar, which is required in virtual worlds such as Second Life, helps to break down traditional social and reputation barriers between, for example, student researchers and Nobel Prize winners. Unfortunately, these services require participants to be on line at the same time in order to derive the greatest interactive and collaborative benefits, thereby introducing a potential time barrier for some.

Moreover, in the current environment, supporting e-research should be identified as a key role for librarians, which have a significant curatorial role to play in the digital era. The two challenges posed to librarians by the digital age are in the evaluation of primary source materials and to discuss and support the developing Open Access movement and especially publishing in repositories (for other digital lending issues see par. 5.3).

Other important changes are going to affect research tools, offering, for instance, a richer authoring experience: new add-in for MS Word after the Chemistry add-in Chem4Word, the CreativeCommons add-in or the Ontology add-in for a semantic enrichment of the scientific literature⁵¹.

Another example is the node XL project, by Social Media Research Foundation, which is an open-source template for Microsoft Excel 2007 and 2010 that makes it easy to explore network graphs. As a matter of fact, Network Analysis is of growing importance in academic, commercial, and Internet social media contexts, while existing Social Network Tools are challenging for many novice users. Tools like Excel are widely used, so leveraging a spreadsheet as a host for Social Network Analysis lowers barriers to network data analysis and display (Hey, 2009).

There are other main-stream Web 2.0 tools which may have a less obvious value within a VRE: blogs, for example, but also self-publishing sites such as YouTube or iTunesU⁵² already contain a considerable amount of academic material ranging from lecture podcasts to tutorials, and Flickr in addition (e.g. tables, graphs, photos).

To combine all the above mentioned ingredients it is necessary to pull together specialist knowledge of academic networks and relevant resources, bringing together a specific research community.

⁵⁰ www.nature.com/secondnature/index.html.

⁵¹ <http://research.microsoft.com/en-us/collaboration/tools/officeaddins.aspx>.

⁵² <http://www.apple.com/education/itunes-u/>.

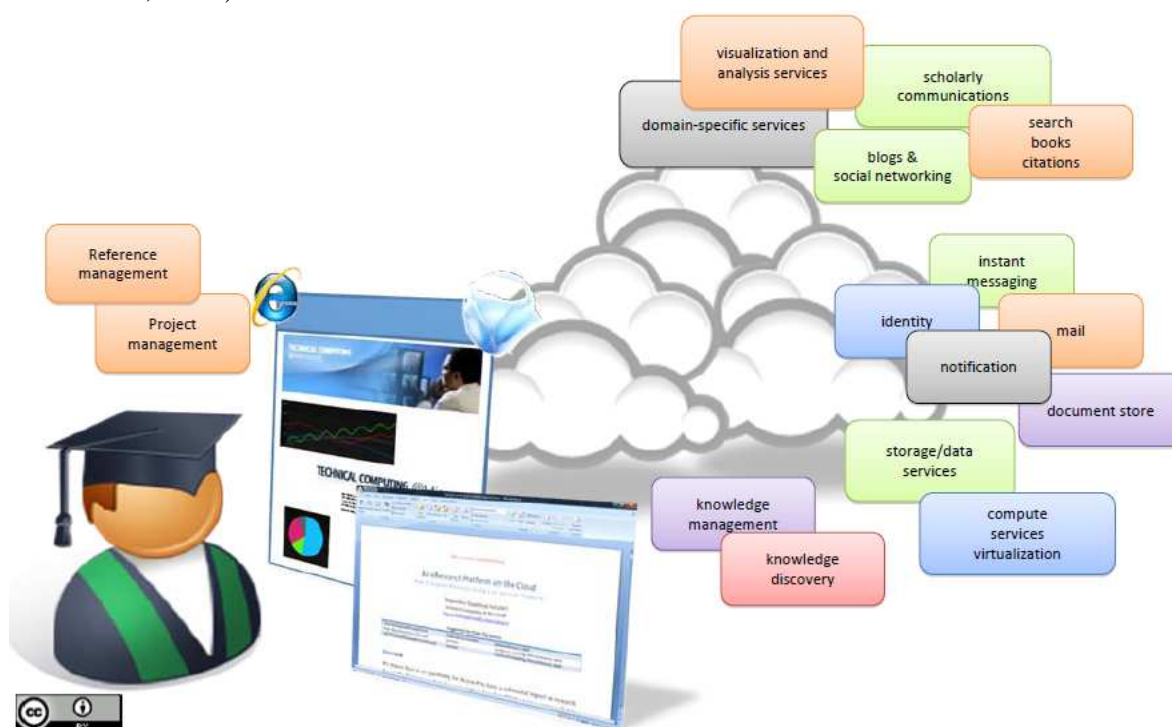
Many Web 2.0 tools are “push” systems, but still require some intervention and contribution by researchers. Actually, the quality of the VRE will depend on the enthusiasm and participation of individuals. We are moving towards a world, where all data is linked and everything is open, collaborative, interoperable and automatic. In this sense, data/information is interconnected through machine-interpretable information (e.g. paper X is about star Y) and Social networks are a special case of ‘data meshes’ (see par. 2.4).

Perhaps Web 3.0, the “Intelligent Web”, will bring additional functionality including the semantic web, micro-formats, natural language search, data mining, machine learning, recommendation agents, and artificial intelligence technologies, which emphasize machine-facilitated understanding of information in order to provide a more productive and intuitive user experience⁵³.

The fact that we do not have fully-operational examples shows that this is an area of some infancy, rather than reflecting an impossibility of this approach.

Collaboration and information sharing among researchers are fundamental in this scenario and challenging aspects of scientific research, in order to create a sort of knowledge ecosystem (see picture 4.2) where both people and data are linked within the cloud, to complete a vision⁵⁴ of the future Research e-Infrastructure using Client+ Cloud resources (Hey, 2009).

While there are a growing number of subject-based VRE examples, most concentrate on collaboration using existing tools based on the traditional internet. The on-going and relentless development of web-based technologies coupled with the exponential growth of academic information and the impending emergence of the Google generation into the academic research arena makes a full Web 2.0 VRE a certainty (Joint Information Systems Committee, 2008).



Picture 4.2 The future Research e-Infrastructure using Client+Cloud resources

⁵³ <http://www.youtube.com/watch?v=u82JSenM0JU>.

⁵⁴ This work is under a Creative Commons Attribution 3.0 United States License.

4.4 New forces in science research field

All proposed features and tools of Virtual Research Environments give some evidence to new approaches in the way we conduct and will make academic research in the very next future. Actually, there are many changes within research field that are deconstructing established academic roles, thanks to new technologies and new processes: from creating networks and partnerships, from publishing to mentoring, from accessing materials to disseminating results, from collaborating across disciplines and countries to cross-fertilization of practices and methods.

For centuries, science has operated through research done in private, then submitted to science and medical journals to be reviewed by peers and published for the benefit of other researchers and the public at large. But to many scientists, the longevity of that process is nothing to celebrate. Actually, this system is hidebound, expensive and elitist. Peer review can take months, journal subscriptions can be prohibitively costly, and a handful of gatekeepers limit the flow of information.

Scott Aaronson, a quantum computing theorist at the Massachusetts Institute of Technology, has refused to conduct peer review for or submit papers to commercial journals. “I got tired of giving free labor,” he affirms, to “these very rich for-profit companies” (Lin, 2012).

But not only peer-review is under discussion. One aspect is quite clear (Aldrich, 2012):

The scientific progress is in a certain sense paradoxical noting the tension between science as a competition between individuals for scarce rewards versus science as a community of inter-subjectively shared understandings about how we gain valid and reliable knowledge about the world.

The “struggle for citations” is a central dynamic in science: scientists compete for recognition from their peers, rather than competing for wealth and power. This competition could lead to extreme individualism, but personal interests are partially held in check because scientists must fit into a larger community, if for no other reason than to have their work replicated and validated. Moreover, the scale of modern scientific work is such that large projects are almost always carried out by teams, rather than single individuals. Being published, winning awards, and obtaining grants depend upon peer reviews, which are embedded in a larger institutional structure to which individuals must adjust. These “individual adjustments” are actually old-fashioned practices.

There are significant forces influencing the way we do research. First, social networking mechanisms have created a social structure facilitating connections between researchers. Second, publication opportunities have increased dramatically. Third, training and mentoring has moved to a collective rather than individual apprenticeship model. Fourth, major foundations and many other smaller funding sources have changed the scale and scope of research. Fifth, new mechanisms have emerged that recognize and reward individual scholarship. Sixth, globalizing forces have affected all of these trends (Aldrich, 2012).

In the following we are going to deepen the most significant of these “forces”, which are connected to sociotechnical capital, to the diffusion of new technologies within research world and to a new active role of the researches within scientific community.

An increased level of *collaboration* is the first evident aspect, with a team-based models for conducting research and growing numbers of knowledge producers and knowledge users sharing core concepts, principles, and research methods. Moreover, a trend toward co-authored work has also emerged in the social sciences, with the humanities lagging behind: high impact work is easier to carry out in larger teams, resulting in papers with multiple authors. Many scientists have documented the importance of collaborative ties between researchers in academic communities, as reflected in the voluntary refereeing process for promotion and journal reviews, supervising students, organizing international events, and creating and contributing to new scientific journals. Scientific networks are based on several forms of interaction that reinforce each other.

Also professional associations and conferences are critical for diffusing a field’s knowledge base to users, but equally important is the opportunity for meeting others who are interested and passionate about their work. Contexts that intensify someone’s identity as a member of a community remind people of why they joined in the first place and also create incentives for scholars to increase their visibility within the community. Thus, social networking is not only about producing and using knowledge but also about developing and maintaining a professional identity and “weak ties” with other researchers (see par 4.1).

Such exponential growth in sharing ties and contents has produced increasingly systematic and interconnected knowledge. Other many mechanisms have emerged that facilitate knowledge diffusion: new journals launched by publishers as well as academic societies; conferences funded by professional associations, universities, and other sponsors; and major developments in the online availability of publications of all kinds (e.g. Google scanning and making available millions of books online). Nevertheless, the creation of new journals has contributed to fields’ fragmentation, a current running counter to the other forces that promote convergence.

The second relevant “force” develops when new journals and all online resources are collaborative built, but following the *OpenAccess* logic. Open-access archives and journals like arXiv⁵⁵ and the Public Library of Science⁵⁶ (PLOS) have sprung up in recent years. Internet sites and blogs give the opportunity to citizen science to collect and contribute to the most various field of scientific research. GalaxyZoo⁵⁷, a citizen-science site, has classified millions of objects in space, discovering characteristics that have led to a series of scientific papers (Lin, 2012), while mathematicians can earn reputation points for contributing to solutions on the collaborative blog MathOverflow⁵⁸, and have found a new proof for a particularly complicated theorem in just six weeks, only commenting on the Fields medalist Timothy Gowers’s Weblog in 2009.

Many scientists advocate for “open science”, claiming that science can accomplish much more, much faster, in an environment of friction-free collaboration over the Internet.

⁵⁵ <http://arxiv.org/>.

⁵⁶ <http://www.plos.org/>.

⁵⁷ <http://www.galaxyzoo.org/>.

⁵⁸ <http://mathoverflow.net/>.

And despite a host of obstacles, including the skepticism of many established scientists, their ideas are gaining traction. Dr. Aaronson, who is also an active member of online science communities like MathOverflow, where he has earned enough reputation points to edit others' posts argues that "We're not talking about new technologies that have to be invented. Things are moving in that direction. Journals seem noticeably less important than 10 years ago."

As a matter of fact, changing the status quo, opening data, papers, research ideas and partial solutions to anyone and everyone, is still far more idea than reality. As the established journals argue, they provide a critical service that does not come cheap.

"I would love for it to be free," says Alan Leshner, executive publisher of the journal Science, but "we have to cover the costs." Those costs hover around \$40 million a year to produce his nonprofit flagship journal, with its more than 25 editors and writers, sales and production staff, and offices in North America, Europe and Asia, not to mention print and distribution expenses. "Will the model of science magazines be the same 10 years from now? I highly doubt it," he says. "I believe in evolution. When a better system comes into being that has quality and trustworthiness, it will happen. That's how science progresses, by doing scientific experiments. We should be doing that with scientific publishing as well." (Lin, 2012).

The idea of an evolution is present also in the words of one of the inventors of ResearchGate, Ijad Madisch, who have seen a vast untapped market in online science. He acknowledges that for many established scientists social networking can seem like a foreign language or a waste of time, but we have to wait until younger scientists, weaned on social media and open-source collaboration, will start running their own labs.

Actually, while science is moving towards a collaborative and open access model, within a Web-connected world, a third aspect should be considered by scientific community: the *digital data deluge*⁵⁹. After the Experimental Science of thousand years ago, the Theoretical Science of last few hundred years (e.g. Newton's Law, Maxwell's Equations), the Computational Science (e.g. simulation of complex phenomena), the challenge of today is Data-Intensive Science. (Hey, Tansley, & Tolle, 2009).

This deluge affects data collection, through sensor networks, satellite surveys, high throughput laboratory instruments, observation devices, supercomputers, LHC; it involves data processing, analysis and visualization, through legacy codes, workflows, data mining, indexing, searching, graphics; archiving, through digital repositories, libraries, preservation. Scientists will be overwhelmed with data.

Professor Douglas Kell, Research Chair in Bio analytical Sciences at the University of Manchester, speaking of the "fourth paradigm" underlines⁶⁰ that:

One of the greatest challenges for 21st-century science is how we respond to this new era of data-intensive science. This is recognized as a new paradigm beyond experimental and theoretical research and computer simulations of natural phenomena, one that requires new tools, techniques, and ways of working.

⁵⁹ In "The fourth paradigm: data-intensive scientific discovery", Redmond, Washington Microsoft Research.

⁶⁰ <http://research.microsoft.com/en-us/collaboration/fourthparadigm/>.

4.5 Experiencing a Cave Automatic Virtual Environment

In this section I am going to describe the opportunities offered by the Italian laboratory CSRV⁶² (Centro Sviluppo Realtà Virtuale), also known as Virtual Reality Development Centre, which I visited in September 2011 and where I have the opportunity of experimenting a CAVE (Cave Automatic Virtual Environment).

Nowadays Virtual Reality is extremely popular and widespread as technology (see par. 3.3). In particular, it has been exploited in educational applications, known as Virtual Reality Learning Environments (VRLEs). These environments allow the visualization of three dimensional (3D) data and provide an interactive environment to reinforce the sensation of an immersion into computer-generated virtual world. Additionally, a VRLE offers the opportunity to simulate a realistic and safe environment for learners and researchers to perform specific tasks (Huang, Rauch, & Liaw, 2010). Even if VRLE are now run on low-cost PCs, users feel motion sickness and experience fatigue than true immersive VR (Taxén & Naeve, 2002). Considering this, only totally immersive VRLEs could be suited for a complete learning (or researching) experience.

The following experience is supposed to complete the analysis of the desired aspects of a Mixed Reality Research Environment, trying in first person virtuality features.

The CSRV laboratory, placed in Lomazzo (Como) and founded in 2010, has its operational headquarters in the Science and Technology Park Lomazzo ComoNExT and thus benefits, as well as the strategic location of the Science Park, the implicit benefits of being part of a Science Park.

CSRV uses hardware and software technologies of a Californian company, EON Reality⁶³, which is a leader in the development and delivery of VR software and in the management of 3D interactive contents, having been working in this sector since 1999. The laboratory is part of a technological center called IDC Italy (Interactive Digital Center) and it is in the network of 18 different centers started by EON Reality all over the world. In particular, the IDC Italy is the reference point both for Italy and Switzerland.

The CSRV laboratory is equipped with any kind of virtual reality, stereoscopic⁶⁴ and immersive tools: a 3D movie concave theatre and a 4-wall immersive environment, also known as CAVE. Moreover, CSRV has 3D stereoscopic portable devices, such as computers and projectors, television sets, HMDs (Head Mounted Displays) and equipment for objects 3D scanning.

This innovative center is unique in Italy and open to industrial, design and educational projects and aims at attracting R&D from VR field for Immersive Virtuality application, in order to refine interaction possibilities (sound, touch, etc.) of a person within the virtual world. The laboratory offers a wide range of services for developing projects about different sectors: convert and optimize 3D formats, offer 3D modeling and rendering services, implement AR application thanks to EON Reality partnership, and VR application for any use or device, and generate customized interaction solutions for new control interfaces.

⁶² <http://www.csv.it/>.

⁶³ <http://www.eonreality.com/>.

⁶⁴ Which gives the illusion of depth perception (e.g. the 3D film Avatar).

My interest for the opportunities offered by this laboratory focuses on the involvement of the center in the research and educational sector to build 3D interactive solutions: the IDC collaborates with Italian schools and Universities.

Whatever the project, the purpose of VR technology is to improve communication, formative processes and planning. For example, the CSRV-IDC has developed the 3D rendering of the architectural masterplan for EXPO 2015 (see picture 4.4), and has presented the concept of the exhibition site during the International Participants Meeting⁶⁵ in Cernobbio (October 2011). CSRV has developed three applications: a real time rendering application, which allowed to follow in real time the contents of the speeches of the different representatives of Expo Direction during the meeting, an application on holographic screen for supporting the description of the project during face to face meetings, and an application on touch screens with simple interface for an autonomous exploration of the Expo 2015 exhibition site.

As a matter of fact, thanks to an intensive reuse of the developed 3D contents, the application created is one, but suited for different devices and aims. The most interesting aspect has been underlined by Arch. Matteo Gatto (Chief Architect - Infrastructure & Construction Direction – Expo 2015 S.p.A.): “I appreciated the opportunity of speaking without worrying about video progress time: the application behind my shoulders followed the rhythm of my words, while a virtual camera focused on the details of the masterplan I was presenting...”. The same freedom has been given to visitors, thanks to the touch screen and the interactive application, which could query the Expo 2015 project in complete freedom without the time and frame boundaries a video implies.



3D rendering of the master plan for EXPO 2015, on the left, conceived as in ancient Rome with “Cardo” and “Decumano”, on the right.



Picture 4.4 The master plan developed by CSRV

Thanks to Leo Miglio, full professor in physics of matter at University of Milano-Bicocca, I get in touch with Carlambrogio Chiodaroli, who is general manager at CSRV and we arrange a meeting⁶⁶, in order to discuss my research interests and their works in progress and to try the CAVE, an immersive virtual reality environment, whose first prototype was presented in 1993: it is a cube shape and it can be equipped from three to six high resolution rear-projection screens.

⁶⁵ <http://www.expo2015.org/press-area/press-releases/presentazione-della-prima-edizione-dell-international-participants-meeting>.

⁶⁶ In September 2011.

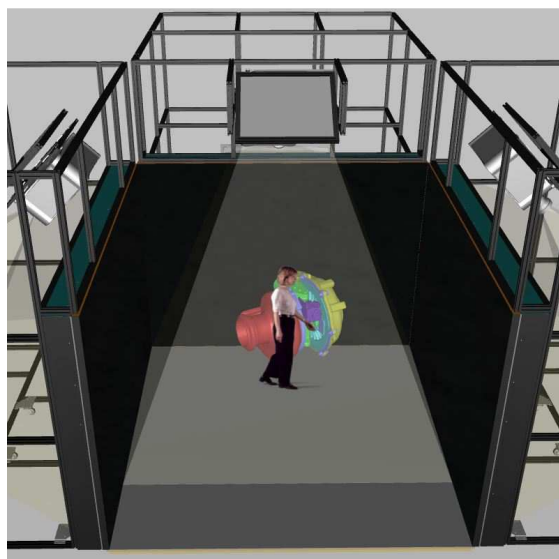
The Science and Technology Park was really big; after a while I entered a quite dark laboratory, equipped with the CAVE, a clear reference to the allegory of Plato's Cave, in his work "The Republic", where reflects upon perception, reality and illusion.

The Icube by EON Reality was composed by four screens: three for the walls and one for the floor, each sized 3x2,30 meters. The user within this environment has to wear special glasses to see 3D graphics generated by the CAVE: you can see objects floating in the air, walk around them, and they appear how if they were real. The glasses (see picture 4.5) are synchronized with the projectors, which are driven by one or more computers, so that each eye only sees the correct image.

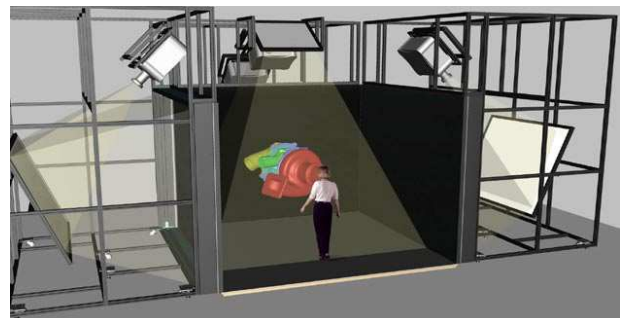


Picture 4.5 The 3D glasses and console

The movement and the position of the user inside a CAVE (see picture 4.6) are tracked by four infrared cameras and the video adjusts accordingly to the user's point of view, giving the impression of being within a real environment. Computers control both this video aspect and the audio: there are multiple speakers placed in different angles of the cube, providing 3D sound accordingly to the 3D video.



The structure of the CAVE with its rear-projection screens for the walls, on the right, and the down-projection screen for the floor, on the left. Since the projectors are positioned outside the cube, mirrors are often used to reduce the distance required from the projectors to the screens.



Picture 4.6 Space occupation of the Icube by EON Reality

Before experimenting the 3D animations within the CAVE, the general manager gave me information about present and future features of their CAVE. First of all, it was possible to upload in the CAVE animations activated with the available console (the one I tried during the visit), but after the release of Kinect, you will be able to activate animations and to interact with scenes only with hands' movements.

Another relevant aspect was the portability of the developed products to other devices available in the center (the holographic screen or the concave cinema of 8x2,6 meters), with little changes in the framerate, in order to adapt the scene to the technological support. In particular, there was also a portable CAVE, in which you had to give up using the floor screen of the cube (developed in collaboration with Panasonic).

One of the characteristics of the software EON was the easiness of use, also by non-programmers, thanks to the graphic interface; in case of a specific implementation (EON API are in C++), you could involve the development center of Singapore. Moreover, in the EON environment you could introduce some particular features or constraints: the flow of water, not allowing to walk through walls etc.), but for a user natural interaction the CSRV used other technologies, not by EON, to be developed by third party.

Considering all these possibilities I understood that EON wants to be the reference center for all VR declinations.

After this short introduction, Carlambrogio Chiodaroli put in my hand the console and I wore a pair of 3D glasses and protective felt babouches: the test of the Icube could start.

The first experience was inside a Bombardier Challenger 850 airplane, where everything was rebuilt in details: leather seats, briar tables, parquet floor (see picture 4.7).

The light could reflect on the surfaces and all the equipment seemed real, moreover, thanks to the 3D glasses, I could slant to look for something under the "virtual" tables and see coherently the perspective changes. Using the console controller I could walk inside the cockpit to understand obstructions in designing the equipment or change the different scenes of the cockpit (trying a wide range of materials and colors for the floor or the seats).



Picture 4.7 Interior design experience in a Bombardier (on the left) and the landscape from a castle (on the right)

During the second journey in the cube, I could visit a beautiful landscape in Portugal, rebuilt using a system of sceneries and levels of backgrounds (see picture 4.7). Consequently to user navigation, the system reacted showing the correct perspective.

Some of the tricks could be easily discovered in a bird's eye navigation, flying actually in the landscape, or zooming in to the smallest level of detail. This place, with its green hills, rural homes and the old walls and stairs of a castle had been rebuilt true to life.

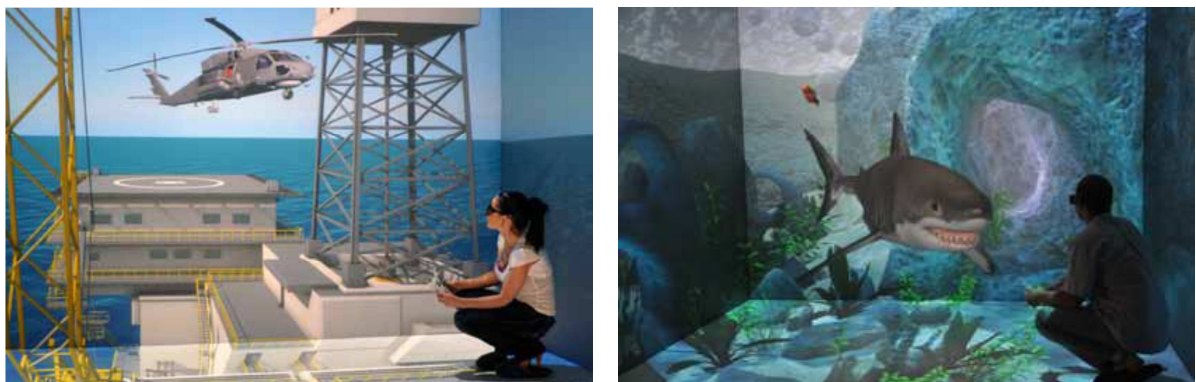
The third scene was in contrast with the second journey, in order to see the big differences between low quality and high quality rendering of an existent site. The one shown in this case, which was in America this time, offered a non-realistic user experience: the shadows were too sharp, the pictures of trees and natural elements were artificial and the overall effect was of an "imitation" of the real world.

The next experience I'm going to describe, has been the most interesting and the one that make me feel the power and the possibilities of this technological environment: I was inside the earth's crust, like in "A Journey to the Center of the Earth" by Jules Verne. I could walk beside the crust, discovering different materials and sediments, which could be labeled and described, maybe through sticky notes, in order to explain temperatures and other parameters of the different layers. I had loved this subject during my past scholastic studies, but having the opportunity to "enter" physically and mentally in the subject, instead of watching pictures or videos, was a completely different experience.

The last experiment, inside the cube was the most unpredictable: I was standing in the middle of the cube's floor without the console, because the user's point of view had been fixed once and for all. A 3D video of a ride on the roller coaster started in the cube and if the first impression was "Gosh! I've never done that..", then I was amazed by the strange effect of having a "real" ride on the roller coaster, without feeling dizzy or having my stomach upside-down.

Even if this final experience was the most similar to 3D films, the effect was stimulating my imagination, thinking that Virtual Learning Environments, particularly the most immersive ones, can offer the opportunity to try that experiences which are impossible in real life and repeating them, every time you need.

Last but not least, immersive virtual reality allows great effectiveness of courses (see picture 4.8), both in immersive and simulated points of view: it is possible to simulate repeated danger conditions in complete safety (e.g. training for security protocol of plants maintenance, evacuation procedures and so on).



Picture 4.8 Training on an oil-plant (on the left) and 3D immersive learning opportunities (on the right)

Beyond the animations I tried personally, the possibilities are really infinite: this immersive environment can be used to win personal fears or even to treat mental disorders with a virtual physiotherapy, conducted in safe conditions. The CSRV develops 3D handbooks to try assembly and disassembly of complicated devices, check and validate prototypes, products or internal layout of planes, boats, showrooms before their implementation, in order to choose features (materials, colors, lights).

I am convinced that today this is a powerful environment for representing situations and data both for research and for learning, but the only big limitation I found was the fact that a CAVE-as it was-limits interaction to one user at a time, because this system can recognize the position of one pair of glasses at a time; the other spectators see double. This happens because the system is not passive as 3D films, where the animations are built once for all, but it is always active, tracking position and movements of the user and adapting accordingly vision and sounds.

Actually, other projects⁶⁷ are exploiting similar technologies, demonstrating how social capital can be enforced by emerging technologies offering new collaborating opportunities across countries and specialized disciplines.

For instance, within the project “3D Digging at Catalhoyuk”, Professor Maurizio Forte and other researchers of School of Social Sciences, Humanities and Arts at University of California at Merced have developed a collaborative virtual environment for real-time interaction with 3D objects in archaeology⁶⁸. Users, represented as avatars, can exploit tele-immersion technology, including 3D laser scanning, remote sensing, global positioning systems (GPS), geographic information systems (GIS), photogrammetry, and computer modeling to collect and document data on significant cultural heritage sites. Virtual reconstructions integrate the complex layers of archaeological, historical, and cultural data and provide the tools to visualize, analyze, and test hypotheses on the data, sharing the immersive experience across different disciplines and countries.

Another interesting installations, combining real and virtual elements, are the Enhanced Reality Labs, called e-Real, of LKN⁶⁹ (Logos Knowledge Network GmbH, Bern – Switzerland), which propose a fully-immersive and multitasking environment, to experience challenging situations in a group setting, with peers, thematic experts, both on site and remotely.

The e-Real environment immerses the attendees into an “augmented” reality where real life situations can be really lived, not only simulated, and the necessary lessons learned without the disadvantage of a negative impact in case of mistakes. In real time they can have a complete overview of a case, access relevant information, take a look at professional literature, and consult strategic guidelines. The most interesting features are the possibility of natural interaction to access holograms, 3D Visualizations and real-time talks with experts (see picture 4.9).

⁶⁷ Known during an informal discussion with Federico Pedrocchi, science journalist, director of Moebius – Radio24 – Il Sole 24 Ore and of Triwù, a web TV on innovation (21st of February 2012).

⁶⁸ <http://tele-immersion.citris-uc.org/cyberarchaeology>.

⁶⁹ <http://www.logosnet.org/english/index.html>.

