Learning Objects & Mobile Computing

Amedea Barani
Marco Incerti Zambelli
Enzo Zecchi
Istituto Blaise Pascal, Reggio Emilia

Abstract

The study assesses the possible impact of Learning Objects (LOs) and Mobile Computing in the field of education. The issue is dealt with according to two perspectives. The first considers LOs as a product whose creation is entrusted to the students. This leads into the realm of constructionist learning and to using technologies within perspective of "not to learn from them but to learn with them" guarantees the effectiveness of integrating them in education. To put this approach into practice effectively, teachers are required to learn to manage a new form of education. This is the focus of the first part of our study. The second part examines the idea of using LOs as pre-constructed objects and as resources that promote significant learning. In this context, after examining some of the criteria that LOs have to meet in order to be considered as such, we go on to describe the likely LOs of the future as envisaged by Fletcher (2006), namely, LOs implemented in the form of conversations. The system and the student will hold conversations by means of natural language, based on open questions and answers, and the system will be capable of adapting itself to requirements and thereby of generating itself. A possible consequence will be a new kind of school, without a planned curriculum, explicit tests and perhaps even without lessons. Within this renewed learning environment, the teacher will have the crucial role of acting as a resource and a guide.

Rapporto su buone prassi nello sviluppo di molecole formative per
m-learning. Guida per docenti e formatori.
Progetto Leonardo da Vinci "Molecole" n. I/05/B/F/PP-154063
Capofila: ITGS Pascal Reggio Emilia Italy

1. The problem of integrating technologies in education.

It has been approximately 5000 years since the first forms of writing were introduced and about 500 since printing was invented. From then on, while man has made enormous strides in stretching his physical skills with the invention of tools –so that they are now almost extensions of his limbs– he has done nothing, or almost nothing, to boost his mental skills. Books are the only real extension of the mind, and libraries are the only places that have allowed culture to be passed down through the generations.

Finally, in these last fifty years, with the introduction and subsequent exponential growth of information and communication technologies, we are witnessing what in our view will prove to be an epochal revolution. These technologies are destined to make a deep mark in the field of tools for the mind. Computers, in fact, make it possible to perform calculations –even complex ones– extremely swiftly and to manage huge quantities of information; they interact with human beings and new generation models can be considered user friendly thanks to their advanced multimedia features. Computer networks have done away with physical distance and enable us to have access to information anytime, anywhere. The whole system appears to have the right credentials to offer itself also as a vital tool for teaching and learning. Nevertheless, we cannot take this prospect for granted. Suffice to recall the long history of failures in man's attempt to introduce technologies in education (Cuban, 1986), starting from Thomas Edison's unfortunate prediction in 1913 that books would soon become obsolete in schools and that students would eventually learn from films (Edison 1913). All this ended up with the great expectations followed by the great disappointments with the PLATO and TICCIT authoring systems, which seemed set to revolutionize didactic practices but proved instead to be less effective than traditional teachers, despite huge investments (Cognition and Technology Group at Vanderbilt, 1996). We could go on to quote further examples but these, we believe, are sufficient to illustrate the prevailing climate.

Communication and information technologies have advanced significantly since the time of PLATO. However, we believe that the idea of introducing lessons based on computers, somehow capable of substituting the teacher in the task of knowledge transmission, is bound to fail. On his side, the teacher has the skill and the opportunity to interact with the class, to capture the mood of the students, adapt to the situation, create empathy and experience first-hand the anthropological community of the class group. All this gives the teacher a position of great advantage vis-à-vis the computer.

Numerous attempts have been made in the past to introduce in the classroom multimedia aids, i.e. those tools which until a few years ago we used to call audiovisual aids, but without any success to speak of. It is certainly true that the new multimedia tools have much more alluring features: first and foremost the possibility of being interactive. In the final analysis, however, despite the great strides made on the technological front, if we are thinking of substituting the teacher in his basic activities, i.e. in the act of teaching, explaining and interacting with the student, then we are still not looking at a level playing field.

Situations where teachers are not available or costs are too high are quite a different matter. In such cases technologies have a competitive advantage. In-house company training is a classic illustration of this point. In this case too, however, despite the progress made from traditional audiovisual aids, the road ahead is not completely smooth. In short, it is an uphill path.

To get a better understanding of this process, we should consider the gestures and the rites performed in a specimen lesson delivered by a teacher, the sort of lesson we have all witnessed and which is part of our DNA. The teacher walks into the classroom, fills in a couple of registers, checks that the homework has been done, gives oral tests, explains, and gives the assignment for the next lesson. With a few variations on the theme, this is still what happens. The performance of the ritual is so firmly codified that the teacher is supported, safeguarded and assisted by this series of rites, which act as a safety-net against unforeseen circumstances. Indeed, there are no unforeseen circumstances, or almost none. Nor is there any time, space or need to introduce anything else. The flow, the rhythm and the programme of the whole process is set by a succession of modules, course units and classes, so that any kind of interference would be inappropriate. From this perspective, the computer seems like a useless and inconvenient adjunct: it gets into the school but not into the classroom. It gets into the school for the purposes of organization, administration and laboratory-based subjects, but not for educational purposes as such.

The reason why technologies have not been integrated in education is not the teachers' poor skills in this field but the adopted strategy. Teachers will learn how to use a technology if they know it will be useful to them. That is what always happens. Who would ever think of learning how to use a software system, knowing that he won't have to use it? Technologies are also getting easier to use and the opportunities to learn them are increasing by the day. The real point is that even skilled teachers use these technologies to write, keep a tidy

register, store information, carry out research on the internet, communicate, and so on, but they don't use it to teach.

This being the case, should we then give up hope that technologies can get into the classroom as a tool to improve teaching and make learning more meaningful, and resign ourselves to the idea that computers can stretch and boost man's intellectual skills in almost all the professions but can do nothing for teaching, which is the most emblematic of all the intellectual professions?

1.1 The solution to the problem is pedagogical in nature.

In our view, a solution to the problem, to the dilemma, can be found by turning around the rules of the game. It is neither a matter of how to introduce technologies in education, nor of how to improve technologies or have more technologically-minded teachers. This is not the point, although it is certainly this, too. The real problem to be solved is how to act upon education itself, i.e. on pedagogical strategies. By changing the methodological paradigm, and consequently, the learning environment as whole, technology can become a necessity, a *sine qua non* condition in the absence of which it becomes impossible to practice the teaching profession correctly. This will come about once we replace our existing perspective of education based on the transmission of knowledge with a constructivistic approach, whereby the computer is no longer seen as *the tool from which to learn but the tool with which to learn*.

If all this is implemented through an educational method based on problems and projects, where the goal is to tackle real, complex cases, where we proceed by group work, where language is no longer just sequential writing, where we need to access information, even in a random way, where grammar becomes hyper-media-based and where the underlying cognitive schemas are networked, then the computer will become a necessity. In this case, teachers themselves will demand computers and while the problem of training will persist, it will become secondary and be resolved one way or another. The problem will no longer be to integrate technologies in education and how to go about doing so. Computers *will* be integrated because we won't be able to do without them. The rest will follow automatically.

