From conceptual change to discourse analysis. The paradigm shift induced in Science Education by e-Learning

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Summary: In addition to explaining the complex paradigm shift from *conceptual change* to *discourse analysis* in Science Education, due, mainly, to the increasing influence of the use of electronic communication for learning, the aim of this paper is to describe the most significant current practices in Science Education and Distance Learning associated with this new paradigm, particularly those that may fall under *distributed constructionism*: Such practices build both on c*onstructionism* and *distributed cognition*, focusing particularly on the use of computer networks to support students working together on design and construction activities, the latter being particularly effective in supporting the development of *knowledge-building communities.*

Key concepts: Activity Theory; Discursive Psychology; Distributed Cognition; Learning Communities; Learning Environments; Situated Cognition; Social Constructionism.

1. INTRODUCTION. THE CHANGING PARADIGM

During the early stages of Science distance learning, it may have been described as correspondence learning. At the time, electronic means were not yet available and instead, very well written, self sustained manuals formed the basis of education, supported by several programs in free view TV and open Radio. The most popular recipe was a blend of behavioural objectives and discourse conditioning learning, including the correct use of marginalia. In fact, certain minimal behavioural targets were directly proposed to students, who were tested either by means of self-assessment or indirectly through quizzes.

When electronic means became available both for the handing in of didactic texts/ hypertexts and for registering the learner's behaviour, the main emphasis of the teaching/learning activity was based on the analysis of the interaction itself, i.e. the teaching/learning discourse, which was and still is the only existing entity available for evaluation. This gradually led to a new learning paradigm, currently referred to as *discourse analysis* (Cubero, 2005), which challenges the still dominant cognitive *conceptual change* paradigm, undisputed in face to face learning.

The growing importance of e-learning in Science Education, both in its pure form and as blended learning (b- learning), mostly acting asynchronously through text, has accelerated this process in recent years. Such is mainly due to the fact that teachers in this new situation, cannot easily access the minds of their students as required by the still dominant cognitive *conceptual change* paradigm, nor can they access the *behavioural change* implied by the earlier paradigm of behavioural objectives, which, although not dominant, is still very much in use in face to face science teaching. The transition between paradigms is not always direct and involves intermediary paradigms such as *social constructivism*, associated with

situated learning, and *psycho-social constructivism*, commonly characterized by help in the *zone of proximal development* (Vygotsky, 1978) as well as other less current practices in Science Education, but quite frequent in other less structured subjects like cognitive flexibility hypertexts (Spiro, 1991).

The consequence of this state of affairs is that not only is *cognitive psychology* replaced by *discursive psychology* which has developed as an approach of *social psychology*, but also behaviour, unduly banished by the cognitive approach, has reappeared, associated with volition under the label of *conation* (Kolbe, 1990). The main tendency is to pursue a special type of constructivism, neither relying on *psychological constructivism* (Piaget, 1972) which has emphasized the role of mind in learning according to the cognitive approach, nor on *psycho-social constructivism* (Vygotsky, 1978) emphasizing the role of society's intervention through the instructor in the *zone of proximal development*. Instead, these forms of constructivism are replaced by *social constructionism* (Burr, 1995) which is based on discourse, regarded as a series of *speech acts* (Austin, 1962) and considered to be the sole ontological basis of learning. Neither is it *endogenous* nor *exogenous* constructivism, nor is it constructivism, but rather *constructionism*[1], meaning that construction is instrumental, caused by the interaction of discourse. This construction doesn't depart from the mind nor does it depart from the external world, but from a continuous contingent flux of interaction (Shotter, 1995) that is *language*, or rather, according to Potter (1996), *discourse*. By discourse we mean speech and text as situated actions, co-constructed in social action. Instead of using language and human subjectivity in order to explain human activity, an analysis is made of the interactions in which, according to Gergen (1994), both language and understanding are generated and which is the only objective element at our disposal. To use the idea expressed by Prawatt (1996), it consists of a strategy which, instead of putting the mind in front of the world (which involves a circular reasoning), brings the mind to the world. The philosophical consequences are enormous as this implies the annulment of epistemology, or, epistemology not being distinguished from ontology.