All these technological examples, fostering knowledge creation and sharing, underline what Antonio Casilli, an expert in digital culture, argues in an interview (Gambaro, 2012):

More than within the dichotomy between real space and virtual space, today we all live in a mixed reality, that we can define an augmented reality, where the real is augmented, amplified and transformed by virtuality. [...] Computer science is an extension of past mnemonic technics, which were not devoted to empty our brain, but to make it more effective. Computers should be considered as a memory extension and not as a threat to cognitive capabilities. The informatics universe is a sort of cognitive and social extension that allows a wide number of relationships.



Picture 4.9 e-REAL installation within the American University in the Emirates⁷⁰

More complicated but fascinating issues about this and similar new research opportunities have to be tackled, but the actual scenario within the world of research underlines how knowledge, both materialized into new digital products or into new research practices and paradigms, is circulating within the research community, promoting new bottom-up participatory approaches and changing conventional schemas and processes.

⁷⁰ Image courtesy of Dr. Fernando Salvetti, founder of LKN.

Chapter 5. Rethinking authorship and readership

In the ongoing process of “disappearing computer” into everyday objects and tools, the technology has enveloped hardbacks and paperbacks, novels and newspapers, comics and magazines: we started to read “digital” also what was born paper. Paper books and the like are going to be replaced by technological instruments: rethinking the roles of writers, publishers, readers and librarians will become a necessity.

The chapter will explore the possibilities offered by the diffusion of e-books, as new tools for ubiquitous knowledge, opening a discussion about the future of reading and writing connected both to the traditional paper book and to his new technological descendants (e.g., e-readers, tablets).

5.1 Electronic books, augmented books and hypermediation

For many years, the e-books market has been considered with a high level of skepticism because of the false starts and the overlap of e-books with e-content. Firstly, there were only a few titles available, secondly the content was most of the time very low-quality. With the growth in the number of titles and of available publications and languages, the rise of e-books market could really start. Moreover, in their initial phase, e-books, but also e-content and e-learning, have not been fully understood as a more effective approach than the traditional one (Sangiorgi & Merlo, 2006).

The concrete possibility of plagiarize and the perception of risks connected to the diffusion of digitalized books have slowed down the diffusion curve of these devices.

At the beginning of the new millennium, the generalized diffusion of e-books seemed at the gate and only 2 or 3 years later, electronic books were only one of the big flops for the IT market (Sangiorgi & Merlo, 2006). After other 2 years and the interest for electronic books raised again. Without considering trends of the moment, the diffusion of reading within a digital environment was constantly increasing.

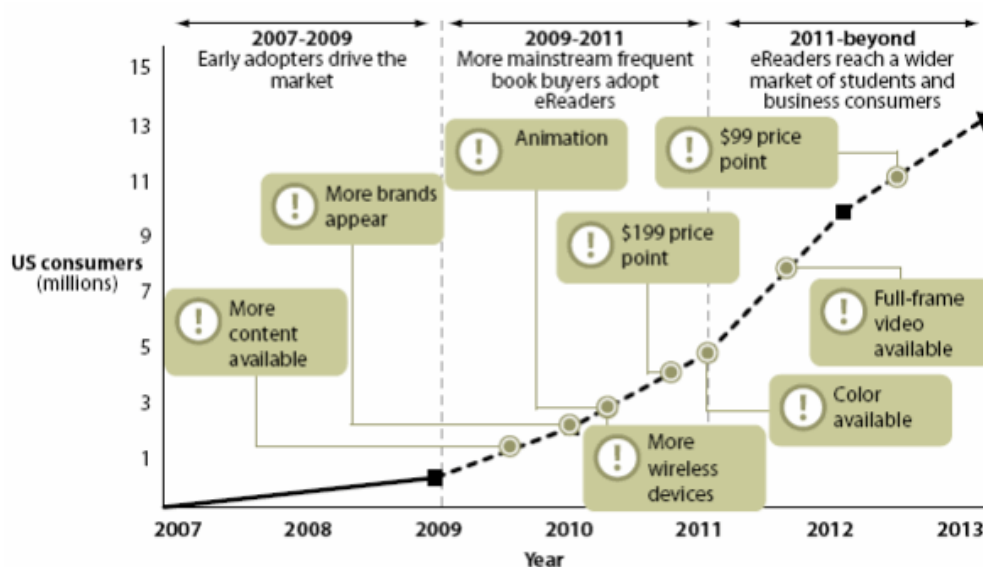
During 2011 Amazon, the biggest US-based multinational electronic commerce company, has claimed that e-books sales had overcome the printed books one: this overtaking is not related only to hardbacks or to paperbacks, but to all of them.

J. Bezos, the inventor of Kindle, commented on this note that he was astonished, because it had happened so quickly. The quantity issue is not only referred to the number of e-books,

but having a look to some analysis it is really interesting to discover that 790 thousands of books out of 950 thousands cost less than 9.99 \$ (Granieri, 2011).

The reason of that growth is that the first uncomfortable interfaces have been replaced by new ones, but most of all, the convenience of the electronic reading environment compensate for the effort of reading on a screen. The fact that e-books have been considered for a long time as not reliable sources also in the research field has been now supplanted by the conviction that e-books are proper instruments for study and research.

As a matter of fact, today libraries and universities are in frontline in the acquisition of complete digitalized catalogues of electronic books and journals and the diffusion of devices (e.g. e-Readers) is constantly growing⁷¹ (see picture 5.1).



Picture 5.1 Drivers of growth for e-Readers in the US

Despite this tendency, the evolution of e-books thanks to Information Technology has not developed in one dimension, but we can recognize three different streams: the digitalization stream, the augmentation and the hypermediation.

Considering the *digitalization* stream, after the invention of typography in the XV century, a new information technology for that time, the first development concerning books is the concept of the electronic paper, which can be derived by electrophoresis studies in 1969 for Matsushita displays and was developed in 1970 by N. Sheridan within Xerox PARC (Palo Alto Research Center) in the US. In this electronic paper prototype, called Gyricon, millions of small two-color spheres (half black and half white), were charged of static electricity and each of them was contained into a microcapsule full of liquid. The static equilibrium of the spheres was perturbed by an electric field that, giving electricity, made them turn opportunely to the white or the black side, in order to compose and visualize the text (Eletti & Cecconi, 2008).

The first advantage is that the electric power is used only to view the text, which is fixed until you change page, so you do not need continuous refresh as in LCDs; the second one is

⁷¹ Source: Forrester Research, Inc.

that you use the same electronic or “Smart” (by Xerox) paper sheet for millions of pages, if you compare it to traditional paper pages; the third one comes from plastic lightness and flexibility, thanks to organic polymers. Last but not least Smart paper can solve also reflection problems, because with direct light, it restitutes light as paper does, moving the reading experience closer to the traditional one.

In 1998 J. Jacobson invented an electronic ink, the e-ink, which is composed by millions of microcapsule, each containing a certain quantity of white particles, with positive charge, immersed in a dark liquid. The real difference with Sheridan’s invention is that the color perception in Jacobson’s prototype is given by the dark liquid and not by the dark particles.

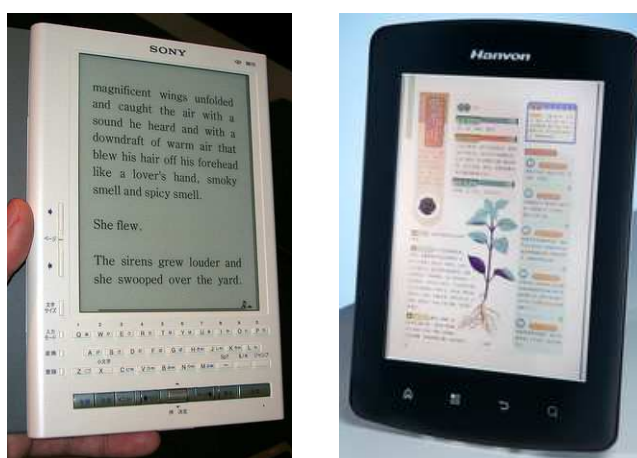
The physical behavior of the liquid and its fluidity are similar to print-ink, so the white particles have the function to define the white background, thanks to the same voltage mechanism.

In 2000 E-Ink, founded by Jacobson, and Lucent showed the first flexible display, using an evolution of the e-ink; the content of the small microsphere was changed: they contained particles, half white and half black, with positive and negative charged respectively, suspended in a transparent liquid. The image was composed by the same particles that rotated up and down, depending on the electric field applied.

From 2004 this proprietary material was used by E-Ink for the production of Electronic Paper Display (EDP), which are flexible electric papers, with the same Gyricon characteristics, while in the same year, in Japan, Sony launched the first hardware for e-books, equipped with electronic paper: LIBRIÉ (see picture 5.2, left).

Actually, if we compare black and white e-books with colored tablets, the first type seems out-fashioned: in 2010 Hanvon Technology, the largest seller of e-readers in China, announced to sell a color display using technology from E-Ink⁷², and not LCDs like for Apple iPad and Barnes&Noble color Nook.

E-Ink screens have two advantages over LCD: they use far less battery power and they are readable in the glare of direct sunlight⁷³. To create the color image, E-Ink uses its standard black-and-white display overlaid with a color filter (see picture 5.2, right).



Picture 5.2 From black and white (Sony Librié) to colored e-ink (Hanvon)

⁷² bought by Prime View Holdings of Taiwan in 2009 and was recently renamed E-Ink Holdings.

⁷³ http://www.nytimes.com/2010/11/08/technology/08ink.html?_r=1&.

Although more recent innovation involving devices and e-ink technology are now available (Park, Lee, & Casalegno, 2010),

the digitalized book transforms the two-dimensional pages of the paper book into the two-dimensional electronic book. There is no dimension added to e-book.

The second stream of innovation for traditional books concerns *augmentation*: the evolution of paper books to augmented books. Augmenting a book experience can be obtained by adding some dimensions or functionalities to the traditional book or electronic book. Augmented book is an instance of Augmented Reality (Park et al., 2010). Many researches on augmented books are augmenting the paper books into 3D screens, so augmenting a book is a first step in the hypermediation process.

Actually, there are several reasons that people still prefer paper books: physical presence, possession, and the high quality of printed material. But AR books integrate the advantages of paper books with digital content, so users can experience both analog aesthetic emotions and immersive digital multisensory feedback. It is now clear the potential and usability of AR books as new generation media. Several implementations of AR books were created for education, storytelling, simulation, game, and artwork purposes.

So, the augmented book introduces a new way of consuming books: while reading a book, the human reader recognizes the invisible codes coated on each page with, for instance, an optical pen and enjoys the relevant multimedia content, or scanning by the PC camera tags drawn on the augmented book page to reveal new contents.

In this case, Augmented Reality visually provides additional and meaningful virtual information about a practically observed object in a current situation. On the contrary, in a Virtual Reality-based experience environment (e.g. within a CAVE), all scenes are represented to the user as virtual objects in a specific computing space (see par. 4.5).

In order to give an idea of how augmented books work, we are going to describe the Digilog book⁷⁴ which offers, like related AR books⁷⁵, an augmented paper book that provides digitized visual, auditory, and haptic feedback, using Augmented Reality technologies (T. Ha, Lee, & Woo, 2010).

The Digilog book presents a “temple bell experience”, that explains Asian cultural heritage to users in a way that a conventional book cannot, with the following significant characteristics: the book is equipped with AR content descriptions for updatable multisensory AR contents through the internet; it enhances experience with multisensory feedback, adding vibration feedback to visual and audio feedbacks via a 3D manipulation tool; it offers an input method for natural interaction with AR content, requiring only the user’s hands.

The Digilog Book consists of a conventional printed book, multimedia content, and a Digilog Book viewer that acquires images of the printed book from a camera (see picture 5.3), fixed on the same table, and augments the multimedia content in the book.

⁷⁴ <http://www.youtube.com/watch?v=TC7KHuuGUhk>.

⁷⁵ <http://www.youtube.com/watch?v=pLciqISv0ec&feature=relmfu>.

The camera view faced the book, so that the entire book area was contained within the camera's viewing angle.



Picture 5.3 Display, printed book, manipulation tool and camera

Users can rotate and observe a virtual temple bell, pointing to facets of the temple bell to play multimedia documents, or hear a tolling bell and sense a vibration feedback, by tapping the 3D bell model with a manipulation tool, or by covering three types of virtual buttons on the book with their fingers: users can simultaneously see, hear, and physically sense the augmented content from the paper book.

White spheres are augmented on specific parts of the temple bell model, and these provide visual annotations to indicate areas that contain information about the bell, including figures, texts, and video clips (see picture 5.4, on the left).

A cylindrical wooden model is selected and moved to the temple bell model with the manipulation tool. When the wooden model collides with the bell model, a bell sound is played (see picture 5.4, on the right).



Picture 5.4 Interaction possibilities with the manipulation tool or covering virtual buttons

The third dimension is *hypermediation*, hyperlinking from one media to another media. For example, instead of embedding the computer display into the newspaper, the user may read an URL of a video on the newspaper with a mobile device, such as mobile phone, and watch the video through the screen of the mobile phone: this already is happening using smartphones scanning QR-codes printed on traditional magazines and newspapers.

An interesting example of hypermediation mixes traditional libraries of paper books with smartphones and Augmented Reality.

The Android App “ShelvAR” installed on a tablet, exploiting its camera and small printed QR-code-like tags on book spines, can show at a glance when books are out of order on a shelf, and where they should be moved (see picture 5.5).

This AR application for shelf-reading and inventory management has been developed by the Miami University Augmented Reality Research Group and is currently under research experiment with human subjects⁷⁶.



Picture 5.5 The ShelvAR App shows a book out of order, thanks to QR-codes

So, all published material can look with interest at the Ubiquitous Computing domain: the ubiquitous computerization of media is not just a digitalization of existing media but the embedding of computing elements into the real world media.

Moreover, our ubiquitous society can be envisioned as a society with media-embedded product, media embedded place, and commerce-embedded media.

Another interesting aspect of hypermediation is related to closed links and open links available within digital books. The first versions of Amazon’s Kindle did not allow readers to enjoy most of the external links in the web, but only gave some internal links such as a dictionary. The first generation of Apple I-Pad had both Wi-Fi and 3G connection and the hypermediating capabilities were different.

Even if electronic books can be classified using the proposed three dimensions, it should not be considered as exhaustive: authorship and other features could enrich this first classification, like open/close, space/time, or static/dynamic.

For the sake of clarity, in the following paragraph, descriptions and reflections on electronic books will refer to the digitalized version, as the most common acceptance.

⁷⁶ <http://www.shelvar.com>.

5.2 Defining the E-book identity

We have seen that the term “electronic book” is connected to something more than the simple reading in an electronic environment. The most relevant difference is in the association with the term “book”, that is, for our cultural tradition, the medium par excellence for knowledge transmission. An electronic book is not only a simple electronic text, as well as a book is not a simple text. Defining what is an electronic book, sometimes the accent is posed on the digitalized content, and other times on the union of the digital content and of the electronic devices designed for the reading; in some cases on the exploration of the peculiar multimedia and interaction features, in others on the reference to the Web as privileged distribution channel.

Summarizing, defining e-books implies a wide acceptance of the term, attributing the label of electronic book to (Sangiorgi & Merlo, 2006):

Any complete text, organic and sufficiently long (monography), eventually adding descriptive metadata, and available in whatever electronic format, that allows network supply and the reading on hardware devices, dedicated or not.

Considering what above mentioned, there are no boundaries for reading devices or software tools for the access to the texts. Apparently, also a document written with any word processor or a normal web page could be considered as electronic books, provided that they are sufficiently long and concluded.

In clear contrast with this positions, there is a minority point of view: people that reject the idea of electronic book, considering it an oxymoron and defending the thesis for which only a printed book can be legitimately said “book”. Underlining that e-books are quite a different thing in respect to printed ones, traditional publishing tries to preserve an own autonomous space and not reducible.

Maybe the truth is in the medium of the two extremist positions: the idea is that practices and theoretic models of five centuries of book culture should not be forget or abandoned, but also it is something changeable, in continuous evolution – taking unpredictable and new shapes – even in the digital media era. This two opposite theories can be identified as “the thesis of the ubiquity of e-book in the electronic environment” and “the thesis of the radical heterogeneity of printed book and digital media”.

A new definition of e-book, that takes into account also the pragmatic dimension of the interface and reading modalities can be suggested (Sangiorgi & Merlo, 2006):

An electronic book can be an electronic text, reasonably wide, concluded and homogenous, conveniently codified and with descriptive metadata, accessible through a hardware device and a software interface that allows an easy and comfortable reading (so comfortable as to not miss the book and to not arise the necessity of printing on paper what you are reading on the screen) in all the situation we are used to read printed books: in an armchair, on the bed, during travels, etc.

Considering the relationship between book and e-book, the physical representation of the book is one of the strategic nodes for remediation. The e-book is a new medium, a synthesis among computer science, Web and books, and is only in a first phase of that hypermediation stream, considered in the previous paragraph.

In the paper book the text is indistinguishable from the support and the e-book is following this immediacy, but it is necessary to understand if e-books have sufficient potential to assume an own identity. Also the simple fact that e-books do not need refresh is to establish a sort of continuity with traditional books, offering the same look and feel.

Electronic books have also different objectives, for example the integration of Web textuality, that readers are used to, within linear textuality, influenced by paper interface, symbolic of the “book culture”. So, one of the first goals of e-books is to provide digital citizenship also to linear texts, as novels and essays of a certain length, which we do not get used to reading and to thinking about, outside reading them printed on paper.

Nowadays nobody can imagine a book as a “Latin volumen” or a “medieval codex”, but even if expressing their novelty, electronic books do not want to reject their paper progenitors.

Moreover, e-books *hypermediality*, in the sense of non-linear medium of information, can give the opportunity of “inferential walks” (Eco, 2011), when the reader leaves the text to venture guesses that can probably satisfy the story of the book.

We can find the first example of hyperfiction, that is hypertextual narrative, in the ‘80s: it is “Afternoon” by M. Joyce: it is a novel which does not offer to the reader a global view of its structure, but can be read only in an explorative way, through 978 hypertextual links and 545 nodes⁷⁷. Today, the market of interactive novels is becoming more and more sophisticated, like in the novel “Locusta temporis” (2012) by Enrico Colombini, an Italian pioneer of Interactive Fiction (Racheli, 2012), starting with “Avventura nel castello” in 1983. In this case interaction, personalization and “gamification” become key features of a textual adventure, which is an e-book and also an App for iPad.

Considering the above mentioned “querelle” about the death of the book, between “digitals” and “bibliophiles”, nobody has really considered the issue of the evolution of book culture, in a situation of overtaking and conservation. Sometimes the e-book seems useful only for some literal genre, especially for bibliophiles the problem of the affective dimension loss has not been solved yet, considering that the book is a hot medium (McLuhan, 1994).

Focusing on the production level, printing-on-demand practices of e-books can be considered as the actualization of a virtual text⁷⁸ (Levy, 1998), while in the Japanese market the merging of e-books and smartphones has created a new content genre, suitable for the medium: the mobile phone novels. So, it is quite clear that the development and the use of e-books will be more widespread in some states, like China, Japan and South Korea, where the market should trigger its novelties.

The matter to resolve concerns not so much the question of whether the paper book will survive the e-book, or hypertextual arrangements that move on from the fixed nature of linear writing.

⁷⁷ <http://www.parolata.it/Letterarie/Iperromanzo/IperAfternoon.htm>.

⁷⁸ In “Becoming Virtual: Reality in the Digital Age”, Plenum Trade, pp. 207.

The wider question is: “will we abandon the cognitive aspects linked to the learning of writing (and also reading), conserving only the capacity to listen?” (Pozzi, 2011).

We do not think so, because there is also a fetish value associated with the book, connected to representations of the present day as a transitional era between the modern civilization of the book and the post-modern civilization of the digitalized book. We have to reconstruct the meaning of the book today, even if the object is placed next to an e-book reader, an iPad or other multi-media devices.

There is a *symbolic meaning* attributed to the fact of leaving a mark of one’s own presence on the paper book: a man creates a private relationship with the book and this relationship becomes so strong and meaningful that the object begins to be defined as a “confidant”, “silent friend”, “travelling companion” and almost anthropomorphized in certain human qualities. It would be a great improvement if this personal relationship could raise also with an e-book.

So, the book has been progressively deconsecrated through the process of modernity: now the access to collections of thousands of books are available to each single man, and, using a e-reader, they are in his hands, actually.

Today the object book still requires forms of behavior and care reserved for sacred (better non violable, individual) objects, while none of this occurs with the new media. It seems that the medium allows the passage from neutral object to fetish (Pozzi, 2011).

It is a medium that involves different senses: in addition to sight, touch (up to now the feel of paper has not been emulated by the materiality of the touch screen), smell (the odor of ink or of new/old/dusty paper) and, last but not least, hearing are vital elements of the intimate relationship that is created with the object.

All of the people involved in a research on the use of e-books (Pozzi, 2011) envisage a near future in which different media – paper and others – will coexist. This thought can be derived from the following issues: firstly, sensory aspects that the paper book allows us to experience and the corporeity involved in its enjoyment are elements useful to creating profound experiences in the practice of study (scholastic and individual), in contrast with the demand for and offer of speed and superficiality in the collection and diffusion of information imposed by society today; secondly, none of the existing digital media appears capable of superseding paper as far as sight, touch and smell are concerned; finally, taking note that, at present, the promise of the sensory reproducibility of paper is a disastrous falsification, it is believed that the new objects can already (and certainly will do so in the future) coexist alongside the traditional book.

The new devices will have a meaning only if they become promoters of *different experiential modes*, because, from the above research, everything is limited to rational usage of these new technologies; perhaps their use and diffusion have not reached a maturity status. Moreover, when reasoning about the new devices and the future they may delineate, almost nobody identifies the e-book as ‘the’ device to use.

To be more precise, despite the fact that it has not yet been exploited to its full potential, in some ways it is already considered almost ‘old’, quickly surpassed, replaced by something even more innovative in terms of new models of practicing reading and writing (e.g. “augmented” reading). The e-book fails to convince precisely because it attempts to emulate the scheme of traditional writing: rigid and linear. It does not convince simply because of its promise to resemble the paper book as closely as possible.

New reticular, hypertextual forms, in which the reader articulates his own path, would be more desirable: a new name is needed for new things. It is not only a question of definitions, but our collective imagination will have to paint itself a new picture, a new representation.

Not only is the technique changing, but at the same time the new representations deriving from anthropological changes in the practice of reading and writing will characterize the change. It would imply full entrance into a future in which forms providing a cross between oral communication and writing (forms that must still be imagined) will be not only a mark of the new medium but also the transformation of its substance.

Today the new multimedia devices give form to paths of meaning that are not exhausted in the practice of traditional reading (see par. 5.3) but proceed through the exploitation of video, images, voices and music available to download elsewhere: connected to each other, but not in a univocal way.

We have seen that most of people are sure that reading a paper book is an unique pleasure and maybe we should think to something really different when we have in our hands e-readers, smartphones, iPhones and iPads, that allow new communicative possibilities. Maybe reading the longest novels on a smartphone is not the best way to exploit interactive opportunities of these new tools and devices. Thanks to e-books we can experiment new creative expressions, imagine a new way of telling stories, of involving the reader, of playing, explaining and informing. But the key point is not to do something “more”, but something different (see table 5.1).

E-books have another shape, but also a different genre of informative architecture and of communicative modalities, enabled by particular features of the digital text readers.

Hypertexts, links, bookmarks	<ul style="list-style-type: none"> •correlate different texts/authors •target information to reader's interest •insert extensive deepenings •allow also sequential reading
Update and updatable	<ul style="list-style-type: none"> •integrate text in real time •highlight past events •follow the news
Multi-user and multi-author	<ul style="list-style-type: none"> •integrate different writings and styles •make comparisons and correlations among different speakers
Rapid	<ul style="list-style-type: none"> •have limited elaboration time •are available in few minutes •use web channel for diffusion
Inexpensive	<ul style="list-style-type: none"> •lower printing costs •cut down distribution charge
Environmentally friendly	<ul style="list-style-type: none"> •save paper for immediate consultation •are useful for proceedings and documentation

Table 5.1 E-books informative architecture

5.3 Technological opportunities and limitations

After considering and reflecting on old and new meanings of the digitalized book, there are some key aspects, which, starting from technical features and possibilities offered by the e-book itself, have opened a kaleidoscope of possibilities, changing the way writers, publisher and readers think about their activities and roles.

If we think to authors, the change does not regard only expressive means, offered by e-books (or augmented); the author is not only the creator of a new title, but, thanks to self-publishing opportunities, the writer can be the *deus-ex-machina* of the entire process: from writing to publishing and advertising her/his work.

The Guardian reports that self-publishing, from being the last chance, is now a concrete writing trend: the British author best known as the creator of the “Harry Potter” fantasy series has announced that is going to auto-publish her e-books, with a lot of extra contents. The cultural setting is even more interesting considering that Amazon self-publishing platform is attracting authors, like John Locke, who has reached the goal of 7-figure sells.

Taking into account these so rapid changes, publishing houses seem really on the chaos margin; this concept, developed by Crichton in “The Lost World”, one of his famous novels and that comes from complex systems theories, explains that the chaos margin is a conflict zone where the old and the new collide continuously. The actual solution may be striking the balance between the need of order and the tendency to change (Granieri, 2011).

Tightly connected to self-publishing there is the print-on-demand issue, which allow to each of us to start auto-publishing our works without particular investments, because only the copies which are effectively ordered have to be print.

The changes within the *authorship* dimension does not affect only publishers, but involve also designers in the book creation process. This is particularly clear if we think to the new enhanced possibilities offered by Augmented Reality on tablets, as it has been proposed within the project for the 4th year “Enhanced E-book Design” class at Emily Carr University of Art + Design, Canada (Martin & Aitken, 2012).

Designers’ role is changing in shaping meaning and content, affecting existing paradigms of authorship: a co-authoring approach emerges between designers and writers. Actually, in a very initial phase of a new technological development, old patterns have been mapped onto new media. In this case, e-books function largely like traditional print books, with the concept of discrete pages, of a linear narrative and a static interface.

But if the hardback of a story is a tablet, with its video, animations, kinetic typography, hyperlinks, geo-location and social interaction, maybe we need to rethink the nature of a book itself. We have seen that a story can be assimilated to a computer game, losing a linear narrative or can be presented in layers, allowing tangential exploration of one topic before proceeding to another.

At this moment, researchers (and also the public) are convinced that (Martin & Aitken, 2012):

The separation lines between e-books, webpages and tablet applications are also difficult to establish.

E-books require a level of processing of textual and image content that form a *specific experience* and considering the expectations of the users. In e-book applications the designer re-conceives the content as an experiential space that becomes part of the content, extending the writing. Enhanced e-book applications allow for a long list of activities of consumption, sharing and production of content, and it is through this close collaboration and co-authorship between designers, writers and other content generators that the writing can be re-contextualized for this interactive and participatory space.

This project of “Enhanced E-book Design” witnesses how the semantics associated with any use of the word “book” brings with it a host of preconceptions, biases and assumptions. Several books produced within the project use traditional “pages”, most has some forms of navigation system that while not essentially linear, encourage a linear exploration.

One of the augmented book produced, “How images think” by Ron Burnett, encourages “vertically” *exploration* rather than linearly (see picture 5.6, left). You can navigate easily by swiping to find an area of interest, then using a 2-finger “pinch and zoom” gesture to explore deeper into that area. Random exploration is encouraged and a map is created tracking connections between ideas. Two significant ideas of book emerge during a parsing, tagging and re-contextualization of the text: the book as a “sandbox” and as “occasion” of a series of participatory and productive activities, which included, of course, reading but also annotating, searching, sharing with other participants and including the participant’s own content in the form of images from their tablet photo stream and their commentary.



Picture 5.6 The concept of “How images think” (left) and “Bhangra.me” (right)

In another augmented book, “Bhangra.me”, the idea is of recreating the exhibition as an e-book (see picture 5.6, right). However, the exhibition itself was highly engaging and interactive. Viewers could play the drums or listen to music, add stories and locations, and explore a culture through objects, sounds and videos. A “drum” allowed experiments with sound: participants could record their creations and share them with other users. In this e-book particularly, the designers have shaped meaning through careful consideration of the user experience. As the exhibition itself, meaning has to emerge from *immersing the participant* in the Bhangra culture, not simply describing it textually.

This project in its whole shows the potential and need for designers to intervene as “imagineers” of new modes of being for the book in tablets. The movement between the text and other media “reframes” textuality. We can no longer see the e-book as a copy or translation of the print book to a screen-based realm but a completely new and transformed space the designer has co-authored.

If we reflect on previous examples, some functionalities, as the possibility of annotating text, underlining it, sending queries and explanations to another reader, sharing notes, rewriting them, make foresee a revival and a new organization of notes in the margin of texts.

From *personalization* to *socialization*, there is a new model of text, shared but highly personalized, which in a certain sense recalls Medieval glosses. Glosses were notes in the margin of a text, for its comprehension. In the XII century, the work of Irnerius, founder of the “Four Doctors of Bologna” based in the University of Bologna, culminated in the Great Gloss, compiled by Accursius (De Maurissens, 2011).

In the XVIII century we found marginalia by Voltaire, who possessed a wide library of 6 thousands books, with annotations, signs, studied today. Thinking to new e-books, new specific methods will develop for modern reading devices. Considering didactics and learning, Vygotsky theories of “zone of proximal development” could be applied to annotations. Notes are like extensions and internalizations, personalizations of a codified knowledge (the text) and so could be situated in the zones of proximal development described by Vygotsky⁷⁹. Specifying, annotating, interpreting stand for personalizing, appropriating a general knowledge, and comparing with the community. The most popular notes will reach the role of Irnerius’s glosses in the past, as interpret and mediator of social awareness of a knowledge always up-to-date and a tie between past and present (De Maurissens, 2011).