On the pedagogical front, however, there are many problems needing to be resolved: from the teacher's point of view, these problems become almost genetic in nature, and any dramatic change in approach will bring with it an array of consequences looming ahead as insurmountable barriers. Such a change would mean the collapse of a ritual that is rich, consolidated and rigidly

deterministic, and moving toward a world of the probable, subject to the rule of entropy and where the rites with the power to moderate such entropy are still few and far between. All this becomes dramatic. In such an environment, desired and feared at the same time, the prime obstacle is the fact that in the knowledge-building process, content –the real lord and master of the cognitive pedagogical system– has to give way to method. The teacher here has to abdicate his role as the unquestioned master of knowledge, and accept the fact that he is a resource in an environment where the key actor, the person at the centre of things, is now the student.

1.2 Technologies: a Trojan horse leading to the prevalence of method.

If contents have to abdicate in favour of methods, however, and if the path seems arduous and even impossible, technologies themselves turn out to be an unexpected source of assistance. The reasoning behind this claim is roughly as follows: faced with the spread of technologies into almost every area of human action, in the name of some sort of globalisation of activities and in a world of increasingly interconnected communication channels, sooner or later, technologies will take their rightful place in education. This process, riddled with failures and yet unstoppable, will occur by forcing methodological changes that have so far remained hoped-for at the theoretical level but unimplemented in practice. In short, they are a sort of Trojan horse leading to the prevalence of method.

Furthermore, although in the final analysis economic interests will be the main catalyst for all this to occur, we believe that technologies have an in-built potential to promote their progressive introduction in the sphere of education. *Interactivity*, availability *anytime and anywhere*, in addition to all the possibilities provided by *multimedia*, are the main points of strength of technologies, and that distinguish them from any of the other available tools for the mind.

2 Learning Objects and Mobile Computing: special technologies

Of all the technological innovations that will impact on learning strategies, Learning Objects (LOs) and Mobile Computing deserve special attention. Mobile Computing, namely the ability to use a computer (or something like it) anywhere, and to be connected to others at any time via the Internet (or something like it) thanks to advancing wireless technologies, is a fact; any future development will be a matter of boosting and consolidating that fact. The situation regarding LOs is more complex. Although much has been written about

LOs and there are many ways of describing them, it is hard to say exactly what they are. There is no precise, unambiguous definition of LOs but Fairweather's assertion (2006) that LO *is a technology in search of theoretical roots* seems extremely useful.

While the definition as a whole is effective, to our mind, the use of the term *technology* seems reductive. Our idea of LOs is that they are certainly more culturally comprehensive. Suffice to think of the spheres of human knowledge affected by them, including artificial intelligence, instructional technology, the study of interactions between man and machines, information architecture, the design and organisation of databases, intelligent tutoring systems, to name but a few. We believe that we have the necessary conditions for attempting to define LOs as a major chapter in the Science of Instructional Design, if not actually a Science in itself. As such, it becomes a field of experimentation for new representations of knowledge, for ontological and logical approaches to –and strategies of– description, for computational semantics, and many other aspects of information. Taking Fairweather's definition a step further, the characteristic which best describes the state of the art in the science of LOs is that it is in search of theoretical roots. This underpins the attempt to define an object, the LO in this case, that does not yet exist but is attempting to surface, emerge, construct and define itself.

Because the LO is still at the embryonic stage, there are many possibilities for it to materialise and consolidate itself. An initial, immediately successful approach to boost significantly the construction of knowledge is to consider the LO not strictly as a pre-constructed object, ready for use, to promote knowledge of contents in individual subject areas, but as an object that students themselves can construct. Clearly these Learning Objects will be simple, perhaps not even equipped with the basic requirements to be considered as such and probably difficult to apply to education. The aim of these LOs, in any case, will be to promote the knowledge-building process of those who venture to create and implement them.

In the first part of our study, we will deal with LOs according to this perspective, while in the second part, we will analyse LOs as objects that have already been created and are ready to promote learning. We will be referring in particular to the aspect of LO implementation that seems to us the most speculative, yet also the most fascinating, namely, the 'materialisation' of LOs in the form of conversation.

3. Constructing Learning Objects to construct knowledge.

Our basic assumption is that students learn much more when they are designing, constructing and assessing LOs, or the like, than when they are attempting to learn from ready-made LOs –at least as far as the current state of the art is concerned. Constructing LOs thus becomes a process that stimulates a significant growth in the students' problem solving and other skills, too. The first problem to be tackled is how to modularise the information that students have to represent through LOs. In other words, the students have to structure the information which they themselves had to learn in such a way as to ensure that other students will easily learn it, too. To achieve this, they will clearly feel motivated to investigate levels of analysis which would remain unexplored and unknown in a method of education based on knowledge transmission.

This, in other words, amounts to adopting a constructivist/constructionist approach (Papert, 1980), applying it through an educational method based on problems and projects, and putting it into practice by actually transforming classroom space to create a suitable learning environment. The learning environment model we have adopted is based on the constructivist model (Constructivistic Learning Environment, CLE) proposed by Jonassen (1999). The focus of our approach is thus on problems and projects, situated in what Jonassen, in his original representation of learning environment, calls the problems and projects space (Jonassen, Peck, Wilson, 1999). The activities to be carried out by the students will be determined by the problems and projects themselves.

What sorts of problems and projects are we thinking about, then? Projects may be specific to every subject area. There is one category of problems/projects, however, which we would like to examine further, since these represent an important issue for problem- and project-based education, namely e-learning projects, i.e. the desired production of LOs. These may seem like a "fixation" of ours, yet, they are a response to the following recurring question:

> *…you are quite right, professor, the way you are putting it to us, education through problems and projects is certainly an interesting and stimulating educational approach; but in my case, as a teacher of philosophy, Italian, or history, etc., what kind of projects could I propose to my students?*

The answer would be as follows:

> *… There is always a category of projects for every subject area that can be made into an interesting moment of real learning, and I mean e-learning projects. It basically means asking students to create multimedia products that would allow them to teach their peers the same contents that they themselves had to learn. They would be some kind of Learning Objects, although they would be no more than distant relatives of the ones meant in the literature.*

Today, this can be done in schools of every level and at every grade, since the technology needed for the purpose is so simple. There is no need to teach students Power Point; all we have to do is get them to use it. Obviously the most skilful users can venture into creating sophisticated products by using state-of-the-art technologies like Dreamweaver, Flash and Authorware, to list just the range of Macromedia products. But this is not the point.

What is important is not the product that is created but the process of creation. Besides, as we have already suggested, our view is that even the best e-learning products rarely prove to be effective learning tools. At least as far as the current state of the art is concerned. The people who really benefit from them are those who create the products. The benefits are countless, such as acquiring significant in-depth knowledge about areas of contents, a "project-based culture" and the habit of cooperative work, learning how to use new cognitive and cooperative tools and achieving fluency in a number of technologies –and that is without taking into account the more subtle implications of promoting the construction of networked and concurrent forms of thinking (Spiro, 2006).