This is also in keeping with the radical post-modern *Knowledge Philosophy* programme presented by Rorty (1979), according to which individuals, objects and facts exist in an essentially linguistic world. According to this perspective, everything exists inside the language, so the nature and truth of the facts are defined by the members of the community, through their way of referring to them, which defines the reality of this particular community. As Cubero (2005) points out, constructionists are like alchemists attempting to transmute the mind/world dualism into another monist "thing", in this case language. The concept of language that adapts to social constructionism is no longer the model of *correspondence* and *communication* adopted by Cognitive Psychology, serving essentially to *represent the world* and to *communicate* to others our *mental states* (Edwards, 1997), transmitting contents between or among minds, according to the various communication models. Instead, social constructionism regards language as an *activity*, taking speech at its pragmatic[2] level as the point of departure. Instead of being viewed as a channel through which messages are transmitted, language is viewed as an *activity* in which *meaning is generated.*

This concept of constructionism is very important in Education and shared by a large number of contemporary thinkers in several areas, and with different degrees of radicalism. It certainly stems from the philosophical view point presented in the *Philosophical Investigations* of Wittgenstein (1953) with his *word games* creating meaning, or in the above mentioned more radical post modern views of Rorty (1979). From a linguistic point of view, the basis is also Austin's afore-mentioned theory (1962) of *speech acts*, which are statements that realize actions within certain contexts with particular consequences.

The theories inspired by these principles and relevant to the educational practices in use in distance learning, have already been around for quite a long time, as they are also the ones that serve as the basis for the design of *constructive learning environments* (Jonassen, 2002), although

[1]In addition to the idea that knowledge is constructed by the learner, constructionism (like constructivism) expresses the further idea that this occurs when the learner is engaged with something external or at least sharable, which may be discourse or other tools leading to internalization and externalization cycles. For social constructionism the sharable thing is discourse, but it may vary for other forms of constructionism (a sand castle, a machine, a computer programme, a book, provided it is the aim of a collaborative enterprise).

[2] In Linguistics the following levels are usually distinguished: *morphological, syntactic, semantic and pragmatic*

constructionism requires more radical solutions detached both from the self and the external world and centred around the discourse and tools used to mediate learning. Several theories have emerged as candidates for inspiring the learning environments in this sense:

- The *Activity Theory* of Leontiev (1978), as it undervalues conceptualization, considering it an epiphenomenon or sub-product of activity, indissociable from it.
- The Theory of Situated Cognition (Brown, Collins & Duguid, 1989), because it insists on the inseparability of the context and the concept in order to achieve learning
- The Theory of Distributed Cognition (Cole & Engeström, 1993) to the extent that it admits the sharing of meaning created in the speech act among participants, including people and tools.
- The Cognitive Flexibility Theory (Spiro, 1991) inspired by Wittgenstein's Philosophical Investigations, and in his famous criss-cross (cognitive) landscapes, particularly suited to describing the ill organized knowledge domains

In the cognitive paradigm all these learning theories, and also some instruction theories based on them[3], have been applied to the design of learning environments used either in face to face or distance learning. In the latter case the paradigm shift constructivism → constructionism is most important, so we then follow the characteristics of constructivist environments (Jonassen, 2002) in order to understand the processes they have to undergo so as to be transformed into constructionist environments. First of all, it is important to understand, as Potter (1996) suggests, that the metaphor for language is no longer the *mirror*, which has served most forms of constructivism but *workshop*, where reality is constructed as one speaks or writes about the world. In fact, Berger & Luckman (1999) point out in their *Social Construction of Reality*, that the establishment of *fact objectivity* is no longer the reflection of a natural reality but the *application of a set of practices and social conventions inside the discourse*. This workshop metaphor is not only related to conventional speech production and perception but also, and most importantly, to the discursive elements disregarded as noise by cognitivism, such as *intonation*, *silence* and *reformulations*. This imposes a new formula for data exploring and collecting where the expressions and their production context cease to be separable. Also, anticipated meaning categories are no longer acceptable as they were in cognitivism. It is also important to bear in mind that in all of its forms, social constructionism, the basis of the new educational paradigm, is interested in the psychological processes without being interested in the mind or even recognizing it as a distinct category. Nevertheless, the social processes are still accepted as references, as they are more difficult to exclude from the analysis.