In this moment, different projects are developing (Book in Progress by ITIS Majorana, Brindisi; the experimentation on iPads by liceo Lussana, Bergamo) in order to put under discussion the model of didactical materials, which are often stiff and reflect a single point of view, a unique interpretation of reality. This projects stimulate teachers and pupils to co-produce e-books for specific subject matter, starting from the experience on everyday classroom activities. This is another point of view of the change in within authorship: the traditional receivers (recipients) of established knowledge (from teachers, through books) are becoming protagonists of knowledge production process.

In front of such openness, thinking to digitalized or augmented books, there is also the other side of the coin.

A relevant issue considering e-books are mechanisms of *standardizations*. Even if the actual .ePub extension, which has been developed by the IDPF (International Digital Publishing Forum), is a common open standard, it is not so easy to insert multimedia content. The components of a file .epub are basically two XML (eXtensible Markup Language) files: the content document, that is the text, and the package document, that is the logic structure. The problem is that these first IDPF specifications did not foresee the possibility of introducing multimedia contents, different from images.

⁷⁹ The concept has been developed further by Brown and Campione (1994), into a zone of multiple proximal development, considered as interaction not only with persons (adults or peers), but also with instruments (multimedia devices in general).

With the last release of ePub3⁸⁰ on October 11, 2011 by IDPF, some relevant limitations and problems of the previous version (2.0.1) have been solved. The integration with the language Javascript allows now the introduction of multimedia content and the presence of links to dictionaries and external sites (e.g. social networks) will open new interaction possibilities. Moreover, the presence of metadata allows programmers and editors to describe e-books within catalogues and trace their changes. A new support for touchscreens and for math symbols and formulas will probably open new markets for e-books, such as their diffusion within schools. The synchronization of text with audio offer a better accessibility to people with visual impairments.

Concerning this, despite the E-book publishing industry is rapidly growing, new efforts should be done to allow everybody, the blind, for instance, to have full *accessibility* to electronic books.

As a matter of fact, industrial fabrication of tactile print books or Braille books is nowadays poor and their implementation is a challenging and slow manual process: each letter has to be translated into 6 contact points involving cutting, stapling and gluing plastic point labels on a paper. Coding even a small 5-page text becomes a titanic effort. Unfortunately, the resulting Braille book is burdensome and uncomfortable to hold and carry, once read it is less interesting and sometimes it does not last very long with enthusiastic use, especially by children.

During the last years, the Mechatronics and Control Systems Lab (MCS) at Pan American University (Mexico) has been developing systems which are able to provide blind subjects access to visual information by means of touch stimulation (Velazquez, Preza, & Hernandez, 2008).

One of these systems is the TactoBook, a novel assistive device that allows visually disabled and blind users to read practically any text document using a portable electronic refreshable Braille tactile display (see picture 5.7).



Picture 5.7 TactoBook with its Braille tactile display

This study propose a system that exploits the popularity of E-books by making them accessible to the blind.

⁸⁰ <http://idpf.org/epub/30>.

The TactoBook concept uses standard computational resources, translating an eBook to Braille code, and encrypted as a file and stored in a regular USB pen drive. This memory drive is then extracted from the computer and inserted into a compact, lightweight and highly-portable tactile display where the file is opened, processed and reproduced in a set of 10 Braille cells at a time. By touching the pins, the user is able to read the E-book.

Moreover, the TactoBook system intends to overcome the accessibility problems of tactile print books by offering a simple, fast and automatic translation to Braille, the possibility of multiple use (a wide number of eBooks can be stored and reproduced using the same device), while being robust and portable.

Beyond ePub specifications and first attempt to widen them to allow a more complete usability of e-books, the most significant conservative approach to digitalization of books is in some restrictive *Digital Rights Management* (DRM) policies, adopted by publish houses.

We should consider which is the behavior of the public towards difficulties and problems with DRM protections, to understand better how much copyright is going to influence e-book development. The key point is the “quantity” in controlling user’s activities, that is greater than copyright control for paper books. Therefore, DRM protection systems are not only able to block illegal actions, but can also deny ordinary actions like borrowing and sharing. Users’ attempts to escape from software rigidity give life to hacking actions, which are induced by DRM systems: “domestic hackers” overcome e-books protections only to use them as they want. Publishing must support legal alternatives to piracy, but DRM actually frustrates consumers, for a lot of technical incompatibilities, offering benefits to closed ecosystems, hurting independent retailers.

The DRM problem affects not only the way common users borrow and share digital books among them, but also the wide world of *digital lending*. In Italy, on the platform MediaLibraryOnLine⁸¹ (MLOL) different experiments on digital lending types have been conducted (Blasi, 2010):

In order to give an operational definition of digital lending we can consider whatever technological architecture that allows libraries to deliver – through the Internet and outside the library itself, at home, in offices, schools, in mobility – digital contents to reading devices (PCs, e-book devices based on e-ink, iPad and other tablets, iPhones and other smartphones) of the final user.

The relevant models for the consumer market and the library one are, respectively, the “atomic retail” and the institutional subscriptions. The access to content implies in the first case the downloading of the single e-book, in the second case the e-book is available in streaming.

Within the world of e-book distribution, there are three families of policies: the DRM, the Social DRM and the DRM Free, but all these modalities are not adequate to libraries market. The DRM linked to a specific platform, that is the impossibility of reproducing the e-book file beyond a certain number of devices, does not allow the library loan, which implies the reproducibility on unlimited devices belonging to the library or to the user.

⁸¹ www.medialibrary.it/home/home.aspx.

The Social DRM and the DRM Free are unsuitable because they generate the paradox for which, starting from a single file bought by the library, if the file is over the Internet for allowing the digital lending, then that single file can answer to the demand of the market within a certain territorial area for that content.

For this reason, within the library market, two protection modalities are widespread, being at the basis of all digital lending platform, that are successful on the market:

- the first modality is constituted by DRM strategies on single file download. When the user downloads the e-book (on her/his own PC or on an authenticated device, compatible with the Overdrive DRM), the lent copy is automatically eliminated from the availability for other users. With the download, after a precise period of time, the lent copy expires and the e-book cannot be used anymore;
- the second modality is the one of some operators⁸², which give only a streaming access to e-books. The user can look through the e-book only online and the control or manipulation of the text are not allowed.

The digital lending issue does not regard only e-books, but all the multimedia possibilities, which libraries have to tackle. From this point of view, public libraries have to manage the widest multimedia heterogeneity and complexity. Music, films, newspapers and journals, audiobooks, databases, learning objects and other kinds of products are part of the day-by-day loans, usually managed by public libraries: there is a marked tendency to a half-division between books and other multimedia products.

During an interview, Derrick De Kerckhove underlines the dramatic changes affecting knowledge in its whole (Masera, 2011):

Before it was electronic, the language of writing was silent, inner. Today we are producers of our orality, that is public, because is shared in the Net at speed light, using a language which is both inner and outer. Internet helps in finding everything and makes libraries outdated: the organization of knowledge has changed forever.

5.4 Discussing on E-books: two personal experiences

In the following I am going to offer an overview of reflections on books and e-book issues, during two International Conferences: the first one⁸³ took place on June 2011 within the international and interdisciplinary forum FOCUS 2011 with the title *The book tomorrow: the future of writing*; the second one⁸⁴, took place on February 2012, with the title *If Book Then Conference*.

The range of themes and contents discussed during these two event is really wide, thanks to the different roles represented by the various speakers, who were authors, publishers, readers, librarians, visually-impaired people, educators, teachers and lawyers from all over the world.

⁸² Ebrary, Casalini Libri and MediaLibraryOnLine in Italy.

⁸³ Seminar Title: "Pessimistic vs Optimistic", 6-6-2011, Villa Reale, Monza.

⁸⁴ If Book Then Conference, 2-2-2012, Milano.

Actually, I will concentrate on the most relevant issues, concerning authorship and publishing problems, access, sustainability and aspects of use of e-books, tendencies of the market and new business models.

Within the first Conference, the copyright issue has been at the core of the discussion. As a matter of fact, the copyright law was born in France, during the Age of Enlightenment, where the reward of the author was the symbol of the emancipation of the individual. Maurizio Melani, the moderator, claims that during the XIX and the XX century, authors were paid for the first release of their work and people were used to have libraries where knowledge was stored.

Today, we have to consider some issues: ordinary people write much more than before and we read also more; books are translated into other languages and we are witnessing the inflation of secrecy (with wikileaks as a natural explosion); portable devices market is exploding, with 10 billion of smartphones sold in Korea; our e-books are actual well-organized libraries full of titles, always update and updatable. How can we tackle the issue of remuneration and sustainability of writing?

First we have to consider both authors that live thanks to their work and are paid for that, and authors for which writing is a collateral activity. Even if Creative Commons offer the opportunity of a wider access to knowledge, but are we sure that CC protect the interest of that authors that live on one's work? Actually, Creative Commons are not free: they need search engines, machines, services, and it seems paradoxical that in the end the author is the only one that is not rewarded.

On the other hand, we cannot put under lock and key knowledge production and sharing. There are some problems to be tackled: reconsider the copyright term, understand how to share orphan works to the collectivity, in order to provide an equilibrium between culture and preservation. We should go beyond the misunderstanding that the copyright prevent knowledge access: copyright is only to protect the structure, not the knowledge.

Juan Carlos De Martin, expert in digital rights, underlines that making copies of a file is a way to share knowledge without loss, mentioning the peculiar character of an idea (T. Jefferson):

He who receives an idea from me receives [it] without lessening [me], as he who lights his [candle] at mine receives light without darkening me.

So, if for personal use the copy is only a “lighting candles process”, for wide sharing we have not to consider it as a theft. If it creates an economical problem, we have to re-think the social contract, towards one in which the State do not want to reward authors, adjusting the system and the terminology (without using the words “piracy” or “theft”). The copyright is not the unique solution, but we have to evaluate also other opportunities, with a “global patronage” attitude, maybe reformulating the Berne Convention for the Protection of Literary and Artistic Works⁸⁵ and updating it to a Berne 2.0 version, maybe with a register for copyrights as for patents office.

⁸⁵ Usually known as the Berne Convention, this is an international agreement governing copyright, which was first accepted in Bern, Switzerland, in 1886.

As a matter of fact, considering the account of Florence Devouard, Chair Emeritus of the Wikimedia Foundation, we can understand, for instance, that all the people that use Wikipedia do not have any knowledge about copyright and royalties, because there are so many kinds of licenses. Most of the time, people do not understand licenses and so they do not use them.

A provocative question raised from the auditory about protected and open access content: “What is the surplus value of protected contents? Some brilliant students reveal that they have never read a book, but they read everything is free and open. Some young persons have already the instruments for not taking into account the copyright issue, on which we are so much discussing”.

For some of the speakers we may adopt the United States copyright law “fair use”. In determining whether the use made of a work in any particular case is a fair use the factors to be considered shall include: the purpose and character of the use, including whether such use is of a commercial nature or is for nonprofit educational purposes; the nature of the copyrighted work; the amount and substantiality of the portion used in relation to the copyrighted work as a whole; and the effect of the use upon the potential market for or value of the copyrighted work.

With this suggestion the interests of professional writers seem underestimated, going towards a “fair use” law, because nowadays these authors are a minority, but also because the knowledge society pushes towards a “global conversation”, destroying barriers and not creating new ones. We should be open to new strategies and business models, that exploit internet potentialities and capabilities, like in Brazil, where young musicians upload their songs on the net, changing the vision of record labels. This does not mean that everything should become free, but that the whole system should change.

Last but not least, with the crisis of the publisher, a global publish environment is needed, where digital technology lead to the discovery of “books” and where the information society is not cut off by the previous one, underlines Sok-ghee Baek, from Korean Publishers Association (IPA).

Haruko Tsujita, specialist in digital publishing and robotics, highlights that in Japan, after the 2011 tsunami, e-books have been for some Japanese publishers and booksellers the only alternative, providing digital electric versions to subscribers in the areas where delivery was disrupted.

The position of Cristina Mussinelli, from the International Digital Publishing Forum, about the figure of the publisher is quite clear: considering that each reader has different needs, like a kindle is different from a smartphone, publishers have to restructure companies, changing the way of thinking their role, providing recommendations. In this ever-changing period, publishers should have an active role, speaking with readers, testing market segments with new tools or genres, and most of all having a positive attitude towards novelties.

For Riccardo Cavallero, Mondadori Group, things are more natural: publishers, whose mission is to disseminate cultural content, have to offer quality content, so users can decide; the work seems to be on the reader, not on the publisher. The private world of the reader in front of a book is maybe the key to understand the relationship between the individual and the page (digitalized or not).

The real problem is “who” is the user: in some developing countries, like in Africa, cheap e-books can diffuse more rapidly, but what about e-readers costs and electric power consumption? It is prohibitive, at least in the early phases.

Looking through the eyes of Boubacar Boris Diop, a writer from Senegal, there are other issues of the multifaceted problem of digital books: most of the families in Nigeria and Senegal stand out against the use of the internet and the electric power consumption for e-readers is a concrete barrier for these countries. Moreover, young people are devoted to paper books and the population is not fully inside the paper book era; it would be a great disillusion to think of bridging the gap with digital books. We have to mind the preexistent gap.

Maurizio Melani reminds us that if we think to environmental sustainability, shifting to e-reading seems to offer a reduction of the consumption of paper, but paper is much more biodegradable than the electronic components of the e-readers, which need also the electric power to work. Unfortunately, nobody has the whole picture. The key point is to understand how content can circulate without stopping creativity. It would be of basic importance both to shape and control events.

For Janet Murray, from Georgia Institute of Technology, instead of comparing old and new devices, in this case book and e-books, we have to bear in mind that there is not a moral hierarchy among these means, because each of them has its affordance. One of the relevant aspects to be considered is the deep pleasure of sharing with another human being and this sharing tension helps wisdom and knowledge.

In this sense e-books fulfill sharing and transmission problems, but they do not represent all the possible affordances of a write text, and this is in a certain sense frustrating. We can imagine the potential of movies, for example, but students study with books. Anyway, we have to think what knowledge to teach and rethink the functions of e-books, imagining new genres and representations, maybe like a book, a game or something else. Definitely, we have to think to knowledge in a different way.

Taking into account educational skills, Miguel Barrero, from Grupo Santillana de Ediciones, thinks that new creative competences should be stimulated. If we consider hypertexts, the reader chooses the path; if we use hypermedia (e.g. AR, videos), text loses its prominence, which is so present within traditional books (McLuhan, 1994). New media can be more productive than texts, but maybe we need new skills. Thinking about web literacy, it is also necessary to develop non-linear teaching strategies, with new materials in the curricula (see chap. 6). But how all this thing can affect writing?

This is the fun generation: people communicate more than ever, thinking to blogs, forums and wikis. In these new writing places you have to follow rules (to plan your text, to be correct, to understand relevance criteria towards a specific topic). These competences can be enriched by the web. Finally, new technologies can improve educational and academic performances, but there is lack of debate on objectives and targets of what kind of education can be reached with these new technologies (see chap.6).

Before of the written text, we enter a language. Is the comprehension of the language one of the basic skills or maybe we have reached a totally visual and auditory language? As a matter of fact the first novels were orally transmitted, but books, novels and poetries are not linear texts, but spatial ones.

We need the introduction of a new spatiality, taking into account some aboriginal languages, for which the concept of start and end does not exist. Linearity is a bad habit of western culture, underlines one of the participant.

We have seen that the most relevant aspect of this complex debate is that book carry values and they are not only for sale. Books carry both a cultural and commercial complexity, which should be a chance at a global level. This international and interdisciplinary forum, patronized by UNESCO, will try to propose a platform of professionals to discuss a sustainable approach for the future and to protect the world of books, considering both the book chain and the e-book chain.

Perhaps, the best way to foresee the future of books is to create it, with a cocktail of laws and licenses that can support the human creativity. Working in terms of R&D can be a solution for the development of an open and distributed data infrastructure, where all the information about copyright is easily accessible. We should go beyond the antinomy between open and protected, because openness and protection are not in opposition, considering authors' rights a solution, not a problem.

Moreover, authors need the presence of editors, to assess the quality of their works. If technology goes faster than laws and licenses, these should adapt and change, considering that Internet is in its infancy. In this background Creative Commons could offer a solution to contrast piracy and to respect authors and copyright. The principle of sharing one's works and knowledge is based on the fact that a lot of authors with CC license see their sales growing and also creativity grows in this way and self-sustains.

During the second event, the If Book Then Conference, involving writers, publishers and academics, it has been presented an overview of 2011 International Book Market, illustrating then some new interesting business models.

In Italy, US, UK and Australia, print book sales decline across all markets: Jonathan Nowell, President at Nielsen Book, underlines that Italy is the only country where the market of books grows of 4%, thanks to children books' sales.

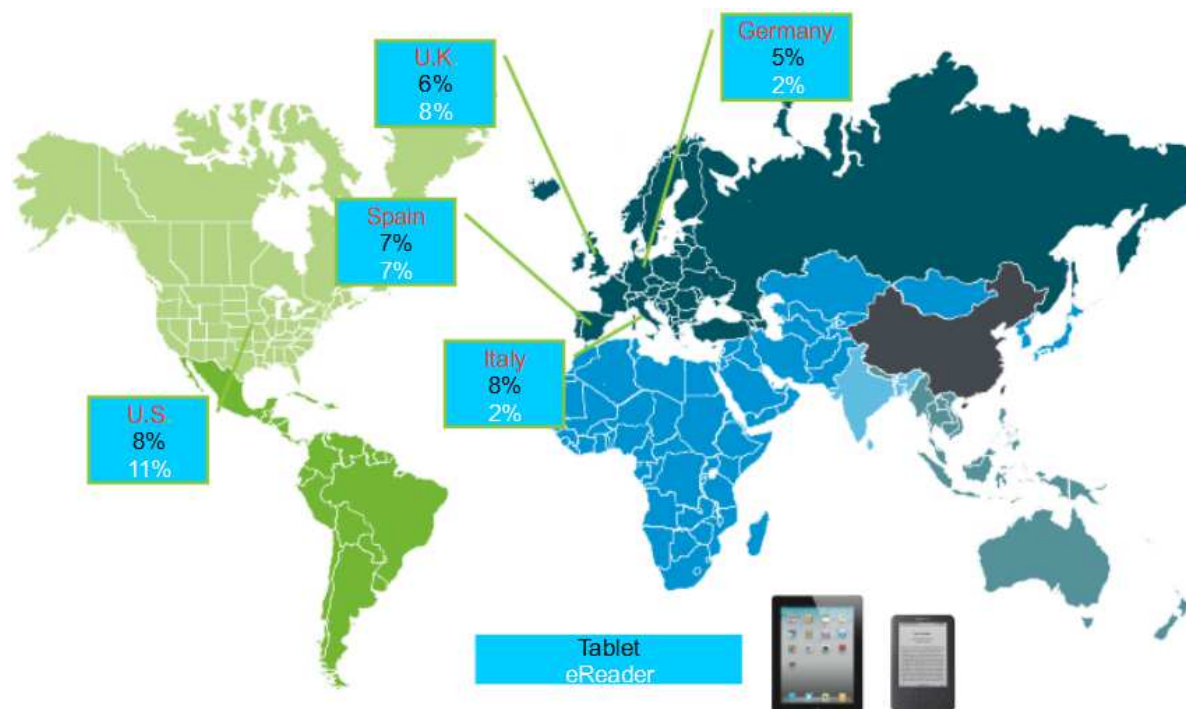
Unfortunately, tablet and e-readers are at a very early stage: for instance, in the US there are more smartphones than e-books, but the impact of e-book sales is now having a clear effect on physical book sales both in the US and UK, with this effect likely to increase in these markets and begin to be felt in other territories.

In India there is a strong growth in book sales, showing that developing economies can hold great opportunities for publishers and booksellers.

Regarding e-books, European society is changing very fast: with more devices on the market, more request of digital content, seems that Europeans really loves technologies and are more social than Americans, suggests Javier Celaya, CEO of Dosdoce digital culture⁸⁶.

Actually, the diffusion of new devices, which enable other activities beyond reading, could mean less reading: this happens in Europe (see picture 5.9), where tablet readers are more diffused than e-Readers (in Italy, 8% vs. 2%), while in the US there is a Kindle-driven market (11%).

⁸⁶ <http://www.dosdoce.com/>.



Picture 5.8 Insights by Nielsen Book Company Tablet and e-Readers (2011)

The Conference speaker stresses that new international strategies have to be developed with a “technology as a service approach” both for authors and readers. To give an example, Amazon has developed financial services for authors, to let them know in real time what happens to their market; as a matter of fact any website is a distribution point, where analyze reading practicing and behaviors (e.g. social reading) and for direct selling.

At the same time, for readers, it is important the creation of readers communities, of recommendation systems, building new services around digital content. There is the necessity of a “New Digital Wheel” value chain through: a Digital Asset Sourcing (DAS), a Digital Asset Management (DAM), and a Digital Marketing and Distribution (DMD).

The suggestion is to build an European Platform for digital contents (books, music, movies) opposed to the “GAFA” market of giants such as Google, Apple, Facebook and Amazon.

For Sascha Lazimbat, managing director of A2 Electronic Publishing⁸⁷, the parallelism between the music digital market and the e-books market is quite evident: there are similarities in the value chain, in the copyright framework, in operational challenges and new digital retailers.

The difference are in the fact that music became digital already with CDs and it is also consumed in a different way: for instance songs do not need translations and have not barriers for an international market. Otherwise, while the DIY (Do It Yourself) approach did not work very much with digital music, it seems to work better with electronic books: self-publishing is an arising possibility.

⁸⁷ <http://www.a2ep.de/>.

In the next section different business models will be presented as clear examples of the new directions of the e-book market and of the changes within relationships among all its protagonists: writers, readers, publishers and libraries.

The Bookcountry⁸⁸ community offers the possibility to use the community to complete a manuscript, in order to find new talents, expand relationships between readers, writers and publishers. A wide range of users are possible customers of this website: aspiring writers, agents and editors, writers, readers interacting with the creative process, users offering creative services to passionate readers, niche communities.

Differently, BookRiff⁸⁹, lets readers to mix and match licensed content (book chapters, recipes, photos, videos...) into a personalized package or “Riff.” BookRiff is a revolution in publishing technology: book and periodical publishers, authors, and other creators around the world are selling their content in chunks of different sizes, allowing anyone to mix published works with their own work and free Web content to create unique custom books.

With new media capabilities of “slicing and dicing”, digital content is divided into discrete chunks, that consumers can purchase and recombine into any kind of form they can imagine. That means professors can put together course books, gourmets can assemble custom cookbooks, and travelers can choose which pieces of content will go into their individual guidebooks. Every time that a Riff is distributed, copyrights of original files mixed within the Riff are paid to their owners: creativity, reuse and copyright can actually coexist.

The most interesting issue to reflect upon is that the concept of author is widening without including anymore the concept of single creator of contents. In the future we have to understand if we are going beyond the idea of a community generating new contents collectively, to reach the idea of author as collector of third party’s contents. No more authors but deejays, remixing text lines and other material to be joined and transformed.

Another business model is the one proposed by Small Demons⁹⁰ which develops another interesting perspective: every meaningful detail from a book, every song mentioned, every person, every food or place or movie title has been connected to the same detail mentioned in other books. They have built a Storyverse, a vast universe of details around each single book, which are all linked together.

One single detail works as a recommendation system that suggests new music, movies, places, people and books to discover. Within this perspective everything can be connected through books, whose story can be deepened in details and can connect you, in a serendipitous way, to unforeseen other digital content.

The next business model is called Readmill⁹¹, which focuses on social aspects of reading, proposing a community of readers. Users can highlight favorite passages and share them with their personal reading community; they can follow people they like and find out what their friends are reading, explore a world of reading and keep a list of books users want to read.

⁸⁸ <http://bookcountry.com/>.

⁸⁹ <http://www.bookriff.com/>.

⁹⁰ <https://www.smalldemons.com/>.

⁹¹ <http://readmill.com/>.

The last one is 24Symbols⁹², which is a service to read digital books on the Internet based on a subscription model. The content is available on the cloud, without any download, and from any internet-enabled device.

It is based on social networks to share favorite quotes and books, with a freemium business model: two versions of the same product are available, the free one is free-of-charge, while the premium one offers advanced functionalities and offline reading. 24Symbols is offered as a SaaS (Software as a Service) to publishers, academic institutions, product and service enterprise, and other types of companies interested in offering a branded cloud reading service to their customers and employees.

Among this creative and open-minded possibilities offered by online communities around the e-book market and considering that we live within a world of micro-contents (Twitter, Facebook and the like), the publisher should offer a relaxing and immersive reading experience: from its very first page, an e-book should greet the reader, without asking copyright permissions, passwords and other DRM which move away from a digital book.

For instance, the table of contents should be clear and accessible (maybe not full of hyperlinks which are not easy to be read), the page layout and typography should be accurate, avoiding pages crowded of paragraphs. Thanks to new social aspects of reading, but without abandon quality content and layout, also digital reading could become a pleasure for all.

We should imagine that in the next years the use of digital contents, thanks to better accessibility and retrieval, will raise a complex dynamic and adaptive system, offering unpredictable developments to our species' collective mind, maybe a great leap forward (Eletti & Cecconi, 2008):

E-books and the like, along with Web 2.0 dynamics and semantic development of Web engines, can turn into critical instruments for knowledge circulation, trying to intertwine tightly all the elements of the new emerging organic networks: millions of "cells", constituted both by human brains networks (mind, memory, perception, reaction, adaptation, learning, memes reproduction) and by their cognitive prosthesis (operative, executive and simulation software applications, dynamic databases, expert systems, single and multiple intelligent agents). A complex evolutionary 'thinking' system, a sort of conscience, superior to every known one.

⁹² <http://www.24symbols.com/en/>.

Chapter 6. New educational environments and processes

Considering the recent introduction of new technological devices and tools into our common environments for learning and sharing knowledge, the aim of this chapter is to present and describe some of the latest possibilities offered by the mutated technological context, where new social behaviors and paradigms can rise, sometimes not completely foreseen.

I move the first steps towards a pervasive classroom, in order to stimulate new pedagogical practices. The work starts by focusing on applications suited for large interactive screens, or Interactive WhiteBoards (IWBs), trying to exploit at best the affordances of multi-touch technology, which should allow new cooperative learning strategies in classrooms, while consolidating the verified benefits of using IWB with single-touch technology. These new possibilities can really bridge the gap between digital natives and their teachers, leading to a different learning approach where technology permeates all educational world and where knowledge is really built through group cooperative activities.

In particular, I describe two personal experiences, starting from the introduction of the use of IWBs with touch-based input within two primary schools and discussing the changes in the design approach of the school environment, of the proposed applications for digital storytelling and music, of the new didactical strategies developed by teachers during everyday lessons.

6.1 Pervasive classrooms: digital natives and technologies

We have seen that the process of creation and communication of knowledge is under continuous transformation (see chap. 2). In the background there is our civilization of the World Wide Web, of the so called “digital natives” (Prensky, 2001), of the ever more massive computerization of public and private administrative services, of the prolific Social Network use, but above all we are witnessing an anthropological change in the practice of reading and writing (Pozzi, 2011).

Thanks to new widespread technologies, people asks for multisensory experiences, trans-disciplinary knowledge, expressive hybridization, creative participation and emotional involvement (Cerroni, 2010), both during working activities and spare time.

New technology-enhanced environments are beginning to change our everyday activities, while in most of schools and classrooms the technological leitmotif it is too far away from the students of the 21st century.

The school system, which is in pole position in the formative process for the acquisition of these skills and abilities, cannot look on. The educational world should have an active role in these changes, sometimes imposed by political choices or introduced without an effective debate within all the stakeholders (Masi, Sangalli, Sannazzaro, Agostini, & Di Biase, 2010): they should be involved in all the transformative processes of knowledge acquisition and production.

In particular, a radical change is affecting two of the most symbolic cultural object of everyday didactical activities: the traditional blackboard and the paper book (see chap. 5). If we considering the recent introduction of Interactive WhiteBoards, which have been installed within 53.900 out of 322.000 Italian classrooms during this school year (only 17%), and that 77.000 tablet are available for students (Chiarelli, 2012), a complete redesign of the classroom and its educational tools is needed.

After the slow introduction of PCs at school over the last decades, it seems that computers are now really “disappearing” (Weiser, 1991): schools are transforming into new learning environments where technology —permeating all the activities— disappears within school desks, walls, and all objects of the classroom. It stands to reason that such a new educational environment asks for different didactical practices and that digital natives’ generation needs more technological-oriented learning activities (Di Biase, 2008).

As a matter of fact, children of the 21st century have been part of a multi-media digital world from birth: they are comfortable with technologies and accustomed to communicate by using simultaneously various media (e.g. chatting on PC, texting on mobile phone). They collect information and build their own knowledge exploiting multiple sources: not only family, school, and books but also TV, DVDs, and the Internet. Even preliminary neurological studies show that they are able to handle multiple stimuli concurrently better than digital immigrants are.

The day-by-day world of digital natives is multimedia and permeated of digital technologies while, in some way, school is still mostly clung to chalks and blackboards: only 17 out of 36.000 schools have been completely digitalized (Chiarelli, 2012).