Setting up and running e-learning projects is also relatively simple from the point of view of teachers, who will not need to feel uncomfortable due to their lack of know-how in specific technologies. The will need to make this clear at the outset and the students who decide to embark on work that requires the use of these technologies will have to be given and bear full responsibility for it. The most that teachers can do in this case is put the students in touch with some experts or encourage them to seek help through chat lines or forums. We have seen that this works in practice. As for the rest, the teachers will be responsible for helping the students as their work evolves, using well-established strategies, planning a time for them to give shared presentations of the results they have reached, and also for them to share with the whole class any problems that have emerged.

If the right atmosphere is created, cross-cutting groups of specialists on different problem issues normally emerge and eventually become points of

reference for the whole class. A great deal of care should be taken when making up the working groups. It is important for every group to contain at least one member with an aptitude for the technological and applied aspects, and one with a stronger inclination for the aspects linked to design and thematic analysis. Holding adequate sessions of real assessment, as we shall see more clearly in the course of this study, is a crucial part of the process. These sessions in fact, also make two key contributions: firstly, they provide appropriate feedback to the student and data to the teacher for assessment, and secondly, they should prove to be an effective tool for controlling the class.

3.1 The real problem: educating teachers to a CLE environment.

The key to success is to give teachers the appropriate tools to deal with this type of approach. The only way to achieve this is to make them construct those tools themselves. It is not a matter of running professional development courses for the teachers; indeed, this would be a contradiction in terms, since it would mean teaching a constructivist approach through a knowledge-transmission method. This is why there should be planned sessions in which the teachers will also experience constructivist-type learning environment situations, similar to those they are intending to introduce in the class. If the aim is for the students to tackle problems and projects by constructing LOs, then what problems and projects should the teachers tackle? Our suggestion is that teachers should be given the means to be able to build up the tools –the tool-boxes, as it were– to manage a constructivist teaching and learning environment. We are referring in particular to the tools needed to run projects, to manage working groups, to assess the students as they are performing real tasks and finally, to enable teachers to use simple technologies. Let us examine these in detail.

3.1.1 Learning to manage projects

Analysis and reflections. Teachers will not be able to implement effectively an educational practice based on problems and projects, and on the construction of LOs and the like, unless they are equipped with an appropriate method. This is therefore the first issue to be addressed. It would be paradoxical to do otherwise in an educational approach based on problems and projects.

Although it may seem absurd, however, this is what happens in practice. We have always wondered why this is, and have never managed to find a

convincing answer. Nevertheless, there are many people concerned with managing group dynamics –and we stress our use of the words *managing group dynamics*, rather than just people trying out tested techniques. There are also many teachers concerned with documenting the process underlying the implementation of projects, and who show the appropriate degree of concern for project evaluation. Yet none of them, or very few, are concerned with seeking a method to develop projects unless they have the right kind of stimulus. Indeed, when asked about this, many teachers are shocked, almost as if we were trying to clip the wings of creativity or wanted to use methods to restrain their own and/or their students' flair and imagination. For decades, teachers have been offered and asked to adopt an educational approach based on contents, and the moment they are offered a method, this becomes an odd model of constraint. It is as if someone were arguing that since modelling comes primarily from the scientific domain, then the reasoning behind it is purely scientific and, as such, the psycho-pedagogical domain should dismiss it.

We would like to point out, that even the scientific domain has undergone some major and much-needed crises. Newtonian determinism faced a crisis when scientists started to examine the motion of atomic-sized particles. Since then, the concept of probability has come to dominate thinking on an atomic scale. Indeed, since Heisemberg demonstrated that it is impossible to know the exact position of a particle without foregoing exact knowledge of its speed, our ability to determine exactly the position of a particle is inversely proportional to our ability to measure its speed, and vice-versa. It is a traumatic situation, but that is the way it is. Einstein didn't believe it and spent his whole life trying to prove that the idea was bogus. Yet it seems that Heisemberg was actually right. So, it is a world where probability prevails over certainty, as Prigogine put it, it is "the end of certainty". And yet, we have not given up our hope of understanding something about it, of creating a model that can somehow provide the phenomenon with a formula, attempt to control it and allow predictions to be made. Accordingly, Schroedeinger put forward his equation on the atomic scale to replace Newton's, giving us probabilities and never certainties. We rather like that. We find it convincing. We also like the fact that man has used his intelligence to work out a formula to understand nature at these levels and, a century later, to be able to say that he succeeded, since Schroedinger's equation works in the same way as the entire quantum system.

So, we use magnetic resonance imaging, computerised axial tomography, we study DNA, explore space, have robots perform surgical operations and

communicate across thousands of miles with small wireless objects –all based on Schroedinger's work and the results of quantum mechanics. We have not rejected probability; we have learnt to accept it as a founding concept and have structured our reasoning, our worldviews and our perspectives on this concept. We have learnt not to condemn this confounded desire of ours to understand the world, but to set it within models that allow us to go further, to probe deeper, to support and overtake even our own thinking. Thus we are led to seek, promote and stimulate the development of a model to manage projects. Not to ban such a model, exorcise or ward it off, as a certain poor way of thinking would wish us to do, in the name of an evanescent, improbable but innocent creativity. On the contrary, we are led to regard it as profitable, advantageous and, paradoxically, unavoidable. This is a generally underestimated point.

Even in school environments where projects are allowed some space, this is done in an empirical way, concentrating on the final result and the product rather than on the process. This educational approach is too unstructured and removed from the rituals of traditional education for teachers, on their own, without the appropriate methods and the right support network to be able to manage successfully the complexity of this emerging classroom. There are many factors contributing to the feeling of unmanageability. The aspect that is most destructuring from a methodological standpoint, but which at the same time is the most valuable from an educational standpoint, is to introduce in the class experience the management of events close to real everyday life. Such events do not lend themselves to the rigid determinism and unambiguousness of solutions peculiar to school problems. It is equivalent to introducing in the system the factors of uncertainty, choice and risk-taking and assessment in probabilistic terms that characterise all everyday life decisions.

Faced with these opposing factors –educational value and methodological disruption– there is a path to be discovered and a proposal to be formulated. And the most obvious path is one that has already been explored.

In pratice. In our view, the wisest and most natural thing to do is set out from the theory of *project management*, as successfully applied in the world of industry and research, and see whether this can be *transferred* to the classroom and how, i.e. in what ways it can be developed for this to happen. In the school context, too, this means to avoid tackling a project through the logic of common sense and/or "do-it-yourself", and relying instead on tested *project management* systems, with the appropriate additions and refinements. The suggestions and models we are proposing are the distilled product of experimentations conducted in several

classrooms over a number of years starting in 1995, when we first presented the idea[1].

Our hope is that teachers will work on a project, simulating in first person the tasks that they will be asking their students to perform in class, and thus become experts in the activity to be carried out by the students. From a constructivist learning perspective, this is a crucial process. It is only by working his way through a project that a teacher will become aware of the difficulties to overcome, the knots to be untangled, the resources and timeframes needed, the flexibility required, the need to seek follow-up solutions and not use deterministic approaches, the usefulness of group work as well as the importance of being equipped with a different cognitive baggage from that required by education based on knowledge transmission.