[3] Like Anchored Instruction, although many of these theories carry important distinctions it does seem like each of them is a kind of tradition or trade mark of its own (USA) University.

2. CONSTRUCTIONIST LEARNING ENVIRONMENT CHARACTERISTICS

One thing that these environments should have in common with the constructivist learning environments characterized by Jonassen (2002) is, for sure, that they should bring about meaningful learning so that the general characteristics and guidelines presented for the latter are also applicable to the former. That is, as Jonassen explains "technologies should be used to keep students active, constructive, collaborative, intentional, complex, contextual, conversational, and reflective". What follows should be read in addition to Jonassen's description of these characteristics for constructive learning environments. Attention should be drawn to the reinforcement or attenuation of these characteristics when constructionism takes the place of constructivism, and discursive psychology replaces cognitive psychology, as is the case of the paradigmatic shift being described.

- *Active*: If this characteristic was regarded as being essential to constructive learning environments, it is much more so when it is the case of their constructionist counterparts. The central role of speech, without neglecting attributes as mentioned above, such as intonation, makes this characteristic even more important in constructionist environments and learners more engaged by the learning process in mindful processing of information.
- *Constructive* → Constructionist: The constructivist perspective, both focusing on the self as in psycho-constructivism and on society as in socio-constructivism, is entirely replaced by a constructionist perspective, as construction takes place on the basis of discourse and steers clear of

both the previous mental constructs of student and teacher concepts. The purpose is to negotiate through discourse so as to guide the skill of making sense or meaning in order to reconcile discrepancy, curiosity or puzzlement. One cannot even gain knowledge about what they know, unless they are supported through the flux of discourse in the process of coming to know.

- *Collaborative*: This is maintained and reinforced particularly through modelling which is achieved in collaborative speech if the interaction is more than simply cooperative and becomes genuinely collaborative (Lewis, 2004).
- *Intentional*: It is possible to extract from speech the learning goals corresponding to the situation as all human behaviour is goal directed (Schank, 1994) and knowledge does improve learning (Scardamalia & Bereiter, 1996). This is an essential feature of the teleological characteristic of constructivist epistemology even more present in constructionism.
- *Complex*: As complexity is one of the essential characteristics of contemporary science, being "the major new theory that unifies all sciences" (Lewin,1993), texts reflect this complexity as they deal differently with the concepts of explanation and understanding when approaching the behaviours of complex systems, in subjects like self-organization , adaptability, evolution,…
- *Contextual*: The roles of context in constructivism and constructionism are qualitatively different as explained ahead. Furthermore, Mode 2 (Nowotny et al, 2001) contemporary science is context sensitive in its production and also, for various reasons and at different levels, in its learning, as it should also proceed from context to concept as in the STS approach to Science Education (Aikenhead,1994)) or in Mode 2 Science and Engineering learning (Hills, 2002). This increased role of context is reflected in many contemporary theories like situated learning and anchored instruction. Also, all the forms of constructionism are much more context sensitive than the corresponding forms of constructivism, as constructionism is based on a holistic and not an analytical view of the problems, thus, preserving the context and avoiding dangerous over-simplifications.
- *Conversational*: This is implied by discourse and is inherent in the constructionist version for which learning is a social and dialogical process achieved through discourse (Duffy & Jonassen , 1992).
- *Reflective*: This characteristic is reinforced by the centrality of discourse in the new paradigm as it is this discourse that supplies the fundamental basis for reflection, which may be viewed as meta-discourse.

3. COMPONENTS OF THE CONSTRUCTIONIST LEARNING ENVIRONMENTS.

In order to be classified as a constructionist learning environment, a distance learning platform should have not only all the above mentioned properties, but also consist of a certain number of elements, similar to that which happens with constructive learning environments (Jonassen, 2002). Let us examine whether the elements suited to the constructive paradigm (Context, Representation/Simulation and Manipulation space) are also suitable for the present paradigm and what changes, if any, need to be introduced in the elements required for Constructionist Learning Environments.