Firstly, the gap between digital natives’ generation and the actual out-of-date school asks for adopting new technology enhanced tools in the classrooms. Tools that support new ways of teaching, engage students, and stimulate their active participation to the lessons, in order to penetrate the digital world of the new generations, which are “nourished of clicks and buttons” (Castells, 1996). Secondly, schools cannot abdicate to their educational role about teaching not only through new technological devices but also how to develop a digital wisdom and awareness of the opportunities offered by technology for learning (Prensky, 2009).

In this transitional phase, only a wise use of old and new devices, of old and new teaching methods could offer a wide range of didactical opportunities to match the needs of both “digital natives” and “digital immigrants”.

Imagining the educational environment of the future in line with Weiser’s vision (Weiser, 1991), I plan to have a technology-pervaded classroom, with few interactive tables and large

screens (e.g. augmenting teachers' desktops and blackboards); various tablets and portable computers and a multitude of technology-enhanced gadgets (e.g., bracelets, pens).

All these technologies, embedded in everyday tools, could allow cooperative and participative learning of students during classroom activities; moreover, some gadgets follow the students outside the school, allowing a learning process available 'anytime, anywhere'.

All these artifacts are part of a context-aware platform, providing appropriate adaptability and personalization to the users. In particular, has been adopted a platform called SIS (Space Integration Services), which supports the exchange of contextual information among client-components, using a publish-subscribe mechanism (Bernini, Micucci, & Tisato, 2010). The focus is to imagine and design applications suited for large interactive screens, or Interactive WhiteBoards, with multi-touch technology.

On purpose, I start from IWBs for their valuable characteristics. It is well known that pupil's learning is reinforced by the physical and tactile interaction with the IWB. By adopting multi-touch technology—allowing multi-user interaction—students' engagement in learning activities and collaboration in building knowledge could be stimulated.

The application has been thought for MultiTouch Cells⁹³, where multiple persons can interact at the same time and the software tracks every user's hands, not only points of contact. MultiTouch Cells are modular LCD displays which can be connected to create a single large display array, available within the laboratory on Innovative Technologies for Interaction and Services (ITIS).

It is possible to use RFID technology for recognizing students in front of the board or in the classroom; sensors and cameras could be adopted for recognizing persons in the next future.

The work above mentioned is based on a project started in 2009 for a platform of Ambient Intelligence (AmI): the Space Integration Services platform, at the Department of Informatics, Systems and Communication (DISCo) of the University of Milano-Bicocca. The SIS platform offers services to diffuse relevant information, supporting space-aware communication (see par. 3.1 for deepening the concept of awareness).

As a matter of fact, the SIS is able to detect the presence and the orders of people populating the environment in a precise moment and to react consequently, using a heterogeneity of electronic devices. These devices have to use the same communication protocol, to interact one another, independently of the device's nature.

Focusing on the range of technical devices included in the project, you can find large interactive screens, surveillance cameras, RFID readers, wireless sensors, mobile robots, electronic paper, and various PCs and servers. The SIS do not need to identify all these devices, because it is each client-component that is recognizable by the other components, which need its contextual information, through the spatial model.

Thanks to a publish-subscribe mechanism, it is supported the flow of contextual information in spatial terms among client-components (e.g. applications, sensors, lights, screens etc.). In particular, "information is delivered whenever a non-empty intersection among publication and subscription contexts is recognized according to the space mappings" (Bernini et al., 2010).

⁹³ MultiTouch Ltd, <http://multitouch.fi>.

Considering that the idea is to create a common environment, it is necessary to think to the infrastructure as a unique identity, managed by a multitude of devices, but necessary flexible and dynamic from the point of view of the offered services and useful for the exchange of information among the various applicative areas.

The AmI project aims at identifying persons inside the environment (using the information coming from the different devices), detecting paths or movements of groups, using data of the entrance of people to make statistical analysis on their habits, or to avoid dangers.

At this point, the AmI project and the SIS platform have been studied to enlarge the vision of a pervasive classroom to an entire school building. However, there are some relevant issues concerning the communication and the integration of devices, in order to have a complete communication network among different environments and classrooms, to enhance the possibility of collaboration and participation to didactics.

After enlightening the salient architectural characteristics of the SIS platform, in the following I am going to describe the specialized spatial model created in relation to the specific domain: the school building.

The objective is to conceive the school building as an AmI environment, in order to support more pervasive classrooms, using the SIS platform, and to offer the better communication among the devices introduced for collaboration and active participation in the classroom.

First of all, I have identified the basic elements of the spatial model, which are: the students, the teachers, the devices used in the platform (the client-components), the devices external to the platform (that can subscribe to it), the physical space in which the platform is configured.

Afterwards, some name spaces have been created ad hoc:

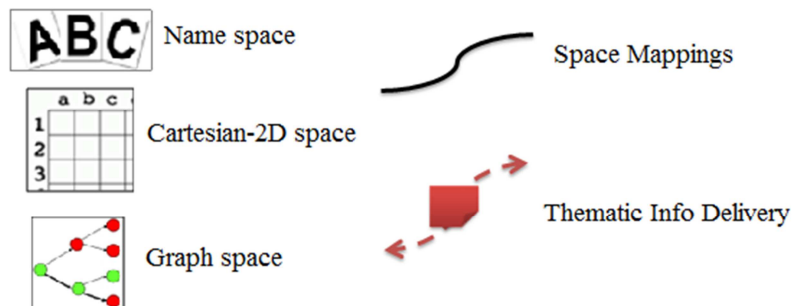
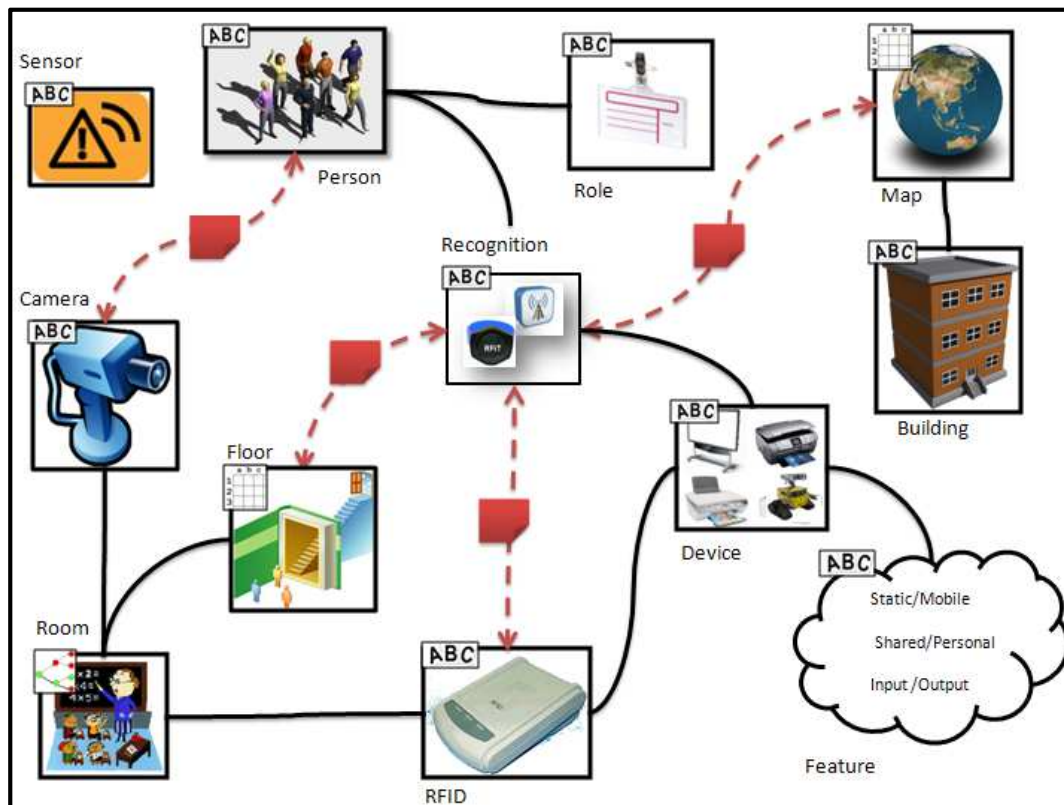
- Person (to define people frequenting the school building);
- Role (useful to provide context-aware information);
- Room (a graph space to identify classrooms);
- Device (to list the range of technological devices inside the school building);
- Feature (to describe specific characteristics or functionalities of the devices);
- RFID (to identify RFID readers);
- Recognition (to show recognition devices with wifi or RFID technology);
- Floor (a Cartesian-2D space to represent a floor of the building);
- Camera (for future image recognition);
- Sensor (to collect other context-aware information);
- Map (a Cartesian-2D space to track the position of people outside the school building);
- Building (name space to identify physically the building found in the Map space).

For each of these spaces has been described a specific mapping; for example, the mapping RFID-Device defines which are the RFID readers that are proximity readers: when a student is near the device (e.g. an Interactive WhiteBoard), the reader can detect her/his presence. In order to understand how the SIS platform works using our school building spatial model, I propose the following simple scenario of use.

The RFID reader, which is placed near the entrance of the classroom, can recognize each single student wearing the bracelet with the RFID tag; the SIS will receive the name of the RFID reader and each tag recognized. So, the teacher can have the list of the teachers or students (in the name space “Person”) being in the classroom (thanks to the mapping between the name spaces “RFID” and “Room”). The IWB (in the name space “Device”), having subscribed to a specific context of interest, can receive the thematic info about the names of the people being in the classroom.

This publish/subscribe mechanism allows the IWB to know if a particular teacher (e.g. the literacy one) is in the classroom and to start the proper applications (e.g. the FairyTale Box, see par. 6.3) or personalized the lesson (e.g. in relation to the number of students within the classroom, to their level, etc.)

The whole platform has been thought in line with ubiquitous computing and “calm” technology approach and it is shown in picture 6.1.



Picture 6.1 School Building Space Model (with legend)

6.2 New roles and rules for Interactive WhiteBoards

After designing the school building of the future, with a wide range of opportunities offered by different technological devices in classrooms, I deepen the study of applications suited for large interactive screens with single or multi-touch technology. In fact, in recent years, the usage of large interactive displays is considerably increased thanks to the consolidation of the equipment as well as the reduction of their cost.

Considering the facilities offered by Tangible User Interfaces or TUIs (see chapter 3.2), large interactive screens are actually used in different situations for a wide range of purposes: organizations adopt them to facilitate group activities (Grasso, Muehlenbrock, Roulland, & Snowdon, 2003) and circulation of knowledge (Streitz & Nixon, 2005); interactive walls begin to populate our cities (Peltonen et al., 2008).

Focusing on the introduction of Interactive WhiteBoards at school, from the teachers' viewpoint the use of IWBs in the classroom provides new opportunities to both teach creatively, thanks to the multimedia content, and teach creativity (Wood & J. Ashfield, 2008). Thinking from students' point of view, digital natives are comfortable with technology and their experience must be exploited in the learning environment (Hall & Higgins, 2005).

Moreover, IWBs seem to stimulate a more *decentralized role* for the teacher as facilitator and knowledgeable guide. These tools facilitates a co-learning approach to education, where teacher and students work together, rather than adopting the usual formal roles. This can induce more independent and self-directed learning (Hall & Higgins, 2005).

In particular, I suggest to rethink IWBs as learning instruments, adapting their didactical use and position (e.g. height in the classroom/laboratory) to young students more than to their teachers. From this viewpoint, teachers should rarely interact with the technology, acting as a mediator between the technology and the class as well as a facilitator of learners' cooperation (Agostini & Di Biase, 2011). The suggested approach is in contrast with the teacher-centric one proposed in (AlAgha, Hatch, Ma, & Burd, 2010), for using multi-touch surfaces in classrooms. However, IWBs, by nature, support a beneficial knowledge sharing across the whole class. Collaboration in building this knowledge could be stimulated by adopting multi-touch technology, which allows a simultaneous use of the tool by small groups of students.

As a matter of fact, large multi-touch surfaces have several natural affordances, which can simplify small group collaborative work, establishing new ways of interacting. First of all, this kind of devices allows multiple-user input, involving all group members to manipulate objects on the display at the same time. Then it is possible to support natural gesturing, helping users to notice their partner's actions, providing rich interpersonal interactions, enabling users to both impart and understand each other's intention seamlessly.

The naturalness of these interactions, typical for Tangible User Interfaces (see par. 3.2), allows exploiting our existing capabilities for interaction in the physical world in the digital domain (V. Ha et al., 2006). The size of the surface and its multi-touch features support bodily interactions with the display, allowing to be expressive towards other participants, and helping them to take up roles and to negotiate turn-taking as well as different kinds of collaborative activities (Peltonen et al., 2008).

A larger display area gives the opportunity to organize objects spatially. In addition, multi-touch input may be a more appealing and natural means of input as users manipulate objects directly and easily with their fingers (Harris et al., 2009).

However, for text insertion tasks, it is uncertain whether, or how much a pure touch-based input—i.e. without devices such as pens or styli—can really be effective. On multi-touch tabletops, people point and touch virtual artifacts on a table in the same way as if they were physical objects, often using both hands (V. Ha et al., 2006), while this is not possible in the single-touch condition, which simulates a mouse-based interaction.

In another study (Harris et al., 2009), the system supported both multi-touch and single-touch interaction. In the multi-touch condition, various children could interact with the digital content simultaneously, talking more about the task, while in the single-touch condition they talked more about turn-taking. The multi-touch mode supports better collaboration by allowing more equitable participation at the tabletop, because everybody can interact whenever they want. Their discussions involved explicit reasoning and justifications, while they can work in parallel way on the same task: this interaction was more collaborative in nature.

A project investigating the impact of using Interactive WhiteBoards for literacy and mathematics in primary schools underlines that children are more motivated in lessons because of the high level of interaction and discussion (Schmid E.C., 2006). Children enjoy interacting physically with the board, manipulating text and images. Literature relates the unique physical and tactile nature of the board with the reinforcement of pupil's learning, especially when they can interact directly (e.g. kinesthetic learning).

Actually, the single-touch feature of the adopted IWBs limits the number of pupils interacting during the lesson. Moreover, not all the teachers let children interact with the IWB most of the time, because lessons are still planned in a traditional way (e.g. frontal lesson), even if using a new tool. With a single-touch IWB the teacher has to concentrate on developing new practical strategies to keep the rest of the class mentally engaged, while one child is working at the IWB (Schmid E.C., 2006). The children that are not interacting with the device may lose involvement during the lesson.

By introducing an IWB with *multi-touch* technology, groups of children can really work at the screen at the same time and interact more often with the device. A multi-touch IWB maximizes these kinds of interaction during the activities within the classroom, offering new ways to think, plan and develop the lesson from the point of view of cooperative work. Considering all the multimedia and multimodal opportunities offered by the IWBs, the adoption of multi-touch technology can enable more children to work and interact together on the display, increasing the number of interactions and the level of participation of the whole classroom.

Despite the introduction of new technologies at school, current views of learning regard the notion of a teacher-dominated classroom; however, learners are also capable of creating and generating ideas, concepts and knowledge, and the ultimate goal of learning in the knowledge age is to enable this form of creativity (McLoughlin & Lee, 2007). The participation metaphor is characteristic of how learners engage in the processes of social interaction, dialogue and sharing, all of which are linked to socio-cultural theories.

Cooperative and social learning (i.e. participative learning) have been a matter of discussion and experience for many years now (Brown & Adler, 2008) and have long been recognized as ingredients of effective pedagogy (Johnson & Johnson, 1986).

In spite of research demonstrating the benefits of participative learning, still the educational world is permeated with the misleading concept that teaching means only to transfer notions and capabilities as well as cultural and moral values from teachers to students. This conception has been generating a sharp dichotomy between teachers and students, as the knowledge flow is strictly unidirectional: from teachers to students, who are accustomed to passively assimilating the lessons.

On the contrary, in participative or social learning the approach is different (Brown & Adler, 2008):

This perspective shift the focus of our attention from the content of a subject to the learning activities and human interactions around which that content is situated.

Learning occurs as a socio-cultural system, within which learners interact to create a collective knowledge: typically, they receive scaffolding through the help of others: peers and teachers, but also virtual community, sources and technology. It is the combination of technological tools facilitating a co-learning approach to education and collaborative learning activities that can stimulate more active participation of the whole class during the learning process.

After all, only new educational agendas and priorities, that offer the potential for radical and transformational shifts in teaching and learning practices, can really move schools towards a 'Pedagogy 2.0' (McLoughlin & Lee, 2007).

These new possibilities can lead to a different learning approach where participative learning practices (e.g. Digital Storytelling) are really enhanced by a new technology, suited for group cooperative activities. Actually, during the last years the development of Web technologies has changed the way persons tell public or private narrative contents: blogs for textual narration and Youtube for the videos. This new way of communication, called *Digital Storytelling*, is nowadays widespread in different levels and fields. It is used in professional environments, for socialization, for a dialogue between different generations or cultures, and in all learning contexts.

As a matter of fact, neurosciences underline the importance of storytelling in the learning process, because it allows an integrated use of different dimensions of the human intelligence (linguistic, interpersonal, etc.). Significant researches on the educational benefits confirm that storytelling develops specific abilities, such as problem solving, task completion and literacy skills. Moreover, it is possible to increase interest in the subject matter and motivation towards learning activities, making more interesting topics (e.g. Prehistory) which are usually found boring (Di Blas, Garzotto, Paolini, & Sabiescu, 2009).

Promoting learning in a more involving way, using emotions and references to everyday life is really effective, especially for children. Exploiting the multimedia possibilities of a digital environment can better stimulate a more engaging and funny way of learning.

Finally, school buildings and classrooms are equipped with large screens for enhancing the social (Lewin, Somekh, & Steadman, 2008) and learning experiences of children (Schmid E.C., 2006).

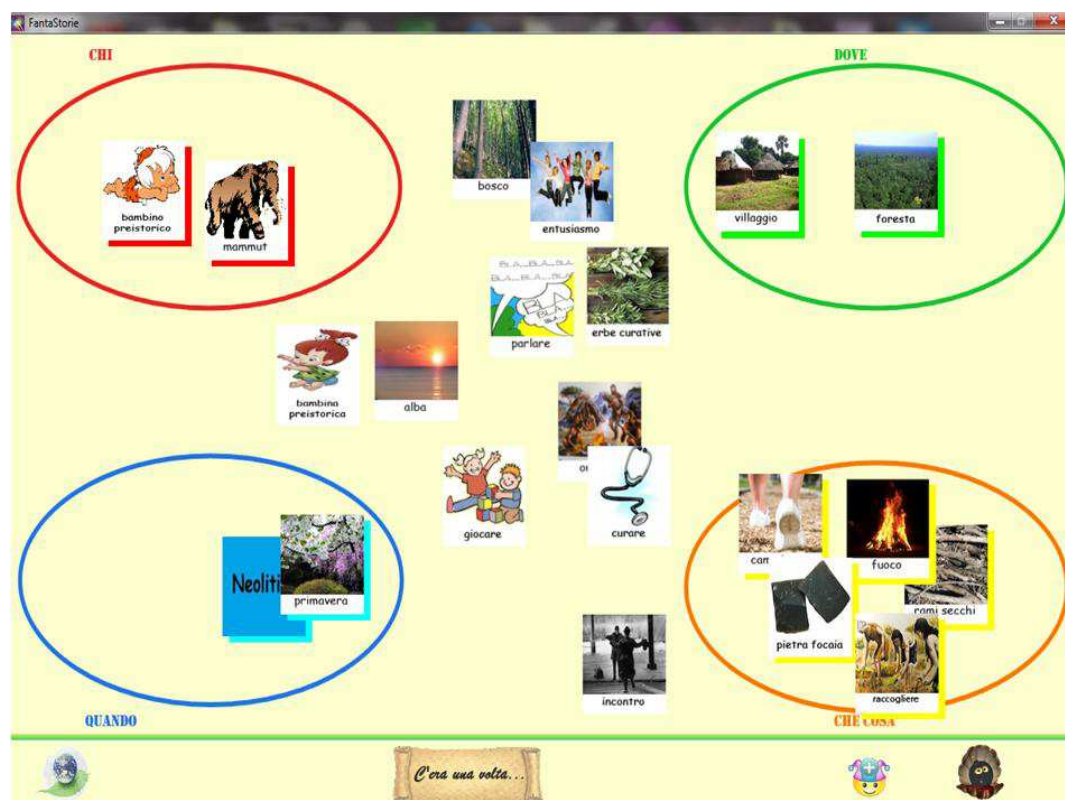
Large interactive screens can really enhance the process of creating narrative structures and integrating Digital Storytelling in the curriculum. Moreover, collaboration within the whole class could be stimulated by adopting multi-touch technology, which allows a simultaneous use of the screen by small groups of children.

Taking into account these considerations, the main goal of the following experimental study is exploiting at best the affordances of multi-touch technology, which allows new cooperative learning opportunities in classrooms for storytelling activities. Actually, Digital Storytelling is not only a multimedia product, completed in its realization, but a real process, living in a context of social actors, technological artifacts and clear purposes (Cappelletti, Gelmini, Pianesi, Rossi, & Zancanaro, 2004):

Digital Storytelling can increase the level of engagement of less motivated children without affecting the involvement of the more active ones.

6.3 FairyTale Box for Digital Storytelling: first experiment

Considering what has been explained so far, this chapter aims at stimulating new pedagogical practices and, more specifically, allowing participative learning, which could increase students' engagement and attainments. In this context, I propose the FAIRYTALE BOX application (see picture 6.2) for primary schools' literacy lessons during which 7-10 year-old pupils can create stories through cooperative storytelling activities on a large interactive screen (Agostini, Di Biase, & Loregian, 2010).



Picture 6.2 The first screen of the application

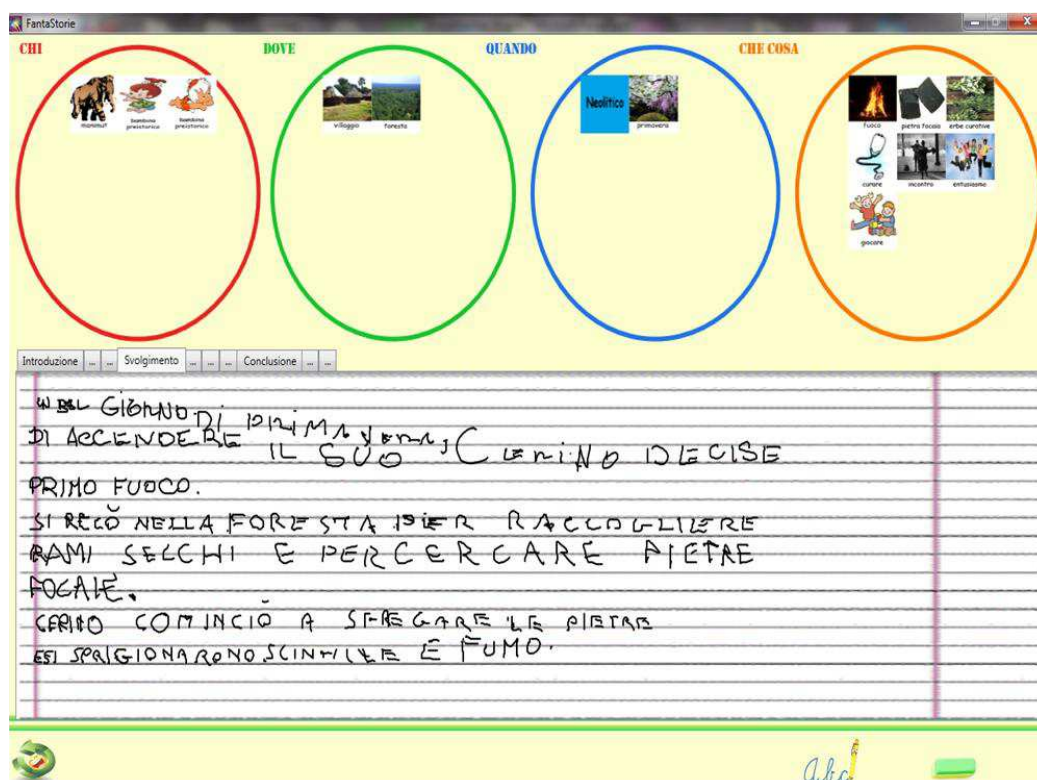
The main screen area of the proposed application contains four rounded sets, empty at the beginning: Where the tale takes place, When it happens, Who the main characters are, and What the characters are going to do. All around the four sets, the application shows images of nouns and verbs, each labeled with proper words, that have been chosen and pre-loaded by the teacher, but that can be modified by children at runtime within the application.

First of all, the teacher is free to reuse the digital content of the other lessons, to use the default Library provided in the Home folder of the program, or to create a new folder with personalized digital content. The folders contain images, words, and pictures, that the teacher can arrange on the screen, in order to suggest some ready-made elements for the developing of the tale by the children. The template built so far can be saved at any time by the teacher and it is made available for everyday classroom activities.

At the beginning of the activity, pupils fill sets little by little choosing the images to build the fairytale: for a complete scenario of use see (Agostini et al., 2010). They can comfortably work together on the screen at the same time, helping each other. For the sake of clarity, all the interactions with the screen are touch-based, both for dragging and dropping images and for writing in the textual area.

After this step, the four sets, filled in with the chosen images, appear at the top of the screen during the collaborative writing activity as reminders, to support the wording of the tale (see picture 6.3). At every moment of the writing process, pupils can easily turn back to the choosing phase to add or delete images.

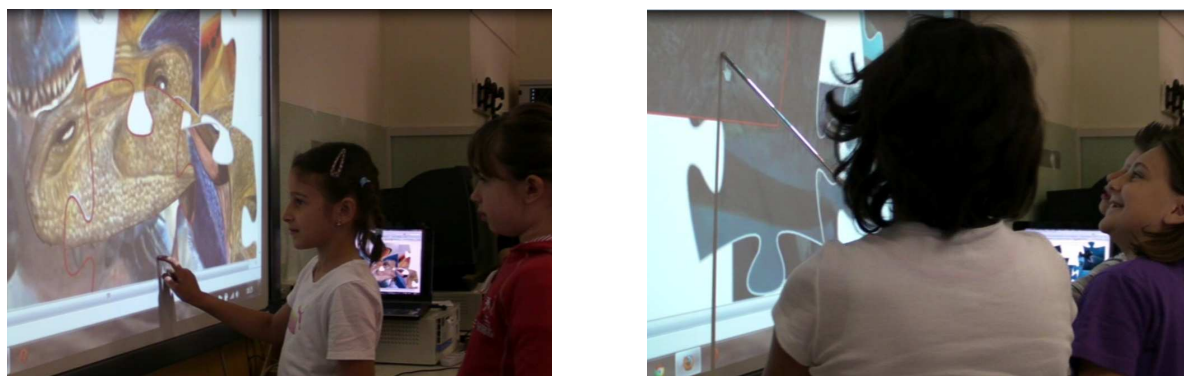
In order to involve all students as much as possible, the FAIRYTALE BOX facilitates a smooth turn-taking in using the IWB by splitting the writing activity into different phases, that can be easily assigned to different groups of pupils. By default, have been proposed three phases (Preface, Development, and Conclusion), which can be revised runtime.



Picture 6.3 The Development phase of the fairytale

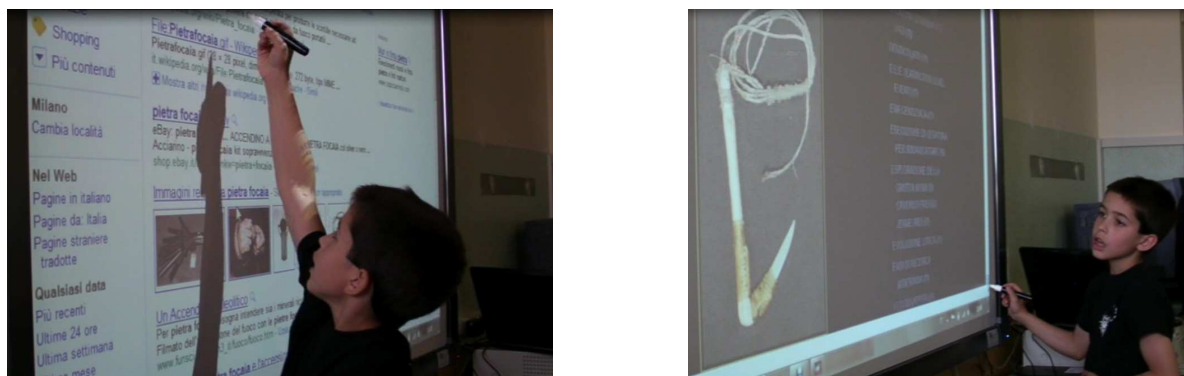
Therefore, small groups of children, one at a time, write the sentences in a textual area placed in the bottom, using touch-based input or the provided marker pen. Whenever necessary, appropriate corrections and revisions are made with the collaboration of the whole class.

Beginning from a particular fairytale and its subjects (e.g. Prehistory), the FAIRYTALE BOX supports various extra-activities (picture 6.4) allowing teachers the design of a complete multidisciplinary project. Teachers need to be engaged with ICT not only at the level of consumer, but also at the point of design and development (Wood & J. Ashfield, 2008). In particular, the teacher should be able to create, or at least to personalize, the content of the lessons instead of receiving complete pre-defined lessons in specific subjects provided by the vendors.