A forthcoming publication by Enzo Zecchi , entitled "Progettare a scuola: dalle parole ai fatti" (designing projects at school: from words to facts), makes a detailed analysis of the basic theoretical foundations of *project management*, outlining each stage of the process and highlighting in particular the adaptations necessary for a natural *transfer* of these foundations to the world of education. While carrying out the activities specific to the various stages of a project's lifecycle, it becomes clear that success is not confined to the *formae mentis* or mind-frames that traditionally succeed in education but that there is ample room for the types of intelligences that do not normally receive due recognition. This contribution is also an effective tool for student guidance.

3.1.2 Training and managing groups

Analysis and reflections. Nowadays it is fashionable to talk about cooperative learning and there are hundreds of teachers' professional development events designed for this purpose. The Fortic[2] project itself includes, among other things, an important section on networked cooperative learning and there are many requests for courses on this subject. If we examine the current situation in schools, however, this level of enthusiasm is not matched by a corresponding transfer to the classroom.

---

1 In our coordination of the "*Per fare progetti: un'ipotesi"* (making projects: a hypothesis) working group, at the "*Autonomia di Ricerca e Sviluppo: I modelli organizzativi*" (independence in research and development: organisational models) seminar, Department of Public Education, Bellaria (1995).

2 Fortic is a professional development project for academic staff dealing with MPI technologies.

Our view is that the starting point is wrong and we are getting the end mixed up with the means. Cooperative learning, in itself, represents nothing unless it is considered as part of a comprehensive approach to education, which to us means a constructivist type of approach. Who will ever benefit from making the students work cooperatively if the pedagogical framework is based on education by knowledge transmission? The idea does stand up to examination. There is neither the need nor the space to do it. The rituals are already codified for individual learning and any attempt to replace this with group learning will fail from the start, unless the overall approach is changed too. If teaching is based on a behaviouralist or cognitivist perspective in the first place, what would be the benefit of cooperative learning? Teachers whose only training is in cooperative learning techniques will learn about some interesting psycho-pedagogical tools, but if these are not set within real-life situations that require these tools, they will remain no more than an interesting piece of psycho-pedagogical culture. This can lead to absurd situations, such as we have witnessed personally, where notions of cooperative education are imparted through knowledge transmission methods, and, obviously, based on individual learning. At best, some enthusiastic tutor will ask you to practice some interesting relationship models such as two-to-two interviews, role simulations and so on. Admittedly, these techniques do represent a break with traditional approaches. When we return to the classroom, however, we start to wonder why we should use these methods and, after a few timid initial attempts, things usually go back to the way they were before and all that survives of the techniques is a strange and pleasant memory.

Our starting point therefore needs to take this into account. The teachers we are going to train will probably already have received some notions of cooperative learning, albeit perhaps just at the theoretical level, or if at a practical level, most probably not in a contextualised form. Our approach will be to provide these notions to teachers in contexts where they will regard them as indispensable. Indeed, even during their training sessions, teachers already need to address the problem of how to divide up into groups. This is the same problem that subsequently, every teacher will have to face with the students in class. And this is indeed our starting point. The first problem to be tackled will no doubt be to determine the make-up of the groups and the number of students in each group. The subject has been extensively dealt with in the literature on collaborative learning (Slavin, 1994). The teacher can decide to form random groups or try to group together students according to their affinities or skills. The

teacher might also choose to let the students themselves decide how to make up the groups. Whatever the case, this is a delicate moment and should be tackled with rigour.

The research on collaborative learning shows that it is possible to favour the formation of both homogenous and heterogeneous groups according to subject-based knowledge/skills, but that heterogeneous groups yield greater benefits at the pedagogical level (Johnson e Johnson, 1996). Hooper e Hannafin (1991) also make interesting observations on this subject, arguing that in a heterogeneous environment, it is the weakest students who gain the greatest advantage. As far as the number of group participants is concerned, Johnson and Johnson suggest promoting small groups, and even go as far as to propose groups of two individuals (dyads) as ideal for many cooperative projects, with the possibility of having larger groups as the projects become more complex. We entirely agree on the advantages of heterogeneous groups (Kagan & Kagan, 1994), while we believe that the issue of ideal group size deserves further examination. In our view, the size of the groups should actually be gauged on the basis of, among other things, the individual members' experience of group work. The number of group members can grow as their experience increases. In other words, the ability to work in a group and the number of group members are directly proportional. Indeed, the students who are used to working in groups devise techniques that allow them to sub-divide their tasks in a rational way.

Interaction, which can initially be a potential factor of disturbance (interference) when not adequately controlled, can turn into a powerful factor of synergy (cooperation) when managed wisely. In some particularly significant cases, it is the group members themselves who eventually identify a role for each student, even to the extent of selecting the person who will act as group leader. The whole thing is experienced as an otherwise improbable need for order, and not as an irritating imposition. This being so, it becomes clear that having a fairly large number of members in a group (around four), can change from being a factor of probable confusion to becoming a valuable asset. It can result in greater exchange of opinions, more mixed cultural backgrounds, a wider range of aptitudes and a more significant variety of skills. Once again, our views are supported by the writings of Kagan & Kagan (1994, p.131).

Based on these considerations, during the first stage of experimentation, we allow the students themselves to determine the make-up and size of the groups. What then turns out to be both surprising and gratifying is the fact that it is the students who reorganise themselves on the basis of heterogeneity of

skills/knowledge and greater number of participants with a precise role attribution. The worrying aspect, of which we are aware and for which we envisage certain resolution strategies, concerns some of the less motivated students and/or students with behaviour problems. For these cases, such simple strategies are inadequate. We have nevertheless found some unhoped-for improvements taking place from the time when the atmosphere in the class group changes. We have already worked profitably with psychologists from the local health authority on a previous occasion ([3]), dealing with cases of behaviour problems as well as with the ordinary management of group work.

In practice. Paraphrasing Johnson & Johnson (1994), we can highlight at least two key reasons why a teacher should master the basic elements of cooperative learning and these will be our starting point in the formulation of possible and concrete professional training activities. Firstly, *teachers have to adapt, contextualise and find a place for cooperative learning techniques to suit their specific situation, their educational needs, their curricula and their students*. They can only do this if they have such significant and extensive mastery of these techniques as to be able to act as professional training engineers, capable of redesigning their lessons, their curricula and programmes in general on the basis of cooperative learning. This can only happen if they have had first-hand practice of these techniques. Secondly, *teachers have to be able to identify problem situations in the different groups and take effective action*.

3.1.3 Building a community atmosphere.

In an educational context based on knowledge transmission, the anthropological connotation of the class group is characterised by a set of individuals with no connecting links among them and frequently in non-collaborative competition, with the teacher as the sole point of reference and the undisputed class leader of educational practice. This cannot be otherwise, since the channel of information flows from one individual to many, and feedback and assessment are the prerogative of the teacher alone.

3 “Sapienti e Contenti” (knowledgeable and happy), a professional development course on problem- and project-based education and cooperative learning, run by Prof. Stefania Mancin, at the Pascal Institute of Reggio Emilia, 2006, with contributions by Dr Ghiretti and Prof. Enzo Zecchi.