Context → Text, Hypertext:

Context is very important in both paradigms. The most important change in the paradigm shift from constructivism to constructionism is, undoubtedly, the role of context in both scenarios. In constructivism, context is what surrounds (the corresponding theories are called *contextualizing theories*) while in constructionism context is what connects (the corresponding theories referred to as *contextual theories)*. There are many differences between these two approaches (Cubero, 2005, p.35), the most important of which is that in contextual (constructionist) theories the object of study is not separated from the context while it is clearly separated in the contextualizing (constructivist) theories. Other differences involve the aims of the theory, the relationship of the subject with the environment, the status of context in research, the research aims and even the methods of research. It is clearly the role and status of context that define the paradigm shift in the best way.

The context in a constructionist environment must be embedded in the text which should be presented on a pragmatic level and according to a

textual grammar (Van Dijk; 1977; Grimes, 1974) with the necessary rhetoric elements, also accounting for collaboration. Ideally hypertext, where not only the syntagmatic relations, common to the "normal" text are present, but also paradigmatic relations (representing rhetoric relations, dialogue relations and pragmatic/action relations) should be explicit. Description is still an important issue and must be implemented through a complete and detailed narrative of the problematic situation in question, as well as how the people in the group react to it.

Representation/ Simulation → Action Register

For all constructivism, including constructionism, learning does not take place by representing or copying reality but by accommodating to it. Thus, strictly speaking, the element of representation does not exist under a constructionist perspective and is replaced by an action register of the discourse related to the accommodation, corresponding to the learning situation. So the representation/simulation element in constructionist learning environments is less demanding than in their constructivist counterparts and reduces to discourse what should be viewed as an action and not a representation. In any case, the need for authenticity and the use of genuine stories stated by Jonassen (2002) with regard to constructive learning environments remains.

Manipulation Space →Text Manipulation

The manipulation needed in constructive learning environments (Jonassen, 2002) is restricted to text and, consequently, the tools for this purpose are textual tools and the manipulations are essentially text coherence tests. The principles for these manipulations are to be found in several Social Sciences subjects, in topics such as Social Construction of Reality (Berger & Luckman, 1999), Sociology of Scientific Knowledge (Woolgar,1988), Constructionist Linguistics (Whorf,1956), Ethno-methodological Conversational Analysis (Drew,1995) and, above all, Discourse Analysis (Edwards & Potter, 1992) developed by Discursive Psychology, with its postulates (Cubero, 2005, p 92-101) which may be referred to as leading to "discourse alchemy":

- Language as activity and action.
- Social reconstruction of the person.
- Meaning as social construction.
- Meaning as context dependent construction.

These postulates lead to the practice of *discourse analysis*, which is the main methodological characteristic of the paradigm and influences its educational implications to the extent of the currently emerging research paradigm in Science Education confronted with the still important paradigm of *Conceptual Change*, called *Discourse Analysis*, the main principles of which include (Cubero, 2005, p.103):

- emphasis on practices and resources,
- public and shared nature of the practices,
- emphasis on construction and description,
- sequential contextual production,
- rhetoric design,
- cognition in action,
- analysis of participant categories,
- identification of the responsible agents.

4. INSTRUCTIONAL ACTIVITIES ASSOCIATED WITH CONSTRUCTIONIST LEARNING ENVIRONMENTS

Several authors, including Jonassen (2002), whose *constructivist* ideas for implementing learning environments we have been following so as to contrast them with their *constructionist* counterparts, mention the following instructional activities as being suited to the constructive learning environments:

- *modelling,*
- *coaching,*
- *scaffolding*.

Others add a further activity called *fading* and refer to the entire process as *cognitive apprenticeship*, which is pointed as the learning process leading to *autonomy*. Let us examine whether these processes are consistent with constructionism by finding their applicability to the new situation and stating

to what extent they should modify in order to adapt to the constructionist paradigm.