Picture 6.4 The puzzle activity on dinosaurs

The FAIRYTALE BOX provides Internet access to look for information on the Net (whose connection is protected by password), giving to teachers the opportunity of teaching to digital natives' generation how to overwork the Internet, considering the critical choose and use of online sources (see picture 6.5). Moreover, this application offers a built-in selection of didactical materials, that can be chosen and added by the teacher. Pupils can discover new characters, objects and other useful information for creating the tale, or for other interdisciplinary purposes, stimulating their curiosity and enabling serendipity in the learning process. For instance, teachers agreed to let pupils watch to the documentary: "The planet of dinosaurs" by the journalist Piero Angela.



Picture 6.5 Internet search (left) and selected material (right)

In line with J. Dewey⁹⁴, arguing that the measurement phase cannot prescind from the qualitative judgment, I have accepted them as complementary aspects of this research. As a matter of fact, these two moments, explorative research and descriptive moment on one hand and intervention and measurement on the other hand, are defined not only in the educational field, within the experimental method (Mantovani, 1998).

In general, referring to the experimental method, you can consider 4 phases: the observation, at first occasional and then systematic, to underline significant and problematic events, in order to describe them accurately; the hypothesis formulation about the observed events, the relationships between them or the effects of controlled interventions on these events; the experimentation in the strict sense of the word, to verify the hypothesis; the interpretation and elaboration of the collected data.

The experiment on the FAIRYTALE BOX application has involved two classrooms of The primary school “Dante Alighieri” in Arona, during the 2010-2011 school year. Considering that repeatability is one of the characteristics of the experimental method, I plan to involve other classrooms, in order to validate the first outcomes.

This first experiment has involved 40 pupils, in order to test a single-touch version of the FAIRYTALE BOX application and to observe the teaching methods adopted by the two literacy teachers.

This proposal has been articulated into different phases; firstly, have been arranged preliminary meetings with all the teachers of the two classrooms involved, in order to decide together the main theme (e.g. Prehistory) and the kind of images to create the tale, but also to illustrate the simple structure and the objectives of the FAIRYTALE BOX application; secondly, have been planned four meetings within the school laboratory to carry out the experiment; finally, a conclusive meeting with the teachers ended the experiment, to discuss together the main issues and to reflect upon the whole experience.

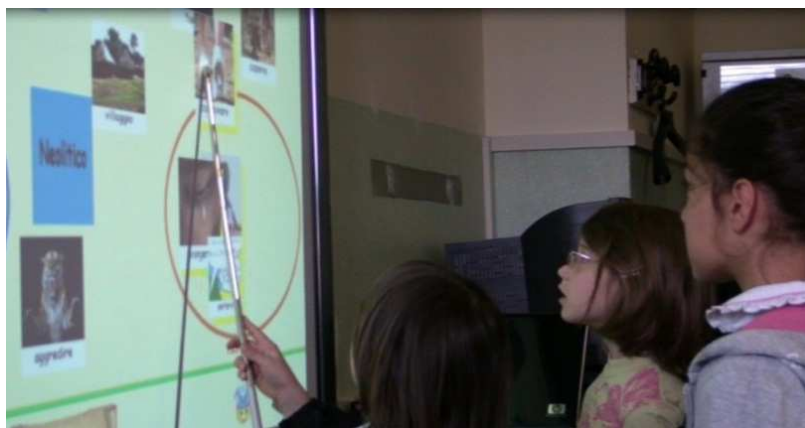
Now I am going to explain some details of the research. I have decided to use both traditional and digital research instruments: participant observation, systematic observation (videotaping classroom activities), pre/post questionnaires for teachers and pupils, informal meetings with teachers.

Considering the young age of pupils, the questions proposed show five possible answers on a Likert scale represented by emoticons, so often used to evaluate children interaction with computers (Read & MacFarlane, 2006); also the open questions have been anticipated with an example set of funny emoticons (see Appendix I).

In particular, the experiment took place within the school informatics laboratory, where the single-touch IWB had been installed. I want to stress the fact that nobody considered that the Interactive WhiteBoard should have been placed at the proper height to facilitate pupils' interaction with the screen.

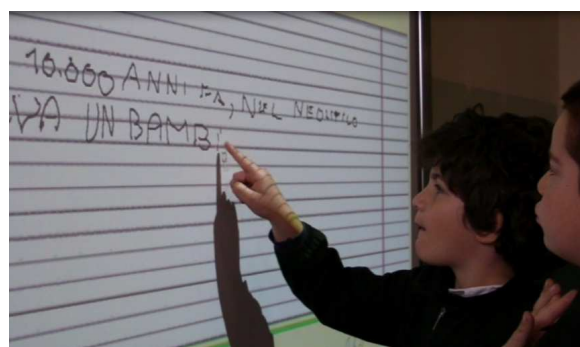
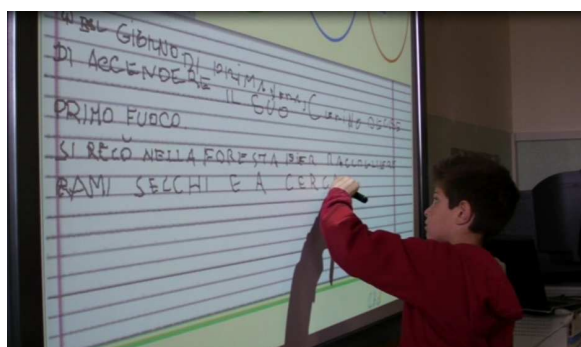
Unfortunately, the position of the IWB was too high for pupils, that can easily interact only with the lower part of the screen. During the choice of the images pupils could actually help themselves with a “magic” wand, within the IWB equipment, that allow them to reach also the images placed in the upper part of the screen (see picture 6.6). As a matter of fact, this interactive wand transformed a real difficulty into a funny opportunity.

⁹⁴ In “Le fonti di una scienza dell’educazione”, La Nuova Italia, Firenze 1929.



Picture 6.6 The “magic” wand to reach far images

On the contrary, during the writing phase, some pupils were not able to write fluently because they could not use the marker pen in vertical position on the screen. So, some of them preferred to write with touch-based input, certainly more appealing and new for most of the pupils (see picture 6.7).



Picture 6.7 Writing with the marker pen (left) and with touch-based input (right)

Focusing on the dataset, the two classrooms, 3A and 3B, were composed respectively by 19 and 21 pupils, being 8 to 9 years old. Both classrooms have never used the Interactive WhiteBoard before the experiment, and this is true also for their teachers.

The two literacy teachers, with a difference of 20 years of teaching experience in the primary school, adopted different strategies during the experiment.

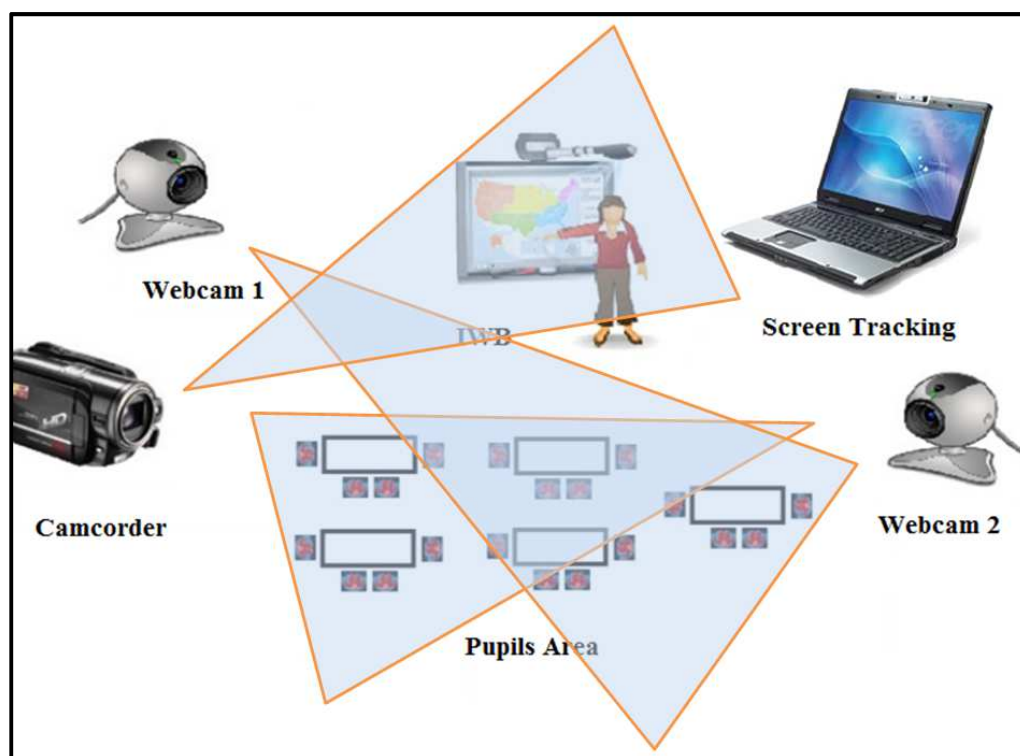
The younger teacher preferred the presence of a pupil at a time, interacting at the IWB during the creation of the tale: she stimulated the collaboration of the whole classroom proposing questions about the plot, making them voting for choosing the images and without interfering with the narrative content.

On the contrary, the other teacher organized 5 small groups of pupils, in order to accommodate in front of the IWB each group, devoted to complete one of the specific phases, starting from the Preface: pupils collaborated both discussing within the small group in front of the screen, and accepting suggestion from the other children at the desks.

As a matter of fact, the first teacher, more comfortable with technologies, was always ready to help the pupil interacting alone with the IWB to solve difficulties or to reassure him/her, while the second one let pupils tackle problems within the group.

As a matter of fact, the first teacher, more comfortable with technologies, was always ready to help the pupil interacting alone with the IWB to solve difficulties or to reassure him/her, while the second one let pupils tackle problems within the group.

Focusing now on the experiment setting (see picture 6.8), I have introduced a camcorder near the IWB to recorder pupils' interactions and speeches, the screen tracking of the activities on the IWB, and a couple of web-cameras in order to register classroom's behavior and turn taking. Pupils were arranged in small groups around desks, in order to facilitate IWB turn-taking and group discussion during the learning activity.



Picture 6.8 Setting of the research instruments

6.4 Preliminary results of the first experiment

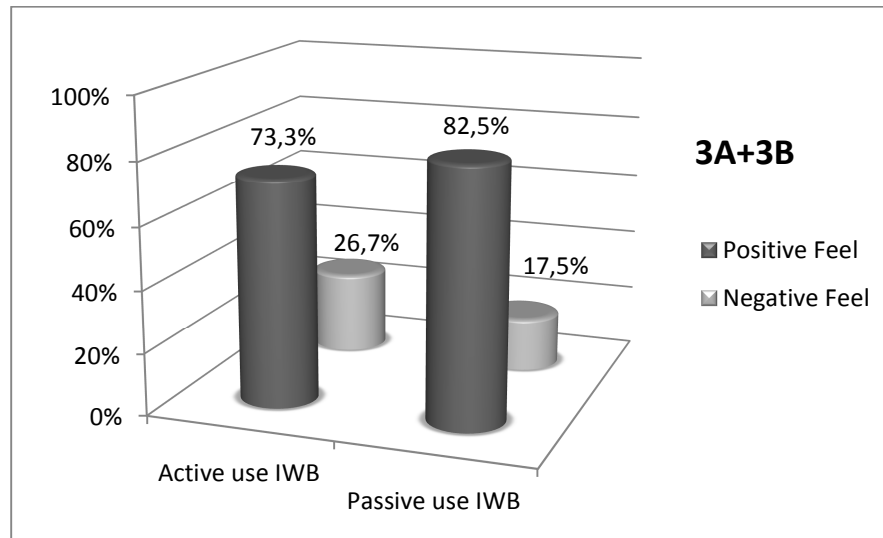
In this section I am going to present the preliminary result from the questionnaires (see Appendix D), in order to reflect upon the following variables:

1. **ACTIVITY and PASSIVITY:** How pupils feel in each phase of the lesson; for instance, when they are choosing and moving images, or writing the tale on the IWB, or when they are at the desk, while their mates are working;
2. **INTERACTION:** How pupils interact with the IWB, using a touch-based input, a digital marker, or the “active wand”;
3. **COLLABORATION:** How pupils feel while collaborating with mates, both in writing the tale and playing with puzzles;
4. **PLEASANTNESS and REPLICABILITY:** How pupils consider this experience, if they like to repeat it or to practice other subjects/disciplines on the IWB.

1. ACTIVITY and PASSIVITY

Considering all the activities practiced during the experimentation, they have been grouped within two variables in order to reflect an “active use” of the IWB (moving images, writing the tale, playing puzzles) and a “passive use” of the IWB (being at the desk during writing, or during playing puzzles, watching the documentary).

The feelings expressed by pupils of both classrooms in respect to all these activities have been then labeled as “positive” (e.g. interest, amazement, enthusiasm...) and “negative” (boredom, difficulty, embarrassment...) and are reported in picture 6.9.



Picture 6.9 Positive and Negative Feelings during Active and Passive use of the IWB

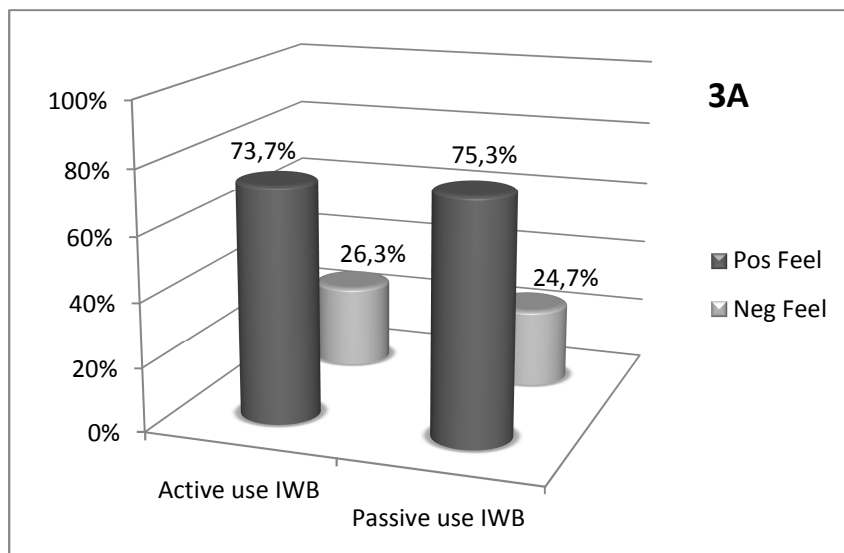
Taking into account negative feelings, these are higher in the “active” use of the IWB, and not when watching other interacting, because in both classrooms, the use of the digital marker was not so easy for some pupils who are embarrassed and could not write with the marker in an orthogonal position to the IWB.

In particular, I have to report that the 37,5% of children expressed negative feelings for the writing activity (embarrassment, difficulty, anxiety).

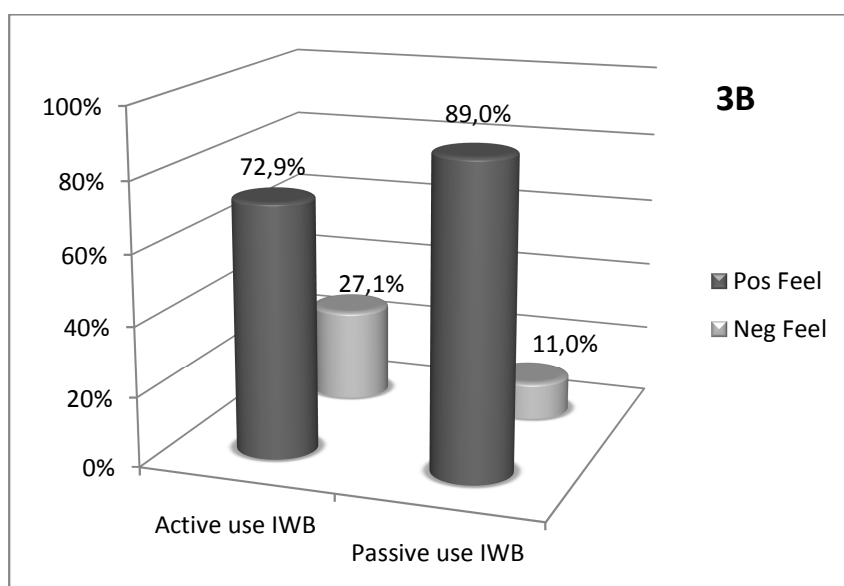
Considering positive feelings, they are so high also when children are at the desk and their mates are writing or playing puzzles, so, when pupils are not interacting directly with the IWB (see picture 6.10 and 6.11).

In particular, positive feelings are higher (89%) during passive use of the IWB in 3B, the classroom in which small groups of pupils can interact with the IWB at the same time, to write the tale (see picture 6.11).

Here, the multi-user interaction with the interactive board, even if single-touch, counterbalanced boredom or distractions due to waiting a lot for turn taking. Moreover, the teacher that allowed multi-user interaction was able to parallelize the writing phase by the pupils at the IWB, with the expansion of the tale by the rest of the classroom: suggestions were collected by the children at the board, not writing in that moment, which probably feel more involved in the creation of the tale.



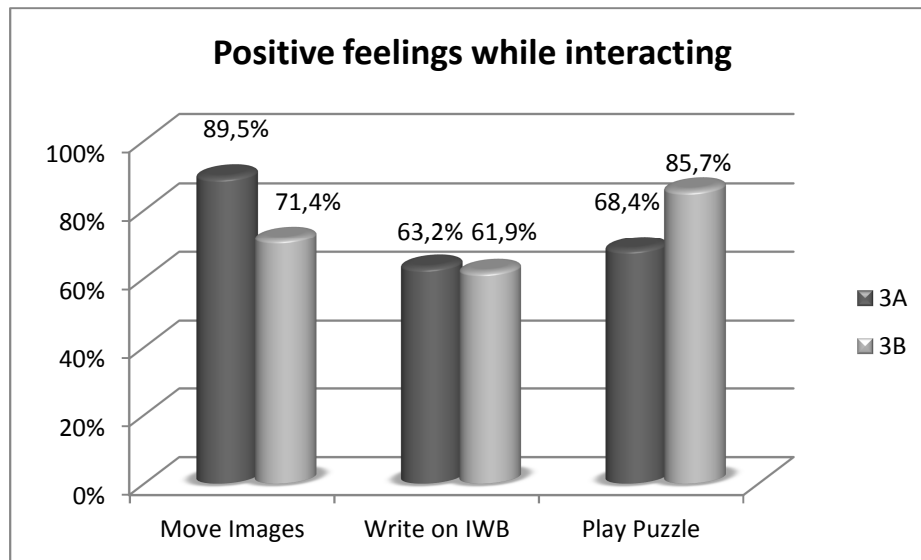
Picture 6.10 Feelings of pupils in 3A



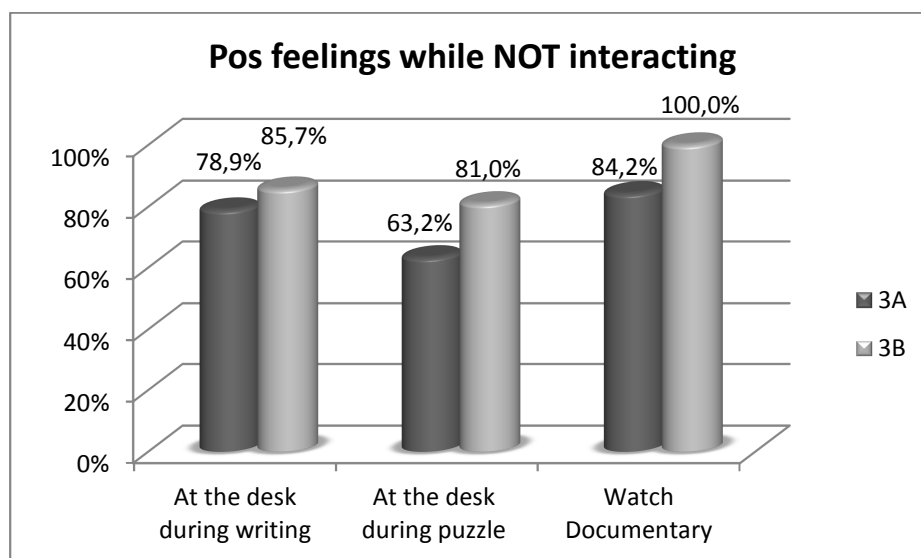
Picture 6.11 Feelings of pupils in 3B

As a matter of fact, all the proposed activities have been really appreciated by both classrooms. In particular, moving images has been more appreciated by the pupils interacting in first person with the screen (3A), thanks to the time spent being alone at the IWB (see picture 6.12).

On the contrary, pupils of the other classroom (3B) have higher percentages in all passive activities, thanks to the didactical strategy of the teacher, who organized a multi-user interaction with the device, allowing to small groups of children to be at the same time in front of the IWB (see picture 6.13).



Picture 6.12 Positive feelings during the interaction with the IWB



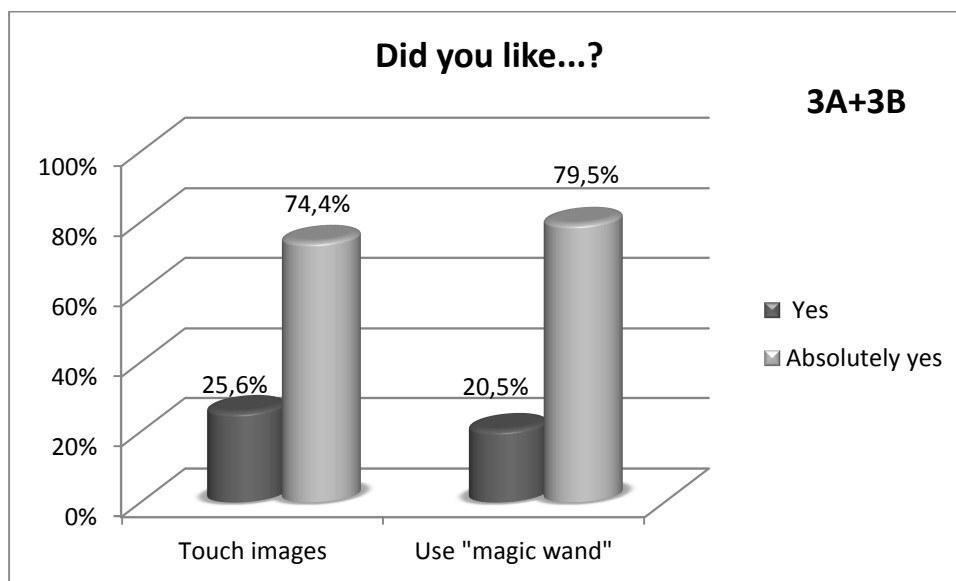
Picture 6.13 Positive feelings while pupils are not interacting directly with the IWB

2. INTERACTION

As already anticipated, pupils found some difficulties in the use of the digital marker, which should be at 90° in respect to the surface of the IWB, to be easily traced, otherwise the touch resulted imprecise when writing. This limitation of the hardware raises the issue of how is important that all technology should be tried before letting students to use it, and placed then in the proper position, which allows an easy interaction with the devices. Actually, the IWB has been positioned to be used by teachers and not by pupils.

In order to compare the kinds of interaction with the large screen, pupils have been asked questions about moving images, both using a touch-based input and mediated by the “active wand”, and about writing the tale directly with their fingers or using the digital marker.

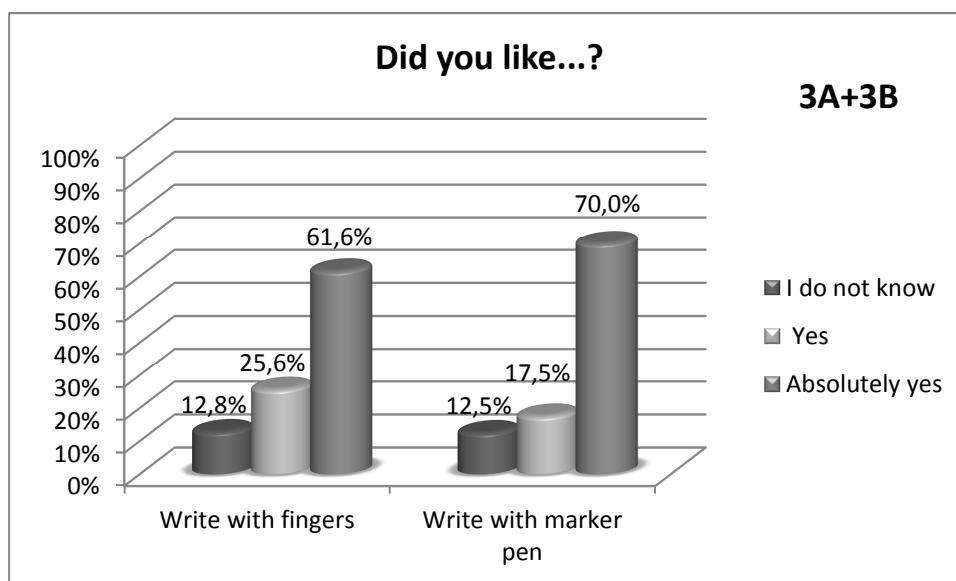
The results, given using a 5-item Likert scale⁹⁵ which represents the five emoticons used in the questionnaires (Absolutely not, No, I do not know, Yes, Absolutely yes), are grouped for the two classrooms.



Picture 6.14 Comparing touch-based input and the wand in moving images

The use of the magic wand has been a little more appreciated by children, because allowed to reach far images that, for a wrong position of the IWB placed too high on the wall, were arranged at the top of the screen area (see picture 6.14).

Otherwise, considering writing modalities, the troubles already anticipated appear clearly in picture 6.15: writing with fingers appeared more unnatural compared to the use of the marker pen. It should also be underlined that not all pupils have tried both input modalities when writing the tale: this explains the neutral answers to these questions.



Picture 6.15 Comparing touch-based input with the marker pen

⁹⁵ Items of the Likert-scale with no occurrences (0%) will not be shown within the tables.

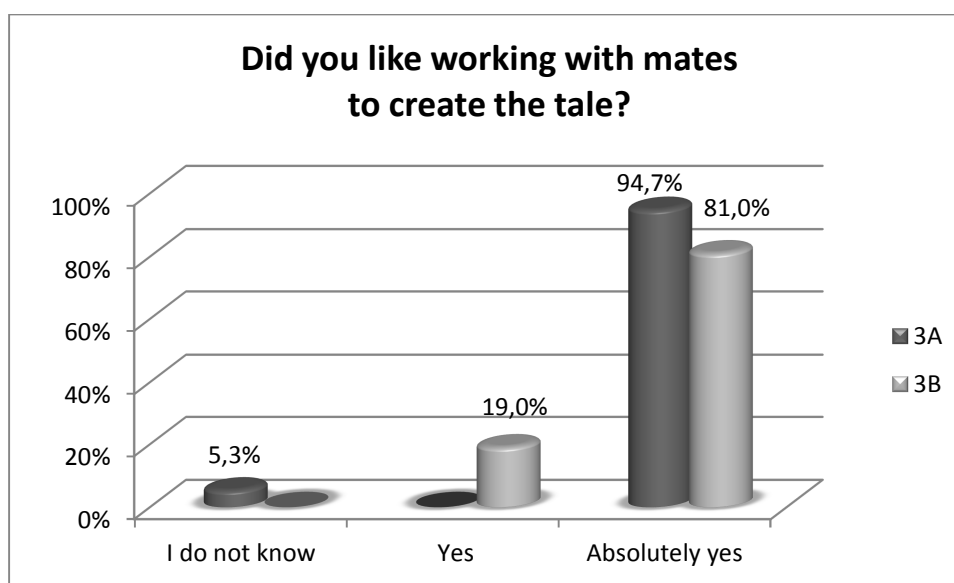
3. COLLABORATION

However, the naturalness of interaction with a wide range of artifacts (images, words, sounds, videos) offered by the IWB gave free rein to pupils' imagination and stimulated the formulation of thoughts and stories; the possibility to interact side by side with classmates during this creative process could encourage all pupils to share ideas and stimulate communication about the current activity.

In this section the Likert scale helps to understand if pupils liked working with mates both in writing the fairytale and playing puzzle. Both classrooms appreciated the help of mates during the writing activity more than during the puzzle game (see picture 6.16 and 6.17).

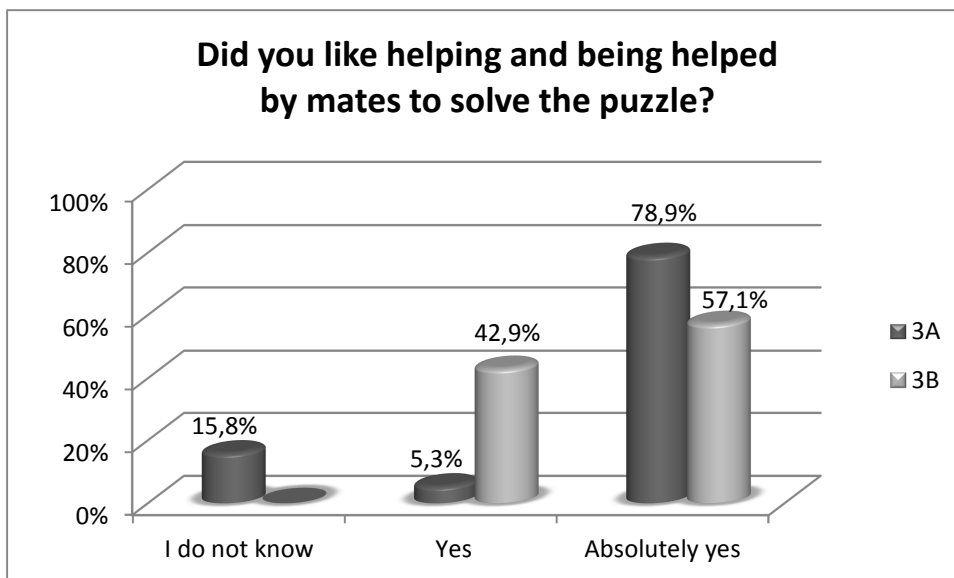
Taking into account the writing phase of the tale, pupils of 3A and 3B appreciated working with mates in creating the tale: in 3B pupils had no doubts on this (see picture 6.16).