Introducing an alternative form of education, however, is no longer compatible with this kind of class group anthropology and for a problem- and project-based educational approach to really succeed, it is imperative to establish an atmosphere of community learning. There is no single strategy to support and control group work. There is, however, a need to shift from the classic atmosphere, in which the predominant pattern of interaction is between teacher and class group, to a true community atmosphere where all subjects interact with each other at different levels. In this community atmosphere, marked by moments of sharing and moments of competition, and by a growing awareness of multiple points of view, knowledge becomes more real and more significant, and there will be a growing propensity to tackle de-structured problem situations. Once this occurs, the next step will be towards the acquisition of strong transfer skills, that is, the ability to transfer knowledge and problem solving skills to other subject areas, too. In the final analysis, the fact that a strong community feeling develops in the learning context becomes a necessary condition for a more authentic form of learning to occur.

3.1.4 Constructing assessment tools.

Analysis and reflections. One of the necessary, sine qua non, conditions for the experimentation to succeed is that the teacher should feel relaxed about assessment tools. Right from the outset, teachers will worry about the dangers of embarking on a new adventure if they feel they are not controlling the boat. One of the key factors in feeling that one is in control, whether we like it or not, is to know that we are able to assess the students in an effective and suitably objective way. An educational approach in which traditional schemas are thrown overboard, where group work prevails over individual work and traditional tests make no sense, requires the appropriate assessment tools. In the jargon, we say that in a genuine learning environment will need to be equipped with genuine assessment tools. And this has to be the starting point. We need to prove to teachers that traditional methods can be replaced with alternative methods that will allow them to assess students as they perform tasks which are probably similar to those they will have to perform in a job or while doing research work. We also have to show teachers that, if managed correctly, such methods can achieve a high level of objectivity or, at any rate, a level that is amply adequate to control, guide and satisfy the class group.

In practice, it is difficult to get a good problem- and project-based educational approach off the ground. Once it does, however, and if we can create the right atmosphere and manage to get the students involved, then we might see emerging the kind of *entropy caused by construction anxiety*. It is unusual to see this phenomenon occurring in traditional learning environments based on knowledge transmission methods where, in fact, the ritual of consolidated practices generally acts as an effective antidote whenever a chaotic situation arises. Indeed, this probable entropy is what frightens teachers most, and when faced with it, in the absence of appropriate assessment tools, they generally feel defenceless. This is the actual context that we have to take cognizance of and the introduction of a problem- and project-based educational approach will only be effective if teachers are able to construct a set of genuine evaluation tools and if their tool-boxes contain these tools, too. Having heard about what these tools are, how they are constructed and how they are used does not mean being equipped with them. To really be in possession of these tools means to have constructed and actually used them in real situations.

In our experience, several teachers have shown confidence in the effectiveness of constructivist educational approaches, but at their first attempts, they became frightened by the feeling that they were unable to manage the class. Charismatic teachers and natural leaders were obvious exceptions to this and, in their case, the problem did not arise. Indeed, thanks to their personal ability to control the class, they kept the situation in hand and carried on exercising their authority without needing to resort to coercive methods. If the problem of entropy was overcome in these cases, or indeed, never arose in the first place, the problem of assessment nevertheless persisted. At the end of the experience, in fact, the assessment carried out on the basis of traditional methods appeared out-of-tune: an arbitrary, entirely subjective process which failed to convince both the students and their families. Both the problem of entropy and of the inadequacy of traditional assessment methods can be overcome if teachers adopt the methods of genuine assessment and use them in class. But how is this to be done?

In pratice. The way to achieve this is clear: one of the key projects to be included in the teachers' sessions on problem- and project-based learning environment should be the construction of a complete package of rubrics, i.e. the chosen tool for genuine assessment. The package we are proposing to develop is the result of numerous experimentations we have conducted, in which we have found it useful not only to moderate any incident of entropy, but particularly to satisfy the overall assessment needs of the students engaged in project activities. A

comprehensive description of rubrics as assessment tools is supplied by Zecchi (2004). In this paper, we will confine ourselves to describing the three types of rubrics that are necessary and sufficient to create an assessment tool.

The first type of rubric is used to assess students during their presentations of the results they have reached. Presentations are the time in which the various groups report to the rest of the class on the state of the art of their projects, i.e. the point they are at in their LOs. Presentations are done by groups, but each group member has to present his individual contribution. Each student is assessed by both teachers and classmates, who have to fill in a specific rubric. This rubric is divided into two sections: one is designed to assess the various aspects of the group work as a whole, the other to assess individual contributions. If, for example, we have a class group of 24 students, subdivided into approximately 6 sub-groups engaged in the project, the process will be more or less as follows. When one group is reporting back, every other group, together with the teacher, will carry out the assessment by completing a rubric. That way, at the end of one group presentation, there will be 5 rubrics completed by the other groups and one by the teacher. Together, these rubrics will allow both the group work and the contribution of the individual group members to be assessed.

The limitation of this assessment, and partly one of its major points of strength, is that it tends to highlight the communication skills of individual students, while it does not always duly highlight the contribution of the more shy and reserved students. The latter, may give their best in workshop activities and in methodical, systematic work, but might not always be able to express that through a presentation. We have been alerted to this problem several times and think we have finally come up with an acceptable solution, by constructing a rubric specifically designed to assess individual contributions during workshop activities. This rubric will be completed by the teacher for each individual student. Filling in this form requires close observation and this is not always possible when the teacher does not have assistants or facilitators to work with.

To complete the package, there is a rubric designed to assess the final product, regardless of the individual members. Here, the final product is assessed in the same way as would be done for any multimedia product. The rubric has to be completed by all the groups in turn, and the final result will be an indirect indication for the assessment of individuals and be used by teachers as they see fit.

Clearly, a complete, ready and tested package of rubrics is available. However, teachers working in the learning environment should develop a project consisting precisely of constructing "their own" rubrics. A good final exercise will be to compare this with the set package of rubrics, also leading to any possible improvements thereof.

4. Using Learning Objects to promote the growth of knowledge.

This is an alternative view of how LOs will impact the world of education: no longer as artefacts to be constructed, or genuine catalysts of significant and effective learning processes, but as potential resources to be used for learning. We have already written at length about past failures and our consequent misgivings about using these technologies based on these perspectives. However, once we have taken all the due precautions and have ascertained that the problem is primarily of a pedagogical nature, we believe that LOs have the full potential to be integrated effectively in learning processes, also as a resource through which to convey contents and, *paradoxically*, allow methods to be regained.

Paradoxes as an unforeseen source of assistance.

We live in an age of paradoxes, and it is paradoxes, among other things, that sustain us in this improbable cognitive corner –both trend-driven and projected into the future– made up of LOs and Mobile Technologies. After being overwhelmed and disoriented by Bauman's lucid sociological analyses, we realise that paradoxes, too, can give us hope for undertaking life paths which are a little less unsteady and a little less fluid –almost plastic, as we like to define them.