Modelling

This basic process, which consists of showing the learner the essential parts of a learning task, namely in face to face teaching where the learning phase demands more time of the teacher, remains as important in both paradigms. In the constructionist paradigm, due to the centrality of text, resources like highlighting text are desirable, not to mention the highly recommended resources of hypermedia, including links to images, diagrams and animations representing the problem and the encouragement of systemic thinking, an important methodological characteristic of both constructivist and constructionist epistemology (Le Moigne, 1995).

Coaching:

Its intervention role in critical points in instruction for encouraging, diagnosis, direction and feed-back, remains as important as it was in the constructive learning environments and is easily implemented through well established techniques of intelligent help in hypertext (Costa Pereira, 1992).

Scaffolding

This is the most typical constructivist learning activity, the importance of which is the implicit change of paradigm. One might say that scaffolds are needed in both types of constructions, although of a slightly different type. The objectives (Dubs, 2002) are quite hierarchical and it is possible to speak about a "taxonomy of scaffolding starting with the planning of learning processes, supporting independent work with literature, stimulating the learning processes by improving active participation and motivation in the group, implementing learning actions either by demanding available or dormant knowledge or by supporting thought processes and evaluating learning actions by supporting self-evaluation, reflecting on learning actions by inviting meta-cognitive reflection and finally demanding interaction." This is very much the natural sequence of the above mentioned operation regarding intelligent help systems for hypertext, which provide ideal scaffolding for constructionist strategies.

Fading

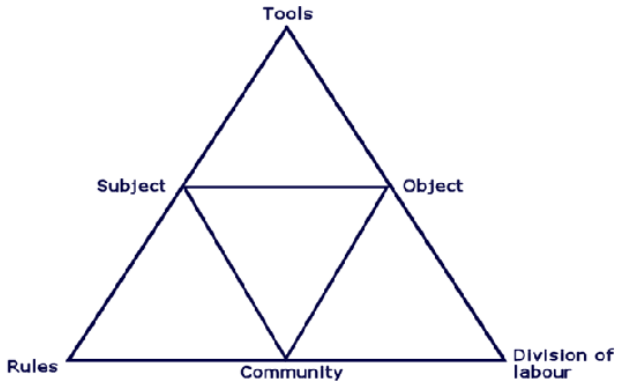
As in the case of buildings, scaffolding should be supported by a de-scaffolding operation in order for the learner to achieve autonomy.

The scaffolding operations correspond to Vygotsky's (1978) approach to the Zone of Proximal Development, where the potential of collaboration is optimized and de-scaffolding corresponds to the definition of the new Core Knowledge area.

5. TOOLS REQUIRED BY CONSTRUCTIONIST LEARNING ENVIRONMENTS

This is where the superiority of constructionist environments becomes clear, as the need for identifying activity structures is associated with language interpretation as speech acts, and activity analysis is provided by activity theory.

TABLE I - The operational unit of activity Theory (Cole & Engestrom, 1993)



The triangle above explains how this is done: one has to identify the "mediation" between subjects and outcome due to tools; the mediation between subjects and community through rules and the mediation of community and outcome by the division of labour. After identifying the activity structures, one has to identify the aptitudes that the learners do not have in order to accomplish them and so suggest the cognitive tools needed for them to accomplish such tasks. These are commonly computer tools

aimed at facilitating specific cognitive processes and helping to establish cognitive aptitudes.

Jonassen (2002) classifies the tools related to constructive learning environments within several groups, all of them also relatively appropriate for consideration in constructionist learning environments. However, some modifications have been made, based on the following reasons:

Tools for the Representation of the Problem → Task Analysis.

Examples: Stella, Didaktos (Moreira, Almeida & Raposo, 2001), Geometry Tutor (graph proof tree); Weather Visualiser; Climatic Watcher; Mathematic and MathLab.

They usually help learners, through specific graphic interfaces, to represent the problem (constructivist variety) or establish the activity scheme (constructionist variety) of the task.

Tools for the Static and Dynamic Model

Examples: Data bases, spread sheets; semantic networks, expert systems and hypermedia systems. They help learners to represent what they know and to relate it to what they are trying to learn (e.g. Gowin epistemological Vs or the simpler conceptual maps).