The positive results in reaching the helpfulness of pupils can be due not to the specific approach developed by the two teachers, that is interacting personally (3A) or in groups (3B) with the screen, but to the communication and collaboration possibilities offered by the IWB. Moreover, collaboration is integral to the design of the whole activity: involving specific moments of collecting suggestions, choosing images or events, and negotiating the development of the story.



Picture 6.16 Pupils' answers about creating the tale with mates

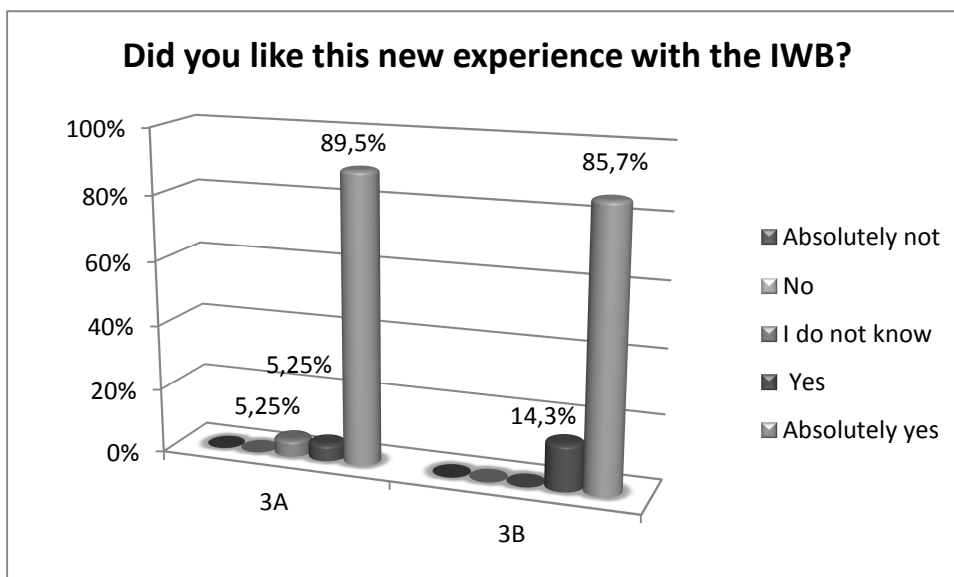
During the puzzle game, even if not interacting in first person with the IWB because other pupils were in front of the device, a challenging attitude alternated to moments of real support for one group or for another (e.g. succeeding in solving the puzzle), building a relaxed atmosphere. But looking at picture 6.17, related to this activity, it seems that, for some pupils, competition prevails against willingness within the group doing the same puzzle at the IWB.



Picture 6.17 Pupils' answers about collaborating to solve puzzles

4. PLEASANTNESS and REPLICABILITY

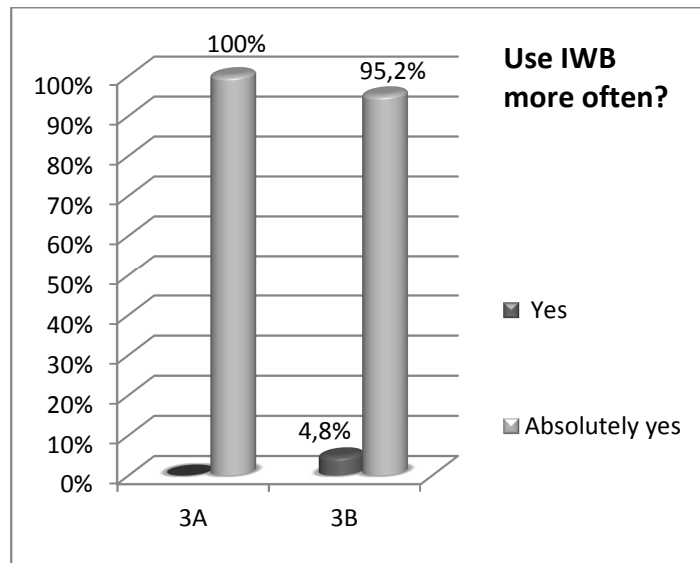
Thanks to the five-item Likert scale, pupils expressed that they have really enjoyed the digital storytelling experience with the IWB (see picture 6.18): all the answers were positive, except one (5,25%).



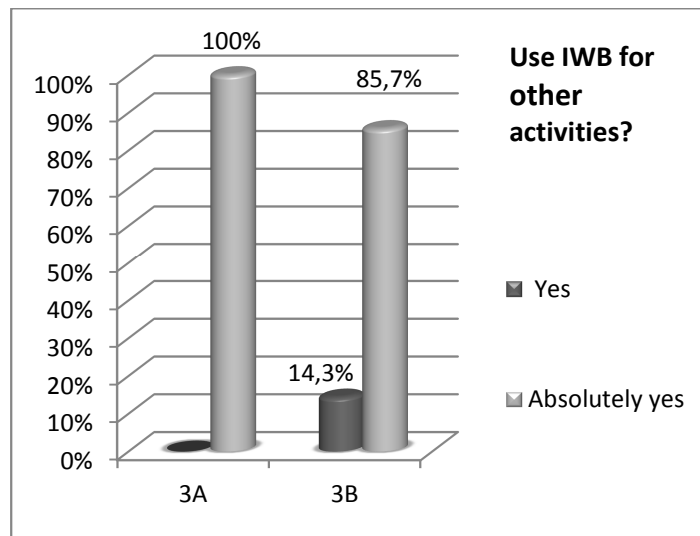
Picture 6.18 The positive results of the experience within both classrooms

Moreover, all pupils expressed positive answers in respect to the fact that they desire to use the IWB more often (see picture 6.19) and have asked also to use the IWB for other subjects and activities (see picture 6.20).

For these two answers, the classroom 3A is completely enthusiastic in respect to the other one: the personal interaction for a certain period of time with has been particularly gratifying.



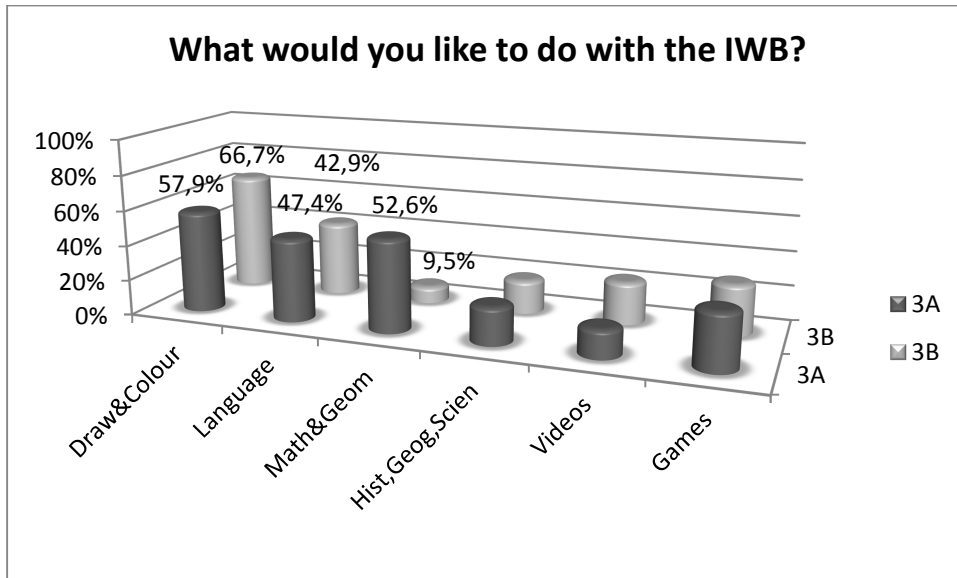
Picture 6.19 Pupils desire to use the IWB more often



Picture 6.20 Pupils desire to use the IWB for other activities

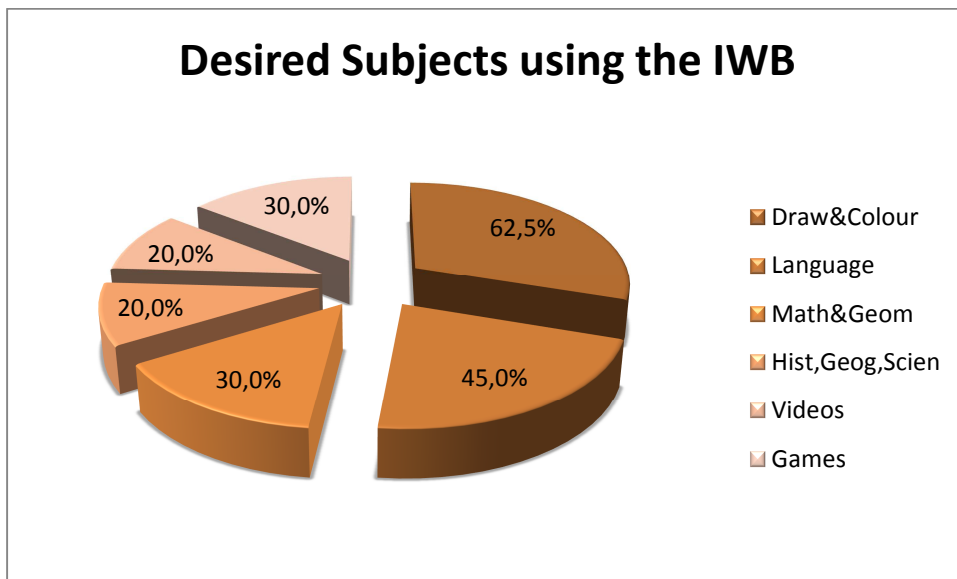
Considering the proposed subjects, there is a significant difference between the two classrooms: 52% of pupils in 3A suggested Math and Geometry activities, while only 9% of pupils in 3B suggested it (see picture 6.21). Actually, the most chosen subjects are related to the possibility of drawing and coloring on the IWB: this struck so much pupils, used to write on the blackboard with very few colored chalks (see picture 6.21 and 6.22).

The use of the IWB for literacy activities, and for digital storytelling in particular, stimulated pupils' imagination: their desire and continuous requests of coming back with new exercises and activities for them have been particularly significant, as underlined by the table.



Picture 6.21 Subjects and activities proposed in the two classrooms

The subject and the activities suggested by pupils have been grouped for the two classrooms (see picture 6.22). Watching videos on the IWB reaches one of the lowest score: pupils prefer to interact with the technology, dealing with all subjects.



Picture 6.22 The suggested subjects and activities grouped for the two classrooms

Also the videotapes of the different phases of the experiment shows pupils really engaged in the process of creating the tale and teachers stressed in their questionnaires that the level of attention and participation of their students during IWB activities was higher than during traditional lessons.

In particular, a pupil with writing difficulties (possible dyslexia) wrote better than usual, both on IWB and on his exercise book. Referring to her classroom, one teacher underlines that “I have noticed more participation in identifying ideas for the text”.

At last, both teachers and pupils were quite satisfied of the experience: teachers easily managed and run the lessons, while pupils well-behaved during the activities, really loving using the IWB.

Even if at a preliminary stage of the research, I have described till now the complete view of a new learning environment, where the classroom of the future should be at the center of a process of transformation, considering both technological and methodological aspects. By starting from previous research on the social impact of interactive screen technologies, my purposes focus on maximizing the benefits of IWBs at school for creating narrative structures. The design of cooperative group activities with continuous turn-taking and a multi-user interaction (which could better be supported through a multi-touch IWB) can really allow to as many children as possible to use the IWB, to stimulate more active participation and the collaboration of the whole class during the creative process. This can happen both for the appeal multimedia devices naturally have on children and for the cooperative mechanisms multi-touch-based interaction is able to trigger.

As a matter fact, starting from this preliminary experiment, children of the 21st century ask for using technological tools for all the subjects and school activities. After a teacher-centric approach to school education, my proposal wants to underline the real importance of placing digital natives’ needs as the focal point in this shifting phase towards new learning technologies and contexts. During this experiment, for example, the higher position of the IWB limited an easy interaction during the writing of the tale with the marker pen, whose position should have been vertical to the surface of the screen. In my opinion, this consideration is emblematic, because underlines the real distance between installing new technologies in classrooms (thought for teachers), and changing completely the didactic approach during every-day lessons in respect to technological devices (thought for pupils).

6.5 Technology Enhanced Music Project: second experiment

Taking into account the positive results of the previous experiment (Agostini & Di Biase, 2011) in stimulating participation and collaboration among pupils in primary schools by using Interactive WhiteBoards to support literacy activities (Agostini et al., 2010), a second experimentation has been planned and developed within a different school: the primary school “A. Moro” in Canegrate (MI) during the 2011-2012 school year. This further experiment has been planned in order to enrich and expand the research itself.

First of all, this time I have not met teachers in order to propose and test a software prototype for IWBs and involving them only in deciding few features: the topic of the fairytale (e.g. Prehistory), the pictures, or some extra-activities, as in the previous experiment. I aim at involving them since the initial design of the lesson and of the technologies they need, in order to reach participatory design phases, before developing a specific tool.

This has been possible lowering the level of difficulty in developing the desired tool, passing from Microsoft Expression Blend, which needs C# programming, to the SMART Notebook Suite, already running on the IWB and already familiar to some teachers.

Secondly, I want to experiment a different subject: music. Generally, music lessons are quite appealing for children and some musical tasks (e.g., playing musical instruments) show a strong physical and emotional involvement. The primary purpose is discovering if the adoption of technology-enhanced tools, e.g. large interactive screens and other small devices like pads and tabs (Weiser, 1991), can enhance pupils' involvement and interest even in those cases, like music lessons, in which topics and tasks are already appealing for children.

Moreover, I would like to analyze what happens to involvement, interest, and participation of students when musical instruments are, partially or totally, substituted by virtual/digital musical instruments. For example, is playing drums 'emotionally' equivalent to beat on pads for digital natives? In some way, I may find educational situations in which technology results unsuitable or useless in order to better understand and delimit the areas of intervention.

Thirdly, this time I plan to have a control group (two classes out of four), in order to compare a traditional music lesson with a technology-augmented one and to discover how technology influences music lessons in terms of changes in teaching and learning practices as well as in terms of differences in students' involvement, interest, and collaboration.

In defining the music lessons the primary aims are to stimulate interest, participation, and involvement of students and to engage them in collaborative tasks. In designing the lessons, I avoid imposing pre-defined activities and technology on teachers involving them, on the contrary, in a participative process for the design of the music lessons and of the necessary tool. It was possible to start from a basic schema for a music lesson of the music teacher, based on the SMART Notebook software, and improving it with the help of all teachers involved in the experiment, both the music teacher and not disciplinary ones.

I scheduled various workshops for collaboratively defining educational goals and contents of the lessons, choosing instruments and technologies to adopt, designing the prototypes, and planning the experimental phase.

The final outcome was divided into three music lessons. The first two lessons, which are only supported by an Interactive WhiteBoard, were closed within the 2011-2012 school year, while the experimentation of the third was scheduled for the 2012-2013 school year.

Taking into account the contents of the lessons, the first one is inspired by "The young person's guide to the orchestra" (B. Britten) and is focused on learning the section of an orchestra as well as the names of the different musical instruments, while the second one is based on the music fairytale of "Peter and the Wolf" (S. Prokofiev) and is devoted to recognize the timbres and melodies of specific musical instruments, through the characters of the fairytale.

In designing the first music lesson together with teachers, we agreed to enrich the flash tool realized by Daydream Education⁹⁶, which is free and available in the multimedia catalogue of the program, translating it in Italian and adding the possibility to move labels on the pictures of each single musical instrument (see picture 6.23).

⁹⁶ <http://www.daydreameducation.co.uk>.



Picture 6.23 Learning the sections and the instruments of the orchestra

Teachers planned to arrange small groups of pupils in front of the IWB, to listen to different timbres of the sections of the orchestra and discover, helping each other, the names of the instruments.

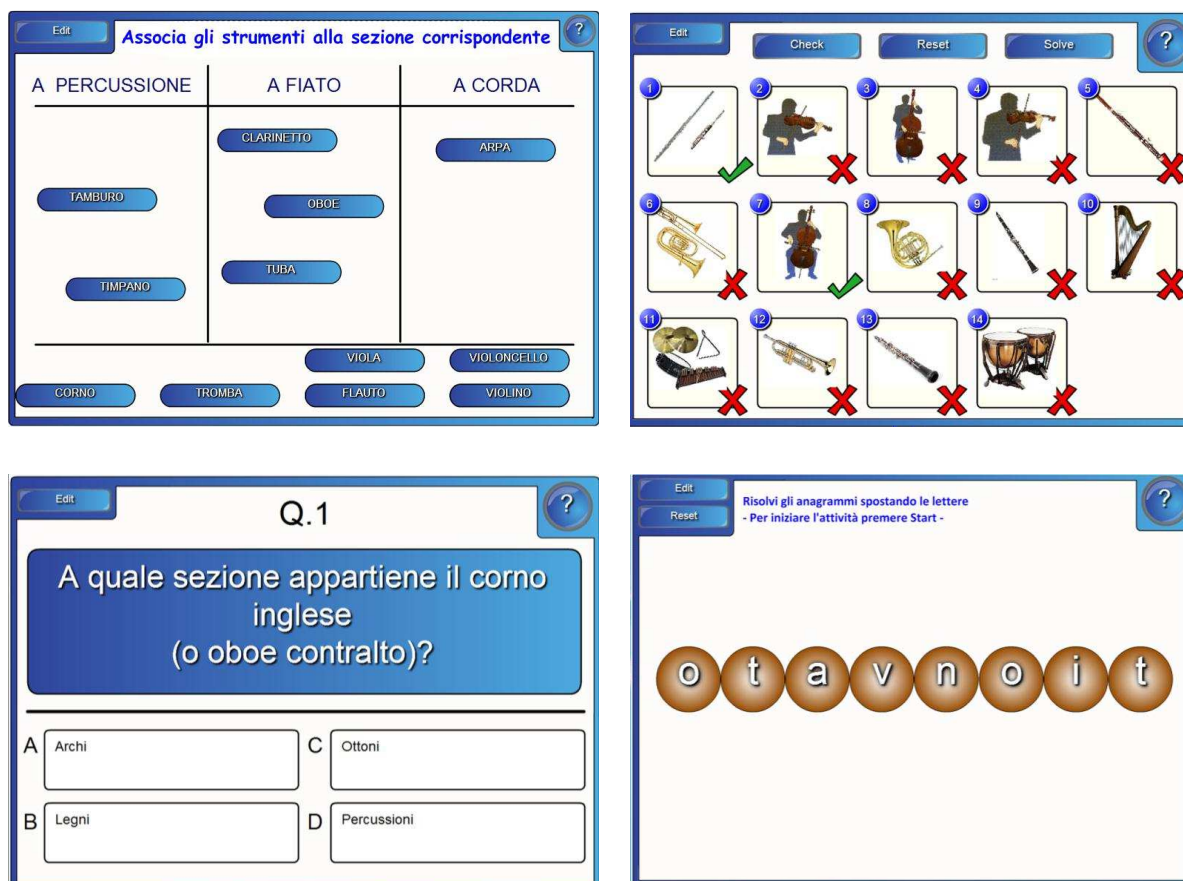
After some exercises pupils should be ready for the core section of the lesson: listening to “The young person’s guide to the orchestra” by B. Britten (17’), performed by the YouTube Symphony Orchestra⁹⁷, and then trying to recognize and order the names of the instruments played within the video (see picture 6.24).



Picture 6.24 A frame of the YouTube Symphony Orchestra (2011)

⁹⁷ <http://www.youtube.com/watch?v=3HhTMJ2bek0>.

Further multimedia maps and schemas, using the SMART Notebook software were proposed together with “Solve and Check” tests to make pupils exercise (see picture 6.25). The following music games and collaborative tasks on IWB, involving small groups of pupils, completed this first music lesson.



Picture 6.25 A selection of exercises and games of the first music lesson

The design of the second music lesson aims at recognizing the timbres of music instruments, at memorizing small melodic patterns and at relating them to specific characters of “Peter and the Wolf” fairytale (S. Prokofiev), as in picture 6.26.



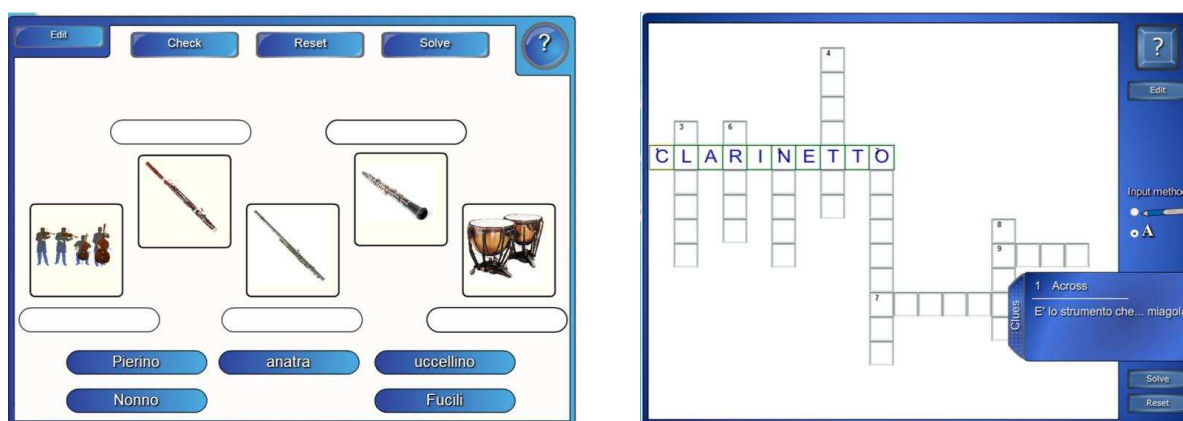
Picture 6.26 A screenshot of the second music lesson

Pupils are stimulated in listening to the melodies of each character of the story before watching the Walt Disney Cartoon⁹⁸ (15'), chosen together with teachers among different possibilities: all characters of the tale (Peter, the bird, the duck, the cat, the grandpa, the hunters, and the wolf) are firstly introduced by a voice-over, with their related musical theme (string quartet, flute, oboe, clarinet, bassoon, kettledrums, and horns respectively), before telling the whole story (see picture 6.27).



Picture 6.27 Two frames of Walt Disney “Peter and the Wolf” (1946)

Some quizzes and crosswords (see picture 6.28) allow pupils to memorize the musical instruments of the fairytale and let teachers understand if the contents of the second music lesson have been completely assimilated.

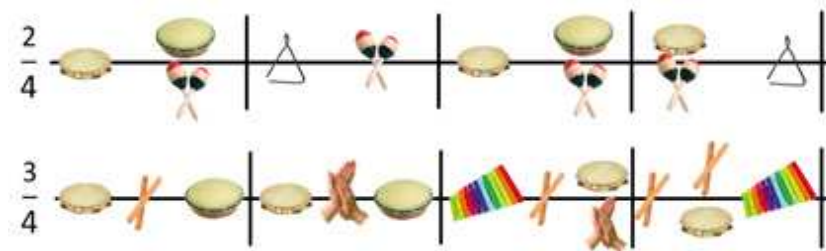


Picture 6.28 A matching-items exercise and a crossword of the second music lesson

In planning the third lesson the music activities are quite different from the previous ones, being more challenging both for teachers and pupils. Pupils are more actively engaged since they have to pretend to be real musicians and to set a fairytale to music: actually, this is an expansion of the multimedia possibilities of the first experimentation of digital storytelling.

⁹⁸ <http://www.youtube.com/watch?v=prI9mAuejA&feature=youtu.be>.

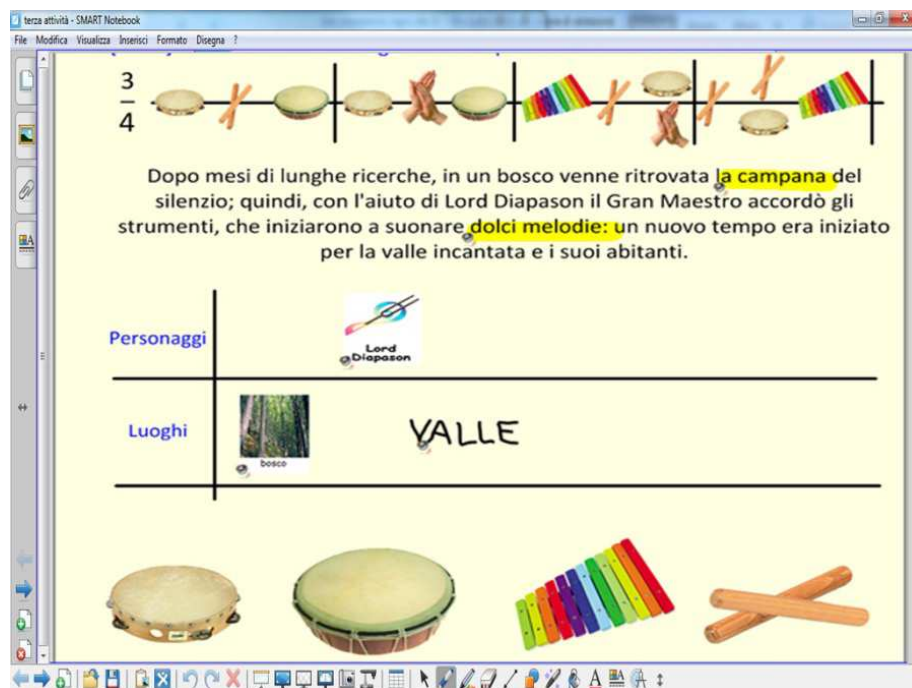
In this case, the IWB can be used as a shared score supporting both the plot and the musical background of the story. Pupils can associate short rhythmic patterns (see picture 6.29) to characters, phases, and particular events of the story (see picture 6.30).



Picture 6.29 Examples of short rhythmic patterns involving different instruments

Taking into account that: “in task such composing, children may have none, some or all parameters assigned by the task, such as given structure, medium, rhythm or pitch set” (Bournard & Younker, 2008), I avoid to establish rules during the approach to this composing task: children are free to experiment sound effects for characters and events. During this phase pupils can play ‘physical’ rhythm instruments (e.g., triangles, drums, cymbals) together with ‘digital’ musical artifacts available on both the IWB and on small portable devices. Children can discuss and decide together, with the help of the teacher, which are the pattern or the melodic effects to be assigned to each character or to a particular moment of the tale.

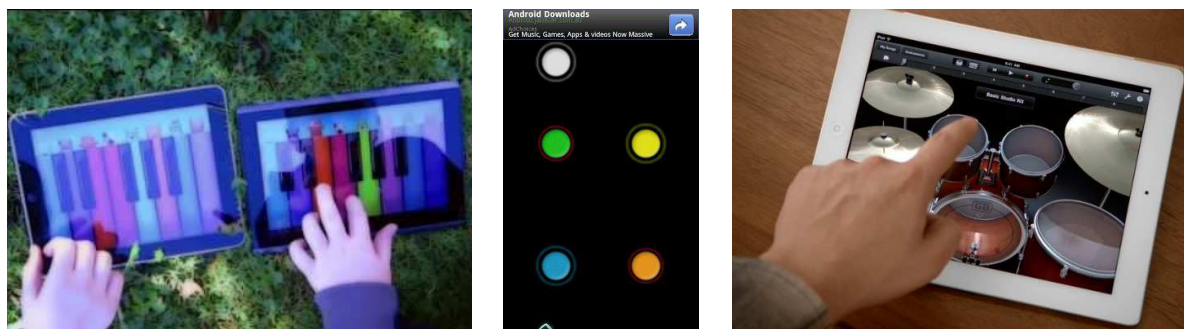
Afterward, pupils and the teacher can try to codify rhythmic patterns and the direction of a single section of musical instruments (traditional, digital or both) could be assigned to a pupil, acting as first violin.



Picture 6.30 A rhythmic pattern describes the setting (valley) of the fairytale

In the end, a director can be chosen to coordinate the different sections in front of the IWB. By taking turns on the first musician's role in each section or on the director's role, a dynamic participative process is assured. Creativity and serendipity are key elements of this open-ended third lesson, centered "more on exploration and discovery than on solution and closure" (Dillon, 2003).

This third learning path merges real and virtual musical instruments (see picture 6.31) within the same context and completes the previous two paths: listening to musical instruments, observing the sections of the orchestra (first lesson), and recognizing melodic patterns related to specific characters of a tale (second lesson).



Picture 6.31 Piano, ocarina, drums apps for smartphones and tablets

Focusing on the experimental phase of this Technology Enhanced Music Project, it involved 4 classes and their 4 teachers: in total, 99 pupils aged between 8 to 10 (52 male and 47 female) participated to the music experiment.

To better analyze pros and cons of using technology (e.g. IWB or pads/tabs) in respect to teaching and learning approaches I had to compare the technology-enhanced lessons with similar traditional ones.