The same is true for the happy paradox that prompted us to give credit to the rubric; a tool of excellence for genuine assessment, though, on the surface, apparently little more than a "second-hand" form. And yet, if we consider carefully the architecture of this assessment tool –of a markedly constructivist nature–, we realise that it has meaning and force because, ultimately, it utilizes behaviouralist contributions, expressing expected performance levels in behavioural terms rather than through generic concepts, and uses observable, almost measurable behaviour. This is how rubrics get to be the means of real, genuine evaluation (Zecchi, 2004)

What technologies are prompting us to regain in the field of methodology is also particularly paradoxical. Paradoxically, in fact, LOs can restore some previously-abandoned methods by making us reconsider the almost forgotten idea that real knowledge is generated by conversations, and in order to improve the quality and effectiveness of our education system that is where we should set out from. Our great dream is to have someone to turn to when we are in need, and that this someone will adapt to our level of knowledge and start from there, answering our doubts and giving us precisely what we feel we need at that specific point in time. This is exactly what happens in cases when we don't know how to do something and have a problem to solve; it might not necessarily be a complex problem but a composite one, frequently of a trivially procedural nature. Some examples might be when we have to learn to use some new function of a specific tool, such as setting the on/off function of an oven, or setting the drill function on a drilling machine, using forms in the Word programme, accessing a new wireless web, and so on.

Our first temptation is to consult someone who knows how to do this already. This saves us from having to read long procedural descriptions that are frequently out of synch with our know-how, because they are either too detailed and boring, or too concise and assume that we are familiar with steps which we, in fact, know nothing about. In these cases, technology comes to our aid once again. Until fairly recently, in times of need, we could never find the instructions booklet, but now, with the Internet, we can normally download the information from the web. If this is true for conversations aimed at finding procedural solutions, it is all the more true when we need to address problems arising within problem situations, where indeterminateness prevails. When the solution is not certain but probable, then, being able to have a conversation, a dialogue with someone and ask them questions becomes crucial.

Socrates and Plato themselves proposed dialogue as a form of excellence in education. Now we have Learning Objects giving us the opportunity to restore conversations as education strategies because, as future objects for learning, LOs will probably be designed in the form of conversations and dialogue (J.D.Fletcher, 2006, Istitute for Defense Analyses, USA). They can adapt themselves to suit the context, the students' interests, their level of existing knowledge and their cognitive styles. In short, they will be adaptive and specific to the needs and requirements of individual students at a particular time. In other words, they will fit into the student's zone of proximal development. Furthermore, they will make use of all the multimedia potentials and will

identify the learning strategies most appropriate to the level of individual students. They will not be confined to promoting specific learning but will go further and support problem solving and project management activities.

It is precisely the idea of having technologies available anytime, anywhere, and capable of interacting by communicating in a natural language that makes it possible to restore conversation as a learning/education strategy. It is clearly unthinkable to have conversations with thirty students, but the required technology is easily available to do that through LOs. Our biggest weakness is the lack of teaching strategies and problem solving skills, and to fully develop them – according to Fletcher's predictions again– we need at least another twenty years. Fletcher himself is expecting a "Christopher Columbus" effect; he was looking for the East Indies and discovered America. LOs as conversation, therefore, should not be seen as a certainty but as something that will probably come about and, in any event, is a significant trend.

Adaptive technologies

The adaptive capacity of computers –i.e. the idea of being able to use computers to individualize educational initiatives in a tangible way– has been the war-horse of CAI (Computer Assisted Instruction) since the nineteen-sixties. Those were the years of *drill and practice* software, of the dawning of *courseware*, and of the first *authoring systems* implemented, among other things, through high-level languages such as PILOT and Super PILOT. These were years in which many teachers, feeling enthusiastic about the opportunities offered by computers, saw themselves as educational software developers. But there soon followed a time in which teachers realised the huge amounts of time required to produce mediocre results. The image of the teacher as a software developer was soon discarded, but not the idea of the computer as a machine that could adapt itself to the student and with the ability to devise tailor-made programmes. This perception lives on. After all, the efforts made had produced a few examples of good courseware used mainly for consolidation sessions or to give fluency to the resolution of certain exercises.

The inherent potential of the computer to be interactive, and therefore adaptive, was too important, and the demand for individualization from the world of education too strong for it to be cast aside. In an interesting and much-quoted study, Carroll (1970) claimed that in a K-8 class, equivalent to the third year of middle school in Italy, there were many students who could learn in one day what it would take five days for others to learn. What frequently happens in

a class is that the teacher is able to follow a certain group of students but has to neglect others, so that one group feels it is getting the attention while the others get bored and waste time. Numerous studies have been carried out, especially in military circles, to quantify the amount of time wasted in this way and, consequently, the potential cost savings that could result from introducing adaptive computers (Orlansky & String, 1977; Fletcher, 1977; Kulik, 1994). A very approximate estimate would put such savings at 30%. Fletcher (2006), however, goes further and provides absolute figures referring to a limited number of residential courses run by the Department of Defense (DoD), indicating estimated savings running into several million dollars. We are certainly not over-excited by these figures, but they do encourage us to believe that the game is not over yet and that studies in this area will not easily slow down.

To all this we should add the fact that, with the growing potential of technologies, the probability that they will be used effectively in education will also increase. The shifts from Computer-Based Instruction to Computer-Based Instruction with Multimedia aids, through to ITS (Intelligent Tutoring Systems) are certainly leading in that direction, although much remains to be done. This is the road to a new generation of adaptiveness that we are trying to achieve through LOs.

Are we facing a revolution?

To paraphrase Fletcher (2006), the real major revolution that technology can bring about, in addition to enabling us to obtain information anytime and anywhere –something which, to some extent, books are already doing– is to allow tutorial interactions to occur through natural language, in effect, a return to the Socratic conversations where it all began.

How will it be possible to implement these interactions at the practical level? We believe that, ultimately, they will appear in the form of something that can generate itself in real time and on demand. Clearly, however, for this come about, there will have to be an underlying basis from which to start and some foundations on which to rest and build them up from. So, what will enable this adaptive and generative potential to be actualised? The initial information will most probably be available on the Internet or something similar; but how will these conversations be structured and organised? Based on Fletcher's vision, again, we believe the starting point of these conversations, capable of generating themselves just in time and on demand, will be some object, of a certain type and stored in a certain place. In other words, they will be object oriented. The starting

information will thus be organised in the form of objects, by which we mean things that have a well-defined spatial location and are therefore retrievable, with the important additional asset of being reusable. We will examine this concept in more detail later. For the time being, we are satisfied with knowing that these "very special" conversations are capable of generating themselves, that they have a starting point and this starting point is a reusable object.

Objects for Teaching and Learning.

This idea of learning based on objects has been very effectively described by Spohrer, Summer and Shum (1998) as "educational object economy". What fascinates us most about this "educational object economy" is its focus; in other words, the real problem is not so much to create objects that somehow correspond to the teaching materials or materials that can be used to support performance, as the fact of taking existing objects and introducing them into "significant, important and effective" interactions.