Tools for supporting the operation

They make it possible to lower the cognitive effort by automating some of the low level cognitive tasks (all the algorithmic tasks). The search for appropriate algorithms for routine tasks is not always an easy process

Tools to collect information

They help the learner to collect information in order to solve the problems that are posed. This includes sophisticated search engines to get information from the Web, some with complex graphical interfaces and intelligent agents.

Tools for Conversation and Collaboration.

They give the learner the collaborative and conversational aspects inherent to genuine learning. They include: e-mail, chats, listservs, bulletin boards, Net News services, MUDs (multi-use dimensions),MOOs (object oriented MUDs)

General Characteristics

- Support collaboration
- Support shared decision making on environment manipulation, possible alternative interpretation of topics, articulation of learners' ideas and reflection regarding the processes used.
- Support shared decision making depending on consensus building activity which progresses to the social construction (shared) of knowledge
- Creation of meta- knowledge about the problem through reflection on it.

6. A SPECIAL CASE: DISTRIBUTED CONSTRUCTIONISM AS AN IDEAL SOLUTION FOR THE IMPLEMENTATION OF THE NEW PARADIGM

Distributed Constructionism (Resnick, 1996), is inspired both by Distributed Cognition and Social Constructionism. It originated in the famous Media Lab of MIT and is very popular in the new distance learning paradigm. It consists of the use of computer networks to support students working together on design and construction activities and seems to be the best practice in use in distance Science Education, particularly since it seems to be very efficient in developing and supporting knowledge building communities, which are of utmost importance in the case of Science and Technology education.

In this approach, the net does not serve the purpose of delivering information (instruction) nor does it serve the purpose of obtaining information (researching). The net is used not for *information* but for *construction*! The main purpose of computer networks is "not as a channel for information distribution, but as a new medium for construction, providing new ways for students to learn through construction activities by embedding the activities within a community." (Resnick, 1996)

Distributed constructionism is based on constructionist theory and extends it, focusing on situations in which more than one person is involved

in design and construction activities. It is based on the research finding (Salomon, 1994) that "cognition and intelligence are not properties of an individual person but rather arise from interactions of a person with the surrounding environment" (people and artefacts). Moreover, research by Scardamalia & Bereiter, (1991) has proved that the use of computer networks can facilitate the development of "knowledge-building communities", in which groups of people collectively construct and extend knowledge through the design and construction of meaningful artefacts.

According to Resnick (1996) the three main categories of distributed constructionist activities are *discussing constructions, sharing constructions,* and *collaborating in constructions.*

Discussing Constructions

In this most basic constructionist use of computer networks, students exchange ideas, tips and strategies about their design and construction activities. It is essentially a forum for discussing construction activities. This is simply done through the use of electronic mail, discussion lists, newsgroups, and bulletin boards.

Sharing Constructions

This practice goes beyond simply discussing constructions. Students use computer networks to share certain types of constructions so that they can try out one another's constructions, and eventually copy and reuse parts of each other's constructions. This is done either on the World Wide Web by creating pages for others to see, displaying "passive" data forms such as text, images, and videos or, in a more difficult approach, posting animations, simulations, and other process-oriented artefacts, the knowledge of Java being required in this case. This may lead to the use of specially designed networks such as LogoWeb (Resnick, 1996), produced to enable students to share dynamic artefacts with one another, a software that seems to be identical to Micro Worlds, and is used by students in order to create animated stories and simulations which they save not on their disk but on the LogoWeb (a totally separate network from the World Wide Web). Also, a new environment called Cocoa (a type of "Java for kids") is being used in order that these types of projects may be shared on the World Wide Web itself, rather than on the separate LogoWeb network. One important concept used is that of "clip behaviours," analogous to clip art. Students can clip behaviour from one page and insert it directly into another object.

Collaborating in Constructions

This applies to computer networks when they are used not only to share ideas with each other, but to collaborate directly, in real time, on design and construction projects.