However, to avoid an excessive penalization of some classes, teachers agreed to have a control group – classes without the support of IWB or pads/tabs – only for the first two lessons but not for the third one. Two classes and their teachers were the control group, using only a CD player. In this case, pupils start by listening to the musical sections of the Britten orchestra and to the Prokofiev musical story. After that they practice on short paper-and-pencil activities, like matching items and filling in the gaps.

All the activities (with and without technological devices) were recorded through videotaping and, if it is the case, screen tracking. Informal meetings and pre/post questionnaires had been administered both to teachers and pupils in order to outline differences in teaching and learning experience of music with or without the use of technology.

Trying to reflect upon the first and the second music lesson with the use of the IWB, the project met teachers' needs to better exploit the large interactive screen available in one classroom as well as to adopt that technology in an unexplored subject: music. Moreover, the in-class support during music lessons helped generalist teachers to feel confident in dealing with this subject (Holden & Button, 2006).

Actually, music is already an appealing subject for pupils, however, the preliminary outcomes of the experiment highlighted that there is a benefic influence of using technology, especially reflecting on the didactical approach: those classes using the IWB were stimulated in doing more and doing better. These considerations are well-founded both for pupils and teachers, which have been involved in designing new musical lessons.

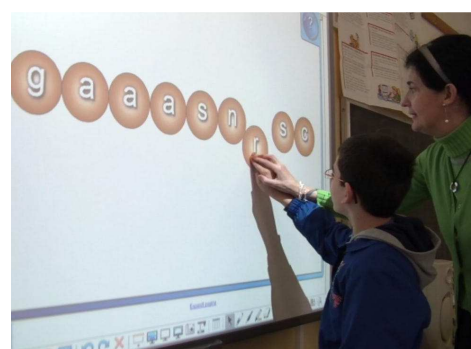
However, teaching methods have been different in the management of the “digital” lesson. In one classrooms (4C) pupils performed all the activities in small groups (four or five pupils chosen by the teacher) in front of the IWB, helping each other to solve problems (see picture 6.32), while the teacher stimulated the rest of the class to act as supervisor.



Picture 6.32 Groups of pupils working and helping each other at the IWB (4C)

In the other classroom (5A), the teacher preferred to divide pupils into established groups, fixed and in competition during the activities: this caused more chatting at the desks joined to competitiveness.

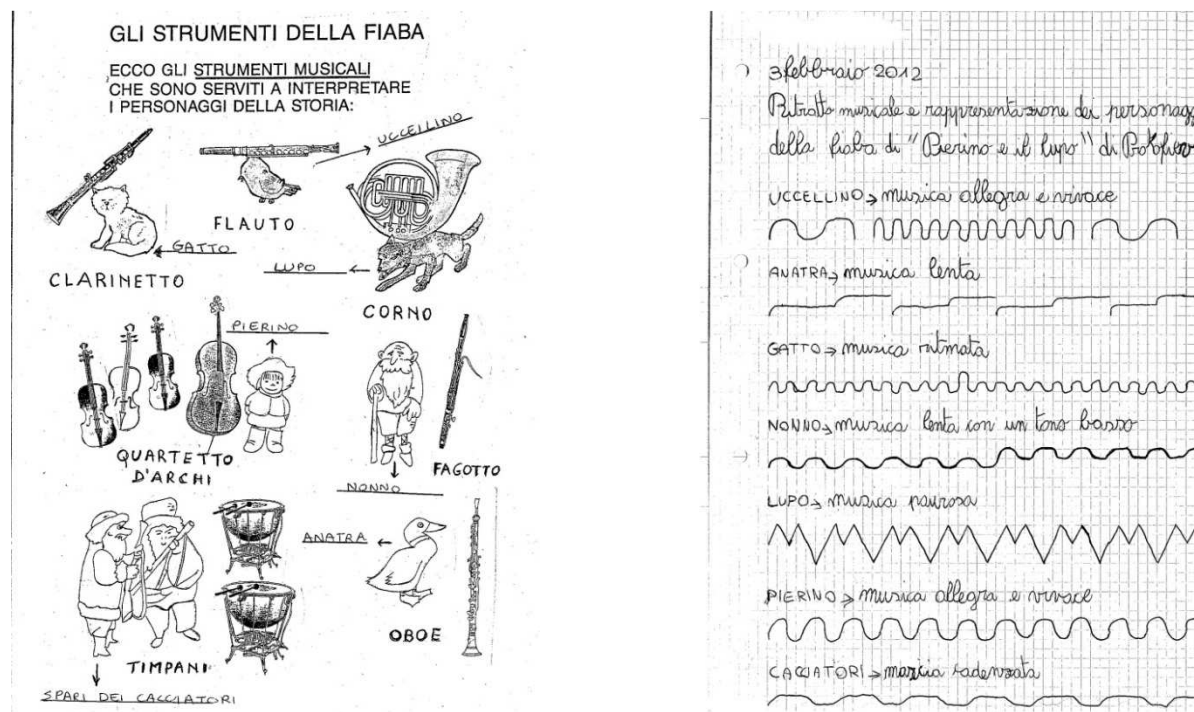
Anyway, she let interact only one pupil at a time to solve very short tasks, in order to facilitate pupils’ rotation, helping in first person in case of need (see picture 6.33).



Picture 6.33 One pupil at a time interact with the IWB (5A)

Moreover, the multimedia capabilities of large interactive screens helped teachers in developing more collaborative activities and in offering more appealing contents and tasks to pupils during lessons. As a matter of fact, technology had been a valid choice in simulating on the IWB musical instruments that were unavailable in this school.

Other significant aspects should be underlined shortly. Teachers from the control group proposed only non-collaborative activities adopting a ‘traditional’ teaching method: frontal explanations, paper-and-pencil activities, listening exercises and drawings of melodic and rhythmic patterns of Peter’s tale (see picture 6.34).



Picture 6.34 Examples of paper-and-pencil exercises and drawings

Both teachers did not plan activities on the traditional blackboard, without considering the importance of collaborative and kinesthetic learning: pupils had been quietly at their desks for the duration of the two lessons (see picture 6.35). Moreover, the activities proposed by teachers of the control group were easier than the technological ones (see picture 6.34).



Picture 6.35 Some pupils from the control groups (4D and 5D)

The other teachers, performing the lessons with the IWB, needed our help in transforming the traditional lessons into technological augmented ones, even if they had a good computer literacy. Teachers “require the opportunity and support to explore new approaches to teaching music in the context of their own classroom” (Holden & Button, 2006).

On the contrary, digital natives are comfortable with touch-based technologies and behaved naturally. Definitely, pupils enjoyed the technology-enhanced activities (see picture 6.36).



Picture 6.36 Pupils' involvement while watching "Peter and the Wolf"

They loved the possibility of listening and recording their performances and showing them to their parents. This is one of the aspects of a pervasive learning vision, which can widen temporal and formal boundaries of traditional school lessons. Moreover, the future possibility of performing the third music lesson, joining together real and virtual musical instruments (thanks to apps and musical artifacts, running on small portable devices) can allow pupils the discovery of a larger set of musical instruments, enriching their musical experience, that can culminate visiting a real "strumentoteca" a private collection⁹⁹ of 10.380 musical instruments of all over the world, where I have been few years ago.

Analyzing the questionnaires, teachers have been satisfied of the experience, but while one of the teacher using the IWB (4C) underlined a diminution of distraction, thanks to a growing interest and participation among pupils, one of the teacher of the control group noticed a lowering of the level of attention during the last phase of the traditional lesson. From pupils' questionnaires, it should be noticed that the control groups tended to be distracted by the cameras recording the lessons, while the classrooms using the IWB were completely hypnotized by the devices, and did not take care of the videotaping.

In the following I report the translated comments written in a specific section of the questionnaires by the pupils of 5A and 4C, the two classes interacting with the IWB, because their voices witness their enthusiasm and participation (especially in 4C, where pupils have been working together and interacting in groups).

Riccardo (5A): *"It was funny and I told to my parents at home!"*

Gaia (4C): *"I enjoy it very much.. and I wish you come back with new pieces, exercises and all that comes in your mind!"*

Martina (4C): *"It was fantastic! This experiences let you know the name of the instruments and their sounds: I wish to repeat it!"*

Sara (4C): *"I loved it. Thanks to having been with us!"*

⁹⁹ <http://www.strumentoteca.it/>.

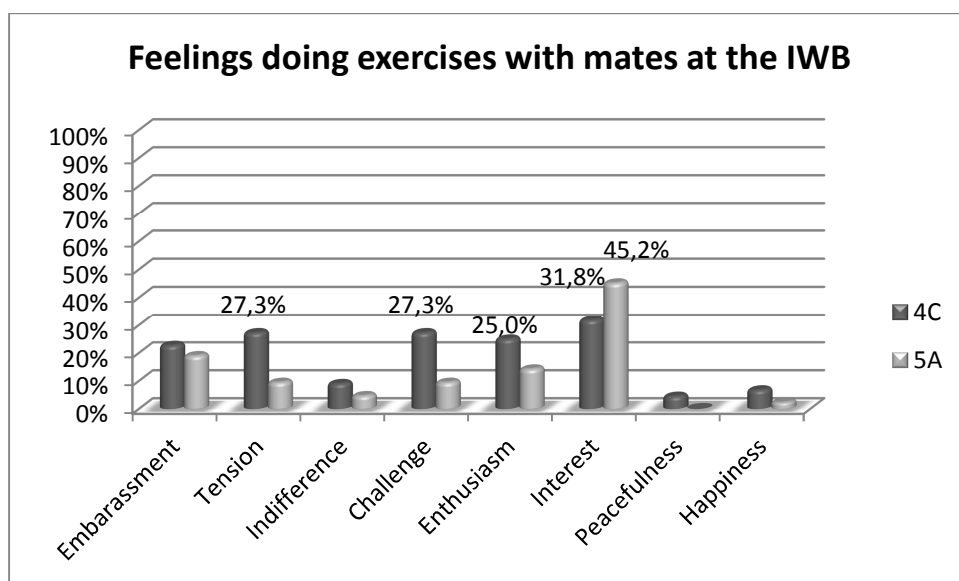
6.6 Results of the second experiment and some observations

In the following, I am going to underline the results related to this second experimentation. In order to understand the following pictures, there are some preliminary remarks to be taken into account. The class 4C started using the IWB only 3 months before starting the experimentation, but use it nearly every day (from the teacher's questionnaire). The class 5A had been using the IWB for more than a year, but use it rarely, 3 or 4 time a month.

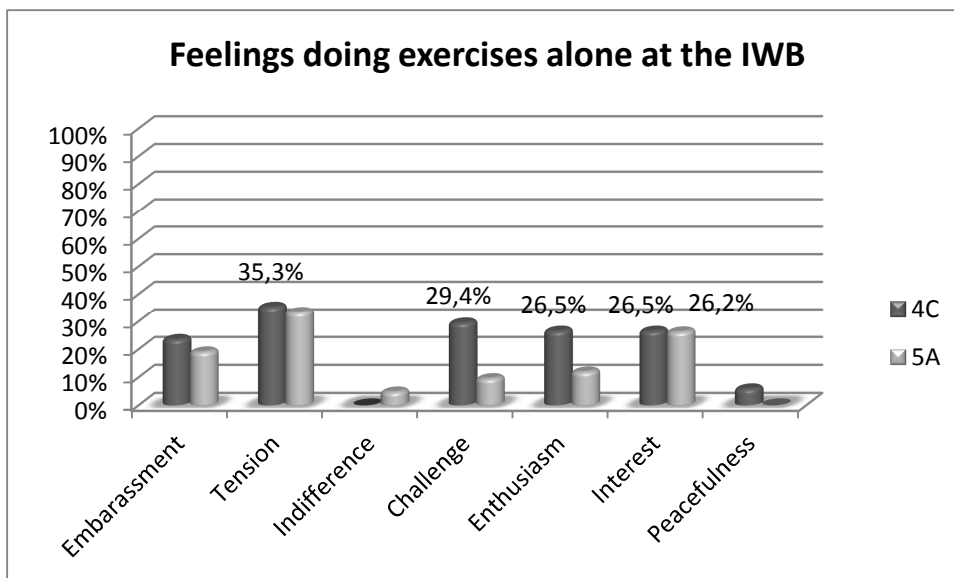
The class 4C underlines a real involvement, even underlined by tension and embarrassment, together with a sense of challenge and enthusiasm when working alone or together with mates at the IWB. As a matter of fact, for the didactical strategy chosen by their teacher, these pupils did never interact really "alone" at the IWB: pupils are called at the IWB in groups chosen extemporarily, and behave as being "everyone against everyone".

The class 5A, on the contrary, did never interact "with mates" at the IWB, but they consider of being working together with their peers, even if not present as a group at the IWB. In this way we can interpret that the interest is really high on what has been done at the IWB by the pupil of the same group (see picture 6.37). The pupils of this class have been divided into established groups at the beginning of the lesson, but they are called individually at the IWB: when it happens the tension arise, but they seem less enthusiastic, even if interacting in first person during the lesson (see picture 6.38).

It seems that even the interest for the device is quite high, the aspects of personal involvement and enthusiasm decrease with a sporadic use of the device itself, or with a slow turn taking in front of the device, or with both conditions. These aspects would need further researches to be confirmed.



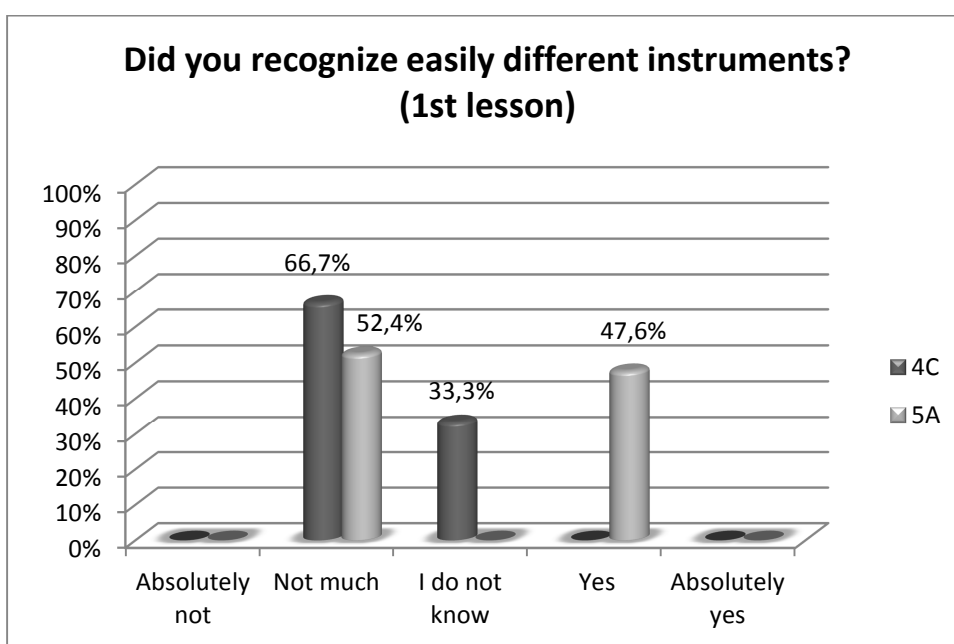
Picture 6.37 Pupils feelings during all music activities with the IWB



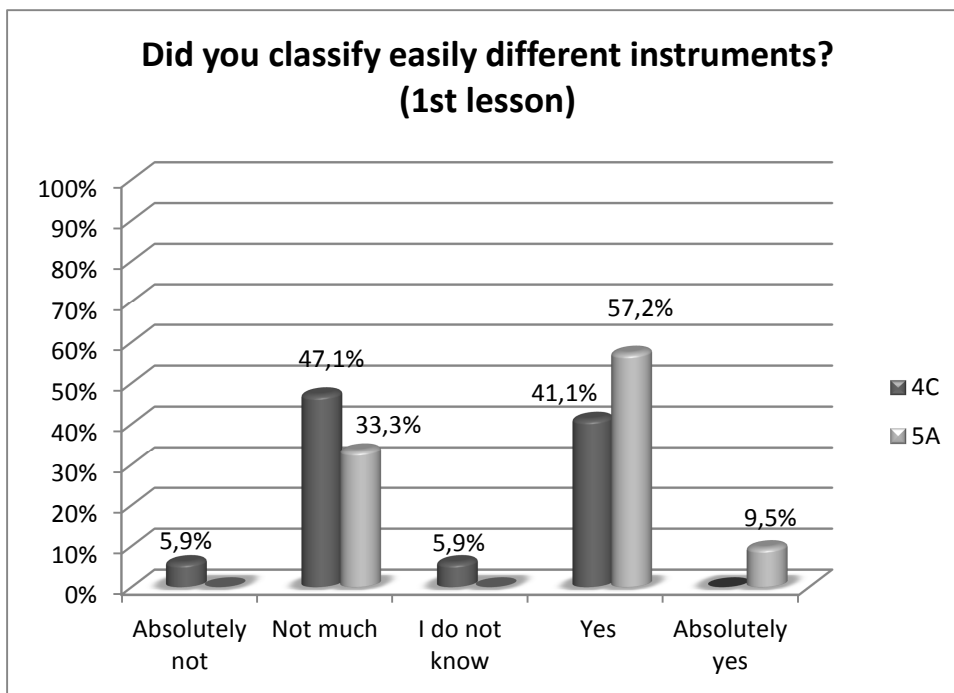
Picture 6.38 Pupils' feelings while interacting directly with the IWB during music

In the next section I am going to compare pupils' difficulties and then preferences for the two music lessons: the exercises on musical instruments based on Britten's orchestra and the ones on instruments and characters based on Prokofiev's Peter and the Wolf.

One interesting factor is that teachers, stimulated by a rich interactive material, developed with our help a wide set of exercises and tests, which have been really challenging for pupils (see picture 6.39 and 6.40) and teachers too! The presence of automatic correction systems for some tests facilitate not disciplinary teachers to get in touch with complicated names of non-conventional instruments (e.g. bassoon).



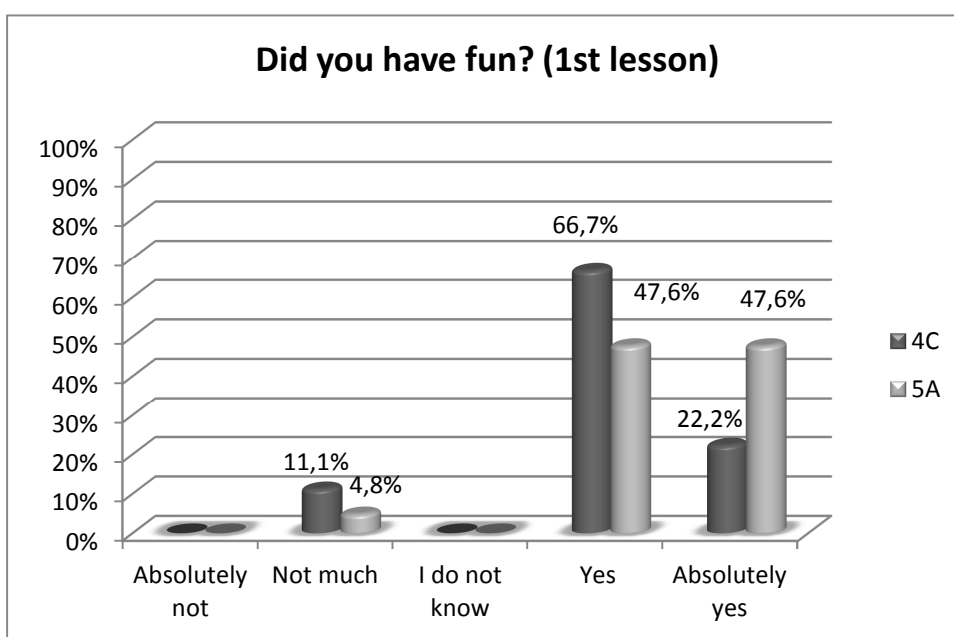
Picture 6.39 Exercises of the first lesson on instruments and sections of B. Britten's orchestra



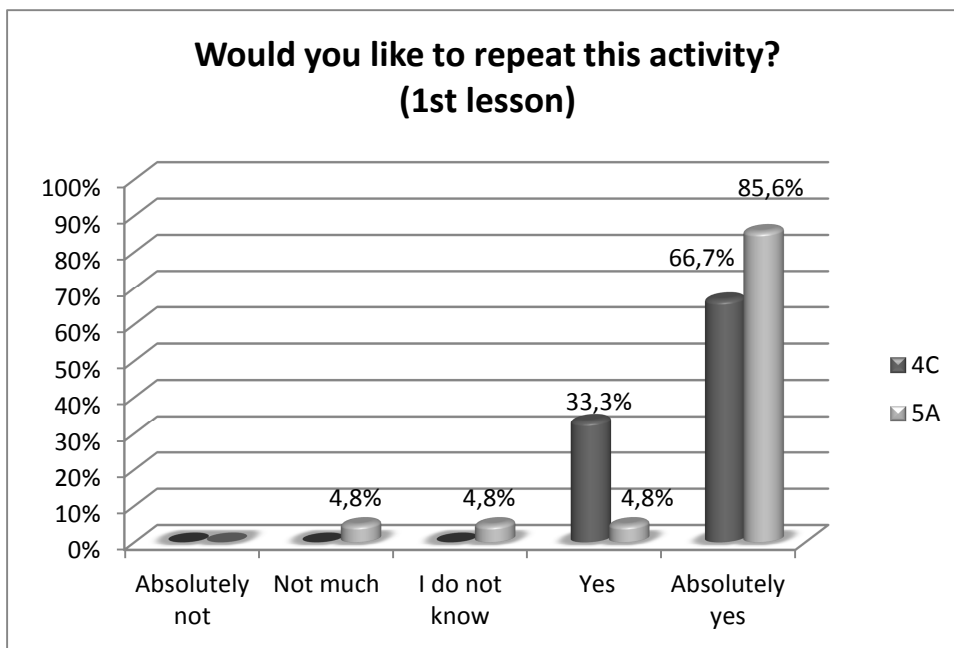
Picture 6.40 Exercises of the first lesson on instruments and sections of B. Britten's orchestra

Even if pictures 6.39 and 6.40 show that pupils are conscious of their difficulties while recognizing new instruments (especially in class 4C, the one tackling the experiment with a non-disciplinary teacher), further exercises of classification and matching items during the same lesson trigger an improvement, which is then consolidated during the next lesson on "Peter and the Wolf" (see picture 6.43).

Moreover, we have seen that their challenging attitude and the support of mates result both in having fun (see picture 6.41) and desiring to repeat this music lesson (see picture 6.42).



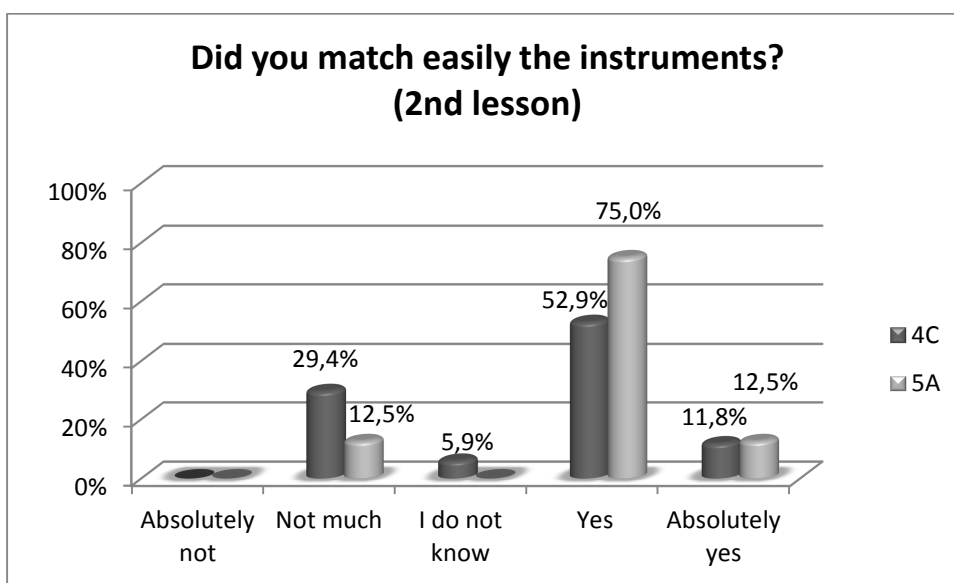
Picture 6.41 Pupils' fun during the lesson based on Britten's orchestra



Picture 6.42 Pupils' desire of repeating the lesson based on Britten's orchestra

In the following the results are referred to the second lesson on “Peter and the Wolf” music fairytale. Here some difficulties are left in matching correctly instruments, but there is a concrete improvement.

Pupils of class 4C reach the 64,7% of positive answers (52,9% +11,8%) in recognizing more easily the musical instruments (see picture 6.43), starting from a 66,7% answering “Not much” and 33,3% “I do not know”; pupils of 5A score 87,5% (75%+12,5%) of positive answers, starting from 52,4% of “Not much” and 47,6% of “Yes”.



Picture 6.43 Improvement in recognizing instruments during the lesson based on Prokofiev's tale

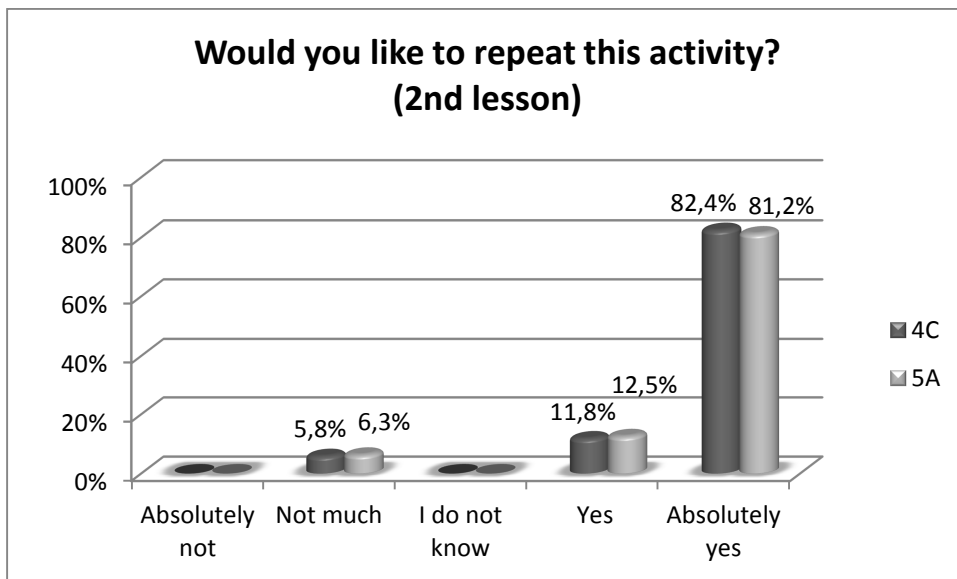
High percentages of fun and desire of repeating this second lesson are shown in picture 6.44 and 6.45, respectively.

The 94,1% of pupils of class 4C and the 93,7% of class 5A enjoy this second lesson.



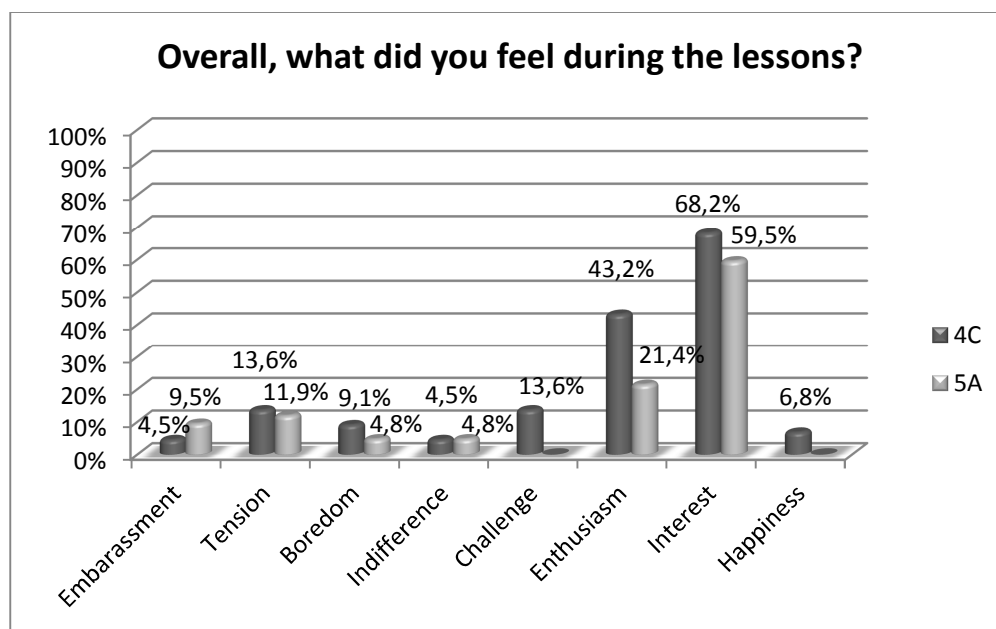
Picture 6.44 Pupils' fun during the lesson based on Prokofiev's tale

Considering the possibility of repeating this lesson, pupils of both classrooms reach high scores.