We can get an even better understanding of the reasons for this choice (the objects) by referring back to the study made by Gibbons, Nelson and Richards (2000). They argue that instructional objects, as they call them, will most probably be the winning technology in that long and agonising process of integrating technology in education, thanks especially to their characteristics of reusability, adaptability and scalability. These characteristics are also necessary and sufficient conditions to make them the starting point, or the foundations, of the sought interactions. In more technical terms, these instructional objects will "provide the primitives" for the creation of the sought interactions in real time and on demand.

Although these objects can "materialise" in many different forms and media, going back to Gibbons et al. yet again, their common denominator will have to be the fulfilment of the following criteria: accessibility, portability, durability and reusability. They will be accessible to the extent that they will be easy to find. This is where the big problem arises, namely to attribute to each object the appropriate metadata, ensuring that they are properly labelled to be easily identified –although we would argue that the problem has been satisfactorily dealt with and partly resolved.

They should be portable. This is a very important feature which IT specialists are very familiar with. It is important that every programme, every object, can exist in different environments, on different platforms, with different Operating Systems. This is a crucial feature to ensure their dissemination and

thus, in a sense, to be global. The issue of durability is an equally important guarantee and goes more or less in the same direction. By this, we mean that on changing platforms, in other words, environments, they should continue to work –otherwise they will be condemned to early obsolescence regardless of their educational value and substance.

Finally, there is the issue of reusability. We are dealing with a concept still held in great value by software developers, that is, to create something that can easily be reused in different contexts without having to make any particularly demanding adaptations. In other words, once we have constructed an object that performs a certain task or solves a certain problem, indeed, every time we are faced with that particular task or problem, all we have to do is reuse that particular object.

These objects, thus defined, can therefore become our starting point, leading eventually to the hypothesised and desired "conversations to learn".

What needs to be done for all this to happen

What will make it possible to achieve this scenario –made up of learning objects and mobile computing– is the progress made in the following four main areas: future developments in the electronics field, increased access to the worldwide web, a better definition of the conditions for reusability, and the development of Intelligent Tutoring Systems.

While the first three are clear, the fourth deserves further analysis. Firstly, in order to draw a significant comparison, we will list the major goals that Computer Assisted Instruction (CAI) had set out to achieve since way back in the sixties, and see how these, while certainly very significant, have nothing in common with the goals we are proposing to attain through Intelligent Tutoring Systems. The CAI courseware, in particular, was meant to be capable of the following:

- Adapting to the pace of every student to allow him to achieve pre-established objectives;
- Adapting both contents and learning sequences to suit the needs of every individual student;
- Adapting the levels of difficulty and of abstraction of the activities;
- Adapting to the students' individual learning styles (with more or less collaborative, more textual or visual events and so on).

It is clear that only some of the particularly sophisticated software has fulfilled its intent to achieve these goals, while most of the software was low-

level. However, the cases of success, albeit few, proved that something new could be done with computers, especially from the point of view of individualising educational activities.

Now let us consider how much more challenging the situation is today with ITS courseware heavily based on Artificial Intelligence, and how computers, or those acting for them, are getting much closer to our way of reasoning –in other words, we will be able to establish a sort of dialogue with Intelligent Tutoring Systems. This will be the testing ground for us to ascertain whether the aspirant coursewares can make a significant and effective entry in education and if, with their introduction, we will really be facing a paradigm shift of the same import as that which followed the introduction of books.

With hindsight, it would have been logical to foresee this emerging gap between CAI and ITS expectations. The teaching profession is too far removed from the procedural, the computational and from memorisation skills. These characteristics are certainly important, too, but in the education profession they are not particularly significant. The interaction here is not with mechanical objects or the like; it is not interaction with people on the basis of protocols alone: it is interaction with students in their completeness as persons, and this kind of interaction will be the testing ground for the potential of any resource aspiring to enter the game of education with full credentials. This is where the effectiveness of any future systems will be tested and the key reason why they will probably be effectively integrated in education.

Among the various potential benefits offered by artificial intelligence, there are three in particular which we believe will stand out significantly in the makeup of future LOs and will enable them to be implemented in the form of conversations, namely:

- They will enable the student to formulate open questions and/or answers and promote the development of a dialogue between the students and the systems themselves.
- The will allow the automatic generation of materials and interactions on demand. It will therefore no longer be necessary to prepare and memorise in advance al the materials and interactions which may subsequently become necessary.
- They will make it possible for natural language to be used as the language of interaction. Many efforts and advances have been made and are continuing to be made in this difficult area (Graesser, Gernsbacher, & Goldman, 2003)

Finally, we notice how being generative –the characteristic peculiar to these systems– implies the ability to set up interactions with students as well as other mechanisms, on demand. Being able to generate problems suited to the needs of students, in fact, is not enough; there also has to be the ability to assist, support and guide the students in the process of generating solutions, to set up appropriate and effective educational strategies and, above all, to provide the kind of interaction that is essential for creating a one-to-one "tutorial" approach. Are these ambitious goals or utopias?

An almost imaginary vision of the School of the future.

We will conclude with Fletcher's ideas, and ask ourselves how far these imaginary opportunities can take us. We can somehow predict that education will undergo dramatic changes in the future, and of all the expected changes, the ones we find most striking are those that are set to erode the foundations of education as we know it. According to Fletcher, there are going to be three major changes. Firstly, we will witness the almost total disappearance of predefined course programmes. Secondly, we will see a decrease in the use of explicit assessment techniques and methods, particularly tests. Lastly, even lessons, which are part of our DNA and of our everyday school experience, will be subject to a substantial reduction.

No planned curriculum. These conversations will not be based on predefined patterns but will follow the flow of emerging requirements. The idea of Instructional Design as a process whereby the curriculum is set in advance in the form of lessons, course units and modules will tend to become obsolescent.

No tests. Another very interesting prospect for the future is the significant decline in the reliance on explicit tests to determine the achievement of learning objectives and problem solving skills. These tests will be replaced by continuous, discrete and confidential assessments designed to develop a model of the student based on his interactions with the system. These assessment methods will be based on the vocabulary of the learner, his use of information techniques, and his ability to abstract and correlate/group together concepts, infer hypotheses, and so on. It may be that explicit tests will continue to be used for cases of specific assessment, but we are absolutely unable to predict what these cases might be.

No lessons. The cognitivist vision of a body of knowledge divided into disciplines, sub-divided, in turn, into modules and courses, linked with a view of teachers as absolute masters who transmit such knowledge from their high chairs, through learned monologues addressed to students as if they were just

receptive subjects –a vision, which has held undisputed dominance for decades and still finds it hard to give way to other educational models– will tend to disappear. If the prediction that sessions of conversation will be restored is correct, it seems clear that lessons, understood as monolithic blocks in which concepts and ideas are presented/expounded to achieve predetermined objectives, will tend to wither away. The objectives will certainly stay with us, as will the need to keep track of the path toward their attainment, but the methods will vary constantly, like the objectives themselves, which will undergo constant and dynamic adjustments and adaptations. This is where the role of the teacher will be crucial. From being the protagonist of the education process he will become a resource of the renewed learning environment. The teacher will play a key guiding role in the student's learning process. In the absence of a teacher, such a process, though effective in the intermediate steps, would be in danger of not being necessarily or adequately geared towards achieving the set objectives.