Picture 6.45 Pupils' desire of repeating the lesson based on Prokofiev's tale

Finally, when we ask pupils how do they feel during the whole music lessons we find some interesting issues: the class 4C, which adopt a didactical strategy of groups turn taking in front of the IWB with groups chosen extemporarily by the teacher, reached higher score of challenge, enthusiasm, interest and happiness (see picture 6.46).



Picture 6.46 A final comparison between the two classrooms

At the end of this second experiment there are some key aspects that, even if needing further experimentation and analysis, are significant.

Pupils love interacting with technologies, and teachers, especially when supported, accept the challenge of reorganizing and reinventing traditional lessons and established roles, acting as mediator of pupils' interaction with both mates and technology. Moreover, large interactive screen gives teachers the opportunity of trying different didactical approaches, exploiting at best kinesthetic and participatory learning, letting student exploit their technological capabilities acquired during everyday life. The organization of small groups for the activities in front of the IWB offers better results in engagement and active participation in both experiences, simulating the multi-user interaction offered by recent multi-touch screens.

Moreover, teachers should be involved within the process of personalization and design of technology-enhanced activities, which should be part of the everyday scholastic curriculum, and not for sporadic use. Thanks to the technological opportunities presented with the model of pervasive classrooms and projecting "intelligent" school buildings, teachers will reduce time spent for calling the register or other bureaucratic activities during everyday lessons, focusing only on didactics and students' needs.

Chapter 7. Conclusions and future perspectives

This last chapter represents a further deepening and then a summary of the ideas and case studies described within the thesis: from the concept of “backbone”, to a rethinking of the knowledge circulation process, from the “thick bit” suggestion till new knowledge types, together with new issues and social perspectives.

7.1 The backbone of Knowledge Society

Even if it is not easy to define what is the actual Knowledge Society, a process continuously changing, I propose a deepening of the socio-technical framework of our Knowledge Society (see chap. 2), introducing the concept of *backbone*.

The Knowledge Society backbone is composed by the intertwined fibers of three key process-oriented concepts: the pervasiveness of *knowledge*, the ubiquity of *technology*, the centrality of *individuals* (Cerroni & Di Biase, 2012a).

All these components are at the core of new knowledge production and circulation processes (see par. 7.2), in which disciplinary boundaries fade away in a converging technologies scenario, where human life and nature are more and more imbued with knowledge.

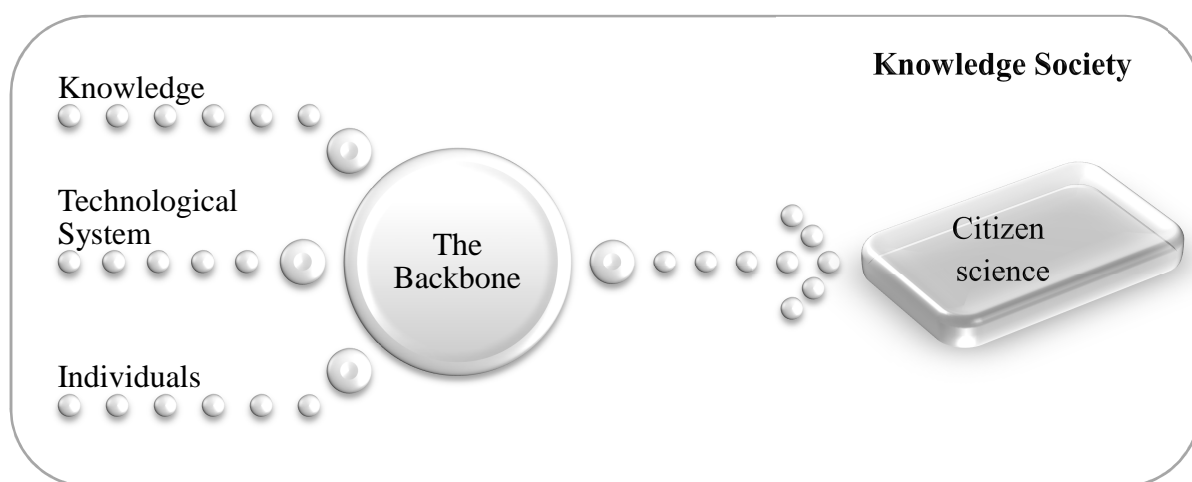
Firstly, *knowledge* is really pervading our world in a chain reaction: it is collectively produced, materialized inside new artificial and intellectual products, sharable in space and time (Cerroni, 2006). As a matter of fact, knowledge permeates people lifestyles, working activities and spare time, new economies and business models, social participation and communities: our life in its whole is knowledge-enhanced, enabling the discovery of new worlds of sense, of new knowledge.

Secondly, *technology* is encapsulated into everyday educational and working tools, into multimedia devices and digital artifacts, or embedded within artificial environments and intelligent systems. In this way the intelligence and the knowledge are within common things, that can: “think” autonomously (e.g. Internet of Things), “help people to think” (e.g. mind maps software), or “let them think” and concentrate on something else (e.g. ADAS, Advanced Driver Assistance Systems), reducing their cognitive/attention load, through sensors and smart systems.

Actually, thanks to new technologies, we have the possibility to expand natural boundaries (e.g. tele-presence within a real environment), to enrich our senses and awareness (e.g. Augmented Reality opportunities), during every single moment of our life. Actually, this is a *Technological System* encompassing, for instance, different objects, devices, artifacts, patents, and environments.

Thirdly, another process is jointly developing with this technology-enhanced society: the society of the *individuals* and their engagement in every social process, declined in different ways. In the social context we can consider bottom-up movements like the regime of economics and socio-politics of collective experimentation (Felt et al., 2007), the community-based innovation, the open science movement and Open Source Software (OSS). Within some fields of computer science the user is at the core of design (e.g. User-Centered Design, UCD), programming (e.g. End-User Development, EUD) and new content production processes (e.g. User-Generated Content, UGC). The world wide web in its whole, perceived as a collective intelligence, is exploited for social computation, thanks to wisdom of crowds principles, social networks and, last but not least, social capital.

The continuous rise of collective instruments and environments, thanks to Web 2.0 technologies, underlines these push-pull phenomena, where user-induced innovation and knowledge generation combine well with technology-triggered processes (see picture 7.1).



Picture 7.1 The Backbone of Knowledge Society

7.2 New processes, dimensions and types of knowledge

Within this work, I have studied and described how *research, cultural and educational processes* have been changed and are continuously changing with the introduction and capillary diffusion of new technologies.

At this point, having in mind the backbone of the Knowledge Society, I can use the knowledge circulation process (see par. 2.1) as the lens through which rethink the way we conduct academic research (see chap. 4), read write or publish new cultural contents (chap. 5) or teach and learn at school (chap. 6): all these contexts could be tackled as liquid phases of this never-ending circulation process (Cerroni & Di Biase, 2012b).

The phase of *generation* of new knowledge and ideas is no more an individual practice, based on personal intelligence and capabilities, but rather a social activity, to which different groups of scientists contribute. Actually, each citizen is now called to participate within the context of a knowledge society. Bottom-up movements are affecting not only the scientific world but every social process.

Moreover, within the *institutionalization* phase, it is more clear the collective effort in identifying and organizing knowledge and in sharing new discoveries and research interests, thanks to widespread technological environments (e.g. research, academic and business networks). Researches are carried out going beyond hierarchical, spatial and temporal boundaries, exploiting the collaborative web opportunities for a global knowledge gathering process.

The phase of *diffusion* explains how knowledge is disseminated and communicated, materializing new ideas into meanings, objects and products. Actually we can witness how knowledge exceeds the linguistic context (Cerroni, 2006): beyond circulating into books, now digitalized or even augmented, scientific articles or seminars, we actually have in our hands, day-by-day, diverse digital devices (e.g. e-readers, tablets, smartphones and the like), which represent this encapsulated knowledge, in order to produce, hopefully, further knowledge.

Last but not least, through the *socialization* phase, knowledge is internalized and reproduced within new generations. Education is in this phase the most emblematic example to understand the complexity of mediating knowledge: educational contexts should facilitate the acquisition of those cognitive abilities that not only allow accessing to “knowledge”, as a cultural issue, but that allow accessing to an “enabling knowledge”, considered as the real opportunity for action (Stehr, 2010).

If our society of citizens, thanks to their knowledge, will have the capacity to set something in motion, then new creative communities will really be able to contribute for a co-construction of new forms of knowledge: the k-circulation process can start again, generating further knowledge and widening as a spiral (Cerroni & Di Biase, 2012a).

Some *general remarks* emerge from this excursus through the knowledge circulation process, reconsidering the proposed case studies.

I should underline that not only individuals, such as knowledge workers or, in a more general conception, knowledgeable citizens, are actors of the proposed process, but also knowledge, permeating products and technologies, participates within this process, through enabling artifacts, for further knowledge production and circulation.

Thinking to all technologies that have been described within the thesis, it can be recognized two different genres: on one hand widespread technologies, already socialized, that have completed a “first cycle” and are now common artifacts/practices of everyday life, from working to leisure and cultural activities; on the other hand emerging technologies, which are still between the institutionalization phase and the diffusion phase, which are encapsulated in new niche product or processes, or which are still under experimentation.

To the first species belong technological devices such as multi-touch smartphones, tablets (I-pads) and whiteboards (IWBs), web 2.0 tools, academic social networks and Learning Management Systems, and the first AR opportunities offered, for instance, by QR-codes.

To the second one belong emerging technologies like OUIs (flexible displays), Immersive Virtual Reality Environments, Advanced AR features encapsulated within eye-glasses, or even contact lenses, holographic desktops, innovative Ambient Technologies, till a full integration with Semantic Web capabilities to connect “big data”, fostering knowledge production and sharing.

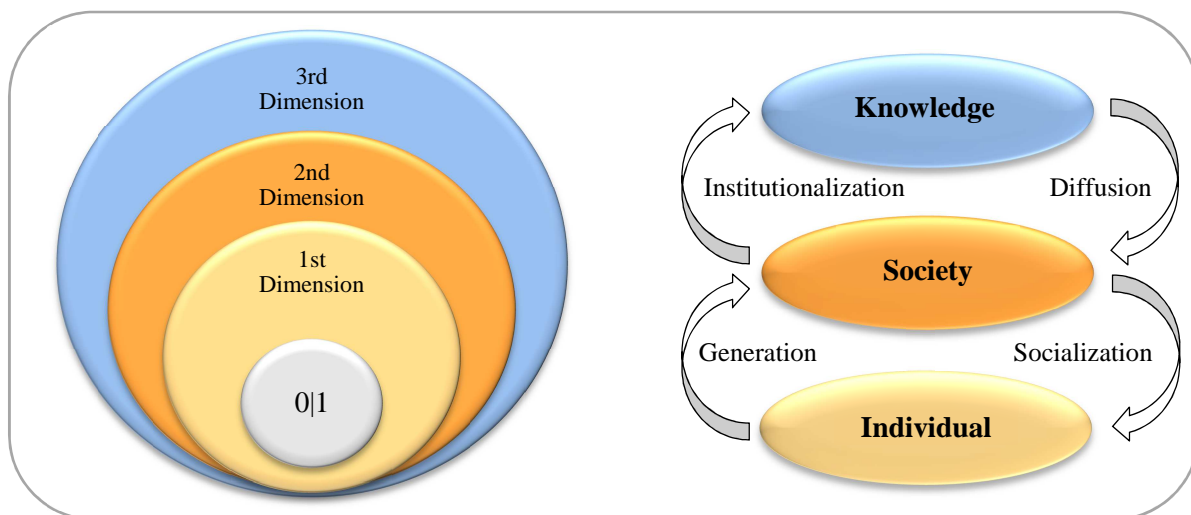
Actually, the 4-(logic)-phase model proposed for the knowledge circulation process can be considered as a fractal, because, starting from being a simple spiral (see picture 2.1), the paradigm can be more and more complicated: each phase includes sub-cycles, can be split into sub-phases, involving different kinds of actors and intermediate steps.

The next step is to zoom in the knowledge circulation process to focus on “which knowledge” is circulating, considering its dimensions and types.

What is really significant is not only the big amount of data (10^{21} bytes), semantically and digitally connected, but also a never-ending process of *thickening* of the information unit: the bit (Cerroni & Di Biase, 2012a).

The information unit is now a “thick bit”, to become a *knowledge unit*, which encompass different dimensions. To explain this thickness, I suggest an analytical interpretation key (see picture 7.2).

The “thick bit” encompasses a 1st Dimension, representing the *emotive/biographic* dimension with all the personal experiences of the individual, a 2nd Dimension, covering the *social* dimension with its relational ties (e.g. of prestige, of trust), and a 3rd Dimension, showing the *symbolic* dimension, described by the different types of knowledge.



Picture 7.2 The “thick bit” of knowledge and its logical dimensions

Taking into account that some of the ordinary ways of communicating knowledge are under a continuous transformative process and that new knowledge types are arising, I refer to the following knowledge types: explicit knowledge, beliefs and ideas, practices and tacit knowledge, and two emerging types, that is embedded and immersive knowledge.

Explicit knowledge is the knowledge codified by words, numbers, mathematical and scientific formulae, and musical notations: it is easily to communicate and distribute to others (e.g. $E=mc^2$).

A *belief* is “a cognitive use, a mind habit regarding mental processes, that is something upon which you can count, with unconscious motivations” (Cerroni, 2002). For instance the Euclidean space represent a belief, because it is not problematized.

An *idea* (e.g. the idea of color) is a thought or abstraction¹⁰⁰, that we formulate, and that we can discuss, accept, actuate, establish, elaborate, clarify, and question, through a more or less intentional reasoning, individually performed (Cohen, 1992). The idea is impossible without speech, and thinking means to give order to our ideas, that is classify.

As beliefs can be considered part of the “conversational implicatures” and ideas do not exist without language in its explicit component, also *practices* and *tacit knowledge* have a privileged communication channel: the first is bound to social costumes and traditions in actions (e.g. shaking hands), the second spreads thanks to imitation of gestures (e.g. riding a bike).

Actually, other two interesting types of knowledge require attention: embedded knowledge and immersive knowledge.

Even if open to further close examinations, *embedded knowledge* can be described as the knowledge “reified” and encapsulated within everyday objects and devices: for instance, computers (knowledge inside) and medicines (active principle). Experts are able to break down such knowledge, as rival firms do with a new product on the market. However, considering these two examples of embedded knowledge, we do not need to know how PCs and drugs work to make them work for us.

Moreover, from being products of embedded intelligence and knowledge, managed only by experts at the beginning, both of them have been simplified (user/patient-friendly) and are now pervading everyday objects/foods. This encapsulated knowledge can be communicated in two different manners: considering a technological device, like a PC or a car, it can be acquired as prosthesis (e.g. cognitive, motor), while in case of a medicine, it can be taken.

Anyway, knowledge, in one sense or in the other, becomes part of our body.

Nowadays the context in which we live is imbued with knowledge and the experience of *immersive knowledge* is more and more frequent: thanks to new technological opportunities (e.g. augmented reality), other new levels of knowledge are available, “materialized” under our eyes.

The impression of an immersive knowledge derives also by the fact that all interfaces and boundaries among levels of knowledge are fading away (e.g. Natural or Organic User Interfaces): in the very next future we will not perceive any more of entering into new levels of knowledge or new worlds of sense. Immersive knowledge opens quite controversial issues, tackled at the end of the following chapter.

¹⁰⁰ In “An essay on beliefs and acceptance”, Oxford University Press, 1992, pp. 174.

7.3 Open issues

In this ending paragraph I am going to wrap-up the conclusions of the thesis in order to reflect and offer some suggestions and future perspectives of the emerging scenario.

All the proposed case studies have been centered on specific technologies, which are emblematic for the deep changes happened and happening within every-day knowledge circulation. Academic social networks and future more complex Mixed Reality Research Environments, the phenomenon of digital publishing and the diffusion of e-books, the introduction of Interactive WhiteBoards within classrooms activities are heralding deep changes about knowledge production, institutionalization, diffusion and socialization in the coming Knowledge Society.

The choice of focusing on a specific technology, which can be considered as a symbol for each of those three environments, is due to the necessity of identifying common aspects of such phenomena and of framing a systemic vision of the changes affecting established academic, cultural and educational roles.

People have changed their lifestyles and will continuously modify, possibly improving, their everyday activities, adopting new technology-augmented artifacts. Actually, all technologies that we are going to use more and more often can be described as *collaborative* and *emotional*, *pervasive* and *situated*, *semantic* and *big data processing*, “*calm*” and *undemanding*, *hypermediating old and new media*, *mixing real and virtual worlds*.

If we consider that all these features and possibilities are not yet exploited in their real potential, the changes we are witnessing are only at a starting point. Moreover, the day by day use of technology is creating a surplus of knowledge, not only because we develop new skills and abilities, but because whenever people learn something sufficiently well, then they are free to use it without thinking, to focus on new goals.

Actually, new *bottom-up movements*, *serendipitous* and *transdisciplinary processes* are affecting the way we produce and share new knowledge. Open Access gives to researchers the possibility of a free access to published scientific works all over the disciplines and to the informal knowledge. The serendipitous aspect of knowledge discovery is of key importance: consulting and comparing big amount of scientific papers or databases, researchers can make important discoveries, that could become more troublesome or expensive if that information space is full of property rights.

Similarly, Creative Commons licenses allow people to create and communicate contents more freely, with different levels of rights, in order to let knowledge circulate within the public. Also self-publishing offers new concrete opportunities in diffusing rapidly best practices: for instance, teachers together with students can collect within a book (or e-book) the results of a year-experimental lessons in which students have been co-authors of the contents and protagonists of the learning (and teaching) process.

Thanks to wide research networks, researchers and their community are *modifying established roles* within traditional institutions, having new opportunities in proposing and joining projects, within advisor and supervisor practices, in publishing and accessing materials, in reaching new international publics, also for the humanities.

Also within cultural context the roles are changing: people are free to be both writers and publishers, or readers and co-authors, or publishers discovering new talents while participating to readers' communities, or even simple readers who offer creative services to writers: the possibilities spread out as soon as people experiment and knowledge circulates.

At the same time, the role of the teacher is transforming into a facilitator of the learning process, in which students are the actors, and into a guide not only in the use, but also in the design of new technological tools: the educational world should be involved in developing the digital wisdom of the next generations, which are actually the real depositaries of the whole knowledge circulation process.

While research, culture and education can all be considered as different steps in the knowledge circulation process, technologies on the inside (at least academic social networks, e-books and large interactive screens here considered) spread over the four phases we already introduced. Each technology gives specific contributions to each phase, as it is easy to see. However, a strong processual view of society shows both the coherence of the circulation process as the engine of the whole knowledge society and the scale invariance of our 4-(logic)-phase model during its expansion.

All in all, new technologies are changing roles so that a citizen science is coming (see picture 7.1) both from the expert-side and the lay-side: we are going to face (more or less professional) *knowledgeable citizens*.

The description of these case studies have introduced the necessity of giving a structure to the present *Knowledge Society*, introducing the concept of *backbone*: I have tried to clarify the intertwining among knowledge, technology and individuals, as the fibers of this dynamic socio-technical framework. In the next future our lives will change dramatically: some of actual complexities of our everyday life will be covered by intelligent agents, exploiting a common format for data exchange, and letting us free to focus on what is really relevant to us. New technology-augmented tools, after continuous processes of "remediation" are going to influence our activities, while "big and thick data" will continue to circulate within the backbone.

As for the *thickness of the knowledge unit*, also for the Technological System of the backbone, from pervasive technologies and situated computing to web 2.0, semantics, crowd sourcing, and social computation, from real or mediated world to tangible or organic user interfaces, we should be use the same analytic interpretation: individual-society-knowledge. At this point, the distance between people and machines will continue to fade away (see par. 2.4): carbon and silicon are true neighbor not only in the Mendeleev's periodic table, especially if we think to the transformation of interfaces, from "bit" to "atoms", from "stones" to "skins" (see par. 3.2). The intertwining within the backbone of individuals and technology is now sufficiently clear. Thanks to humans and smart agents, the collective intelligence which is going to be fostered by the internet of the future would become a collective action movement, which today can be foresee by the prior role given to citizens/users in a growing range of political/economic sectors.

The pervasive aspect of technology is changing and will modify our human perception of the world and even of the boundaries of the human body. About 50 years of virtual reality have tried to convince humans of the existence of a second alienating dimension, inside the computer shell.

The past decades of virtual reality have been an illusion: now the technology is leaving the narrow and complicated world of computers, to expand within the world, reaching easily all life's dimensions, being embedded into common devices and artifacts (see par. 3.1).

In this respect, also the concept of a natural reality, which is the objective "res extensa" has been misunderstood, because what we see, actually, is the *virtualization* of the only existing reality: our subjective experience, which is "full of virtues", and, for instance, is technology-augmented. Are we actually prepared for a "knowledge overload", both cognitively and technologically?

Overtaking the Cartesianism, further reflections are needed in respect to the passage from what has been considered as "reality" to what is now intended as *augmented experience* or augmented world. If augmented-reality glasses would allow us to interact with a world equipped by different layers of information/knowledge or by new interactive opportunities, what now is considered as "reality" will shift towards a personal experience, through which we give a new sense to our presence in the world.

This will become more clear with the contemporary evolution of interfaces: if we think to augmented-reality contact lenses¹⁰¹ or to future brain-interfaces, other issues becomes relevant: are we going to consider our body always "the same", even with unforeseen cognitive/biological prosthesis? Are we going to place inviolable limitations to this possible Ship of Theseus¹⁰² to safeguard our personal identity through time?

The problem of the permeability of our bodies to technologies should be taken into account within new socio-technical environments full of *immersive knowledge*, where there are concrete opportunities of being embedded in a Human Intelligent Task (see par. 2.4) or of embedding some technological stuff within our bodies.

Pretty new issues opens to anthropology and sociology of knowledge society: how will individuals communicate in the future? Which kind of language will be used to interact with new possible "augmentations" within immersive knowledge environments? Maybe old gestures will receive stronger symbolic meanings, or completely new languages will be participatory built. To avoid old and new divides, we should discuss solid educational policies to build and enhance cognitive skills and capabilities, before that the "augmentation" becomes the only way to feel what is around us.

Beyond all doubt, new technologies are no more comparable to "very intelligent computers" and need a synergetic approach while defining constraints and responsibilities, field of application and of intervention. After a hedonistic effect, new technologies could be put aside: if people do not reach an imaginative capability to foresee the use of extraordinary technology-augmented devices to enhance their lives, these technologies could not be part of the next knowledge circulation process.

A lot of work should be done by an interdisciplinary and heterogeneous community of actors: scientists overtaking the logics of NBIC convergence and encompassing researchers from the humanities, experts and knowledgeable citizens, to tackle, with a participatory design approach, existing and future problems. This time we are not sure that "wearing a pair of (augmented) glasses" can be the usual solution to see clearly our common future.

¹⁰¹ <http://spectrum.ieee.org/biomedical/bionics/augmented-reality-in-a-contact-lens/0>.

¹⁰² The Ship of Theseus, also known as Theseus' paradox recorded by Plutarc, raises the question of whether an object which has had all its component parts replaced remains fundamentally the same object.















































Appendix I



“FairyTale Box”

Sperimentazione di apprendimento collaborativo e partecipativo con l’uso della Lavagna Interattiva Multimediale

Il seguente questionario ed i relativi dati immessi saranno utilizzati esclusivamente per scopi di ricerca e non saranno per alcun motivo ceduti a terzi.

<i>Attività: Fanta Storie</i>		
Ti è piaciuta questa nuova esperienza con la LIM?	    	
Ti sei divertito a spostare le immagini?	    	
Ti è piaciuto usare la “bacchetta magica”?	    	
Ti sei divertito a scrivere con le dita sulla LIM?	    	
Ti è piaciuto scrivere con il pennarello sulla LIM?	    	
Ti sei divertito ad inventare una FantaStoria con la LIM?	    	
Ti è piaciuto lavorare con i tuoi compagni per inventare la FantaStoria?	    	
Ti piacerebbe usare la LIM più spesso?	    	
Ti piacerebbe usare la LIM anche per altre materie e attività?	    	
Cosa ti piacerebbe fare con la LIM?		

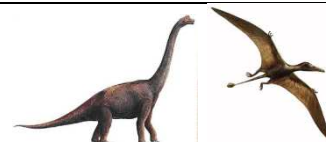
Classe: **Sezione:**.....



Attività: Puzzle sui dinosauri

Ti sei divertito a ricomporre i pezzi del puzzle?	
È stato bello aiutare e farsi aiutare dai compagni per risolvere il puzzle?	
Ti è piaciuto gareggiare in velocità con gli altri gruppi per comporre il puzzle?	

Attività: Documentario sui dinosauri



È stato interessante vedere il documentario?	
Ti piacerebbe usare la LIM per vedere documentari su altri argomenti?	

Emozioni provate:



Difficoltà
Agitazione



Imbarazzo



Noia



Stupore



Sfida



Curiosità



Interesse



Soddisfazione

Cosa hai provato quando hai visto la LIM per la prima volta?	
Cosa hai provato quando hai trascinato le immagini sulla LIM?	
Cosa hai provato quando hai scritto sulla LIM?	
Cosa hai provato mentre i tuoi compagni erano alla LIM per scrivere la FantaStoria e tu eri al posto?	
Cosa hai provato quando hai giocato con il puzzle?	
Cosa hai provato quando hanno giocato con il puzzle i tuoi compagni e tu eri al posto?	
Cosa hai provato quando hai guardato il documentario?	

Appendix II

“Technology Enhanced Music Project”

Nome: _____ Cognome: _____ Classe: ____ Sezione: _____				
1. Sensazioni provate Per le seguenti domande sono possibili più risposte.				
1.1 Cosa hai provato quando la maestra ha spiegato gli strumenti musicali?				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.2 Cosa hai provato durante l'esecuzione del brano?				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.3 Cosa hai provato mentre ascoltavi la maestra dal posto?				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.4 Cosa hai provato mentre facevi gli esercizi con i compagni alla lavagna? <input type="checkbox"/> Non sono stato alla lavagna				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.5 Cosa hai provato mentre facevi gli esercizi con i compagni al posto? <input type="checkbox"/> Non è successo				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.6 Cosa hai provato mentre facevi gli esercizi da solo alla lavagna? <input type="checkbox"/> Non sono stato alla lavagna				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.7 Cosa hai provato mentre facevi gli esercizi da solo al posto? <input type="checkbox"/> Non è successo				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				
1.8 Cosa hai provato complessivamente durante lo svolgimento della lezione?				
<input type="checkbox"/> Agitazione	<input type="checkbox"/> Imbarazzo	<input type="checkbox"/> Noia	<input type="checkbox"/> Nervosismo	<input type="checkbox"/> Indifferenza
<input type="checkbox"/> Stupore	<input type="checkbox"/> Curiosità	<input type="checkbox"/> Interesse	<input type="checkbox"/> Sfida	<input type="checkbox"/> Entusiasmo
<input type="checkbox"/> Altro _____				

2. Lezione sugli strumenti musicali Metti una X sulla casella corrispondente (una risposta per riga)	Per niente	Poco	Boh!	Sì	Molto
2.1 Ti è piaciuta la lezione svolta?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.2 Ti sei divertito?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.3 È stato facile riconoscere i diversi strumenti?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.4 Ti è piaciuto il brano ascoltato?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.5 È stato interessante imparare i nomi degli strumenti musicali?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.6 È stato facile fare gli esercizi proposti?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.7 È stato facile classificare gli strumenti?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.8 Ti piacerebbe rifare questa attività?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Lezione su Pierino e il lupo Metti una X sulla casella corrispondente (una risposta per riga)	Per niente	Poco	Boh!	Sì	Molto
3.1 Ti è piaciuta la lezione svolta?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.2 Ti sei divertito?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.3 È stato facile associare i diversi strumenti?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.4 Ti è piaciuto il brano ascoltato?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.5 È stato facile fare gli esercizi proposti?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3.6 Ti piacerebbe rifare questa attività?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Vuoi aggiungere altro? _____ _____ _____					
5. Conoscenze tecnologiche					
5.1 Possiedi un computer personale?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.2 Se non lo possiedi, hai comunque accesso ad un computer a casa?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.3 Se hai risposto sì ad almeno una delle domande precedenti, quante volte in media usi il computer?	<input type="checkbox"/> Mai usato <input type="checkbox"/> Raramente(fino a 4 volte al mese) <input type="checkbox"/> Abbastanza spesso (2,3 volte alla settimana) <input type="checkbox"/> Spesso (4 o più volte alla settimana)				
5.4 Per cosa usi il computer?	<input type="checkbox"/> Studiare <input type="checkbox"/> Scrivere <input type="checkbox"/> Disegnare <input type="checkbox"/> Giocare <input type="checkbox"/> Ascoltare musica <input type="checkbox"/> Guardare video <input type="checkbox"/> usare internet <input type="checkbox"/> chattare Altro _____				
5.5 Hai mai usato un computer toccando direttamente lo schermo?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.6 Hai mai usato un telefonino toccando direttamente lo schermo?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.7 Hai mai usato un videogioco toccando direttamente lo schermo?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.8 Sai cos'è la Lavagna Interattiva Multimediale (LIM)?	<input type="checkbox"/> Sì		<input type="checkbox"/> No		
5.9 Se hai risposto sì alla domanda precedente, quante volte in media usi la LIM a scuola?	<input type="checkbox"/> Mai usata <input type="checkbox"/> Raramente(fino a 4 volte al mese) <input type="checkbox"/> Abbastanza spesso (2,3 volte alla settimana) <input type="checkbox"/> Spesso (4 o più volte alla settimana)				

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