CONCLUSIONS

Among the various future prospects concerning the use of Learning Objects, we have outlined the one we find most appealing and leads us to believe that, set out in this way, it is unlikely that LOs will turn out to be yet another failure in the long list of past attempts to introduce technologies in education. Despite the enormous progress made so far, however, we are in the realm of speculation and it unlikely that we will be dealing with LOs structured in the form of conversations in the immediate future. On the contrary, we will be faced with LOs made up of contents and little else, with effective systems of storage and retrieval. We have not examined this particular prospect, however, because we believe it is sufficiently documented and particularly because we think it will have a modest impact on education in the immediate future. Conceived in this way, it would be difficult for LOs to enter the everyday life of education, although they may prove to be effective tools, on a level with books, whenever a teacher is not available.

In the first part of this study we have outlined a possible role for LOs for the present and the immediate future, as crucial tools for the construction of knowledge. In other words, we have envisaged LOs as the possible final product in a construction process where students are engaged in an active role: a sort of effective implementation of education through problems and projects in which LOs represent the products to be constructed. To make this approach operational and effective, we have identified teachers' professional education as the major

problem to be resolved. We have therefore analysed and suggested a range of initiatives designed to give teachers the "tools" which they are totally lacking and which are absolutely indispensable to design, implement and practice this methodological approach.

BIBLIOGRAPHY

Barrows, H.S. (1985). How to design a problem-based curriculum for the preclinical years. New York: Springer Publishing Co.

Barrows, H.S. (1992). The Tutorial Process. Springfield, IL: Southern Illinois University School of Medicine.

Barrows, H.S., & Myers, A.C. (1993). Problem-Based Learning in Secondary Schools. Unpublished monograph. Springfield, IL: Problem-Based Learning Institute, Lanphier High School and Southern Illinois University Medical School.

Bersin, J. (2004). The blended Learning , Best Practices, Proven Methodologies and Lessons Learned. Ed. Pfeiffer, John Wiley & Sons, Inc.

Brown, J.S., Collins, A., Duguid, P. (1989). Situated Cognition and the Culture of Learning. Educational Researcher; 18(1), 32-42.

Carroll, J.B. (1970). Problems of measurement related to the concept of learning for mastery. *Educational Horizons, 48*, 71-80.

Cuban, L. (1986), *Teachers And Machines. The Classroom Use of Technology Since 1920*. Ed. Teachers College, Columbia University, New York and London.

Dede, C. (2005). Why design-based research is both important and difficult. Educational Technology, the magazine for managers of change in education, 45(1), 5-8.

Fairweather, P.G., Gibbons A.S. (2006). Introduction to Special Issue on Learning Objects. *Educational Technology, the magazine for managers of change in education, 46(1)*, 7-9.

Fletcher, J.D. (1977). Institute for Defense Analyses. What we have learned about computer based instruction in military training? In R.J. Seidel & P.R. Chatelier (Eds), *Virtual reality, training's future?* (pp. 169-177) New York: Plenum.

Fletcher, J.D. (2006). Institute for Defense Analyses. A Polymath in Every Pocket. *Educational Technology, the magazine for managers of change in education, 46(1)*, 10-18.

Gibbons, A.S., Nelson,J.,& Richards,R.(2000). The nature and origin of instructional objects. In D.Wiley, The *instructional use of learning objects; http//:www.reusability.org/read*

Graesser, A.C., Gernsbacher, M.A., & Goldman, S. (Eds.). (2003). *Handbook of discourse processes*. Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen, D.H. (1999). Designing constructivistic learning environments. In C.M. Reigeluth (Ed.), Instructional design theories and models, vol.2 Mahwah, NJ: Lawrence Erlbaum Associates.

Jonassen D.H., Peck K.L., Wilson. (1999). Learning with technology, A constructivistic perspective. Upper Saddle River, NJ: Merril/Prentice Hall.

Jonassen, D.H. (2000). Computers as mindtools for schools: Engaging critical thinking. Upper Saddle River, NJ: Merrill.

Jonassen, D.H., Howland, J.H., Moore, J. , Marra, R.M. (2003). Learning to solve problems with technology. New Jersey, Pearson Education, Inc., Upper Saddle River, New Jersey 07458

Kafai, Y.B. (2005). The Classroom as "Living Laboratory": Design-Based Research for Understanding, Comparing, and Evaluating Learning Science Trough Design. Educational Technology, the magazine for managers of change in education, 45(1), 28-34.

Kirschner , P.A. (2005). Technology-Based Collaborative Learning: A European Perspective. Educational Technology, the magazine for managers of change in education, 45 (5), 5-7.

Koslowski, B., Okagaki, L., Lorentz, C., and Umbach, D. "When Covariation Is Not Enough: The role of Causal Mechanism, Sampling Method, and Sample Size in Causal Reasoning." Child Development, 60, 1989, 1316-1327

Kulik, J.A. (1994). Meta-analytic studies of findings of computer-based instruction. In E.L. Baker & H.F. O'Neil, Jr. (Eds.), *Technology assessment in education and training.* Hillsdale, NJ: Lawrence Erlbaum Associates.

La Stampa, 5th August 2007. Lepida, la prima telecom regionale gestita da politici. By Raphael Zanotti.

Orlansky, J., & String, J. (1977). Cost effectiveness of computer-based instruction in military training (IDA Paper P-1375). Arlington, VA: Institute for Defense Analyses.

Papert, S. (1980). Mindstorms. New York: Basic Books.

Papert, S. (1991). The children's machine. New York: Basic Books.

Spoher, J., Summer, T., & Shum, S.B. (1998). Educational authoring tools and the educational object economy: Introduction to the special issue from East/Weast group. Journal of Interactive Media in Education; *http://www-jime.open.ac.uk/98/10/spoher-98-10-paper.html*

Zecchi, E. (2003). A probabile mapping between Fortic modular architecture and a particolar implementation of the constructivistic educational perspective. Critical considerations for an effective application. Proceedings of Second International Girep, quality development in teacher education and training, University of Udine.

Zecchi, E. (2004). Per una valutazione autentica in classe. Le rubric. M.I.U.R. Direzione Scolastica Regionale Emilia Romagna. http://www.istruzioneer.it Rivista on line. Sezione Innovazione e Ricerca.

Zecchi, E. (2006). Quando il maestro non è Leonardo. L'apprendistato scientifico: un nuovo modello di apprendistato in tempi, sospetti, di mutazione di paradigma. Enzo Zecchi. 2006. Ministry of Education, Higher Education and Research. Regional Education Office for Emilia Romagna. *Innovazione e Ricerca*, Online Journal, http://www.rivista.istruzioneer.it/innovazioneericerca/index.htm

Zecchi, E. (2007). Lepida Scuola e il doppio ambiente di apprendimento,Strategie e tecnologie per la didattica, verso un modello scalabile di integrazione. Enzo Zecchi. 2006. Ministry of Education, Higher Education and Research. Regional

Education Office for Emilia Romagna. *Innovazione e Ricerca*, Online Journal, http://www.rivista.istruzioneer.it/innovazioneericerca/index.htm