This is the case of MUDs the acronym for "multi-user domains", having initially stood for "multi-user dungeon," since they have developed in the rich environments of computer games. MUDs provide an approach to collaborative construction on the Internet (Curtis, 1992; Bruckman & Resnick, 1995) and can be defined as text-based virtual worlds in which participants literally construct the world in which they live, writing programs to define the behaviours of objects in the online world. MUDs are essentially meeting places on the Internet, where people gather to work together to extend the virtual world, explicitly combining construction and community, some people building new objects and places so that other people act as users, consultants, advisers, and critics. (Bruckman,1994a). In certain circumstances a new computer language is used as is the case of MOOSE (Bruckman, 1994b).

In the same sense Kimberly (1995) developed an environment called Marketplace, enabling students to participate in economic simulations over the Internet, while Resnick(1994) developed a more general-purpose modelling environment for the Internet called the Network Clubhouse, where modelling activities help people develop better intuitions about decentralized systems. In fact the decentralized nature of the Internet makes it particularly well suited for modelling and exploring the workings of decentralized systems that people encounter and often assume centralized control where none exists (Resnick, 1994).

Distributed constructionism implemented in the Internet (Resnick, 1996) enables it to support changes in how students learn and what they learn, as it influences not only the process of learning (bringing students together into collaborative projects) but also the content of what is learned (providing a natural infrastructure for modelling and exploring decentralized phenomena). This also .makes possible new representations and

formulations of scientific knowledge, making such knowledge accessible to more people than previously possible (Resnick, 1996).

7. CONCLUSION: THE CONSTRUCTIONIST USE OF THE INTERNET

The title of this paper led us to believe that we were facing a simple Kuhnian revolution (Kuhn, 1962) as far as Science Education was concerned, and that it was being won by the discourse analysis paradigm due to the "help" of electronic learning, which has recently expanded to a considerable dimension. In fact, the situation is not so simple, and although in Science Education research *discourse analysis* studies are on the increase, most still follow the conceptual change paradigm, not to speak of clear minorities that continue with obsolete paradigms like *information processing* (positive cognitivist) and *behavioural objectives* (behaviourist).This situation in Science Education research is better described not as a Kuhnian revolution but as a Lakatos (Lakatos, 1979) race among scientific research programmes.

The situation is even more confusing as far as practice is concerned. In fact, there are various approaches for using computer networks in education:

The first is based on new ways of delivering training to students, such as lectures by expert scientists beaming down on thousands of schools, or personal workstations presenting problems to students, monitoring student progress on the problems, and automatically downloading video segments from network servers at appropriate times during the training. This is inspired by conventional training theories and may be referred to, after Resnick (1996), as the *information superhighway approach.*

The second dismisses the idea of delivering information to students through the network and focuses on putting students in control of the information, using new tools that allow them to search through thousands of servers on the network, locating information they are interested in. This is typically the constructive approach of the still dominant *conceptual change* paradigm and of the *constructive learning environments* (Jonassen, 2002) and may be referred to, also after Resnick (1996), as the *information society approach*.

The third is based on the interaction that actually takes place in learning and consequently in *social constructionism*, which involves a completely different type of Psychology – Discursive Psychology- and is the basis of a new paradigm in Science Education and *discourse analysis.*

The fourth, given priority by the MIT Media Lab, is the approach called *distributed constructionism*, aimed at exploring the educational possibilities for using computer networks in support of construction activities. This is particularly suitable for pre-college students to collaborate in the construction of dynamic artefacts (such as animations and simulations).

The obvious conclusion of what has been said is to recommend an eclectic use of these four approaches in due proportions adapted to the particular context, which may be taken as a fifth constructionist approach and called the *constructionist use of Internet*.

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Resumo: Para além de explicar a complexa transição paradigmática da mudança conceptual para a análise de discurso, que está a ocorrer na Educação Científica, devida principalmente à crescente influência do uso da comunicação electrónica na aprendizagem, a finalidade deste artigo é descrever as práticas mais correntes em Educação Científica e Educação à Distância associadas com este novo paradigma, particularmente as que podem ser rotuladas como construcionismo distribuído: estas apoiam-se tanto nos conceitos de construcionismo (social) como de cognição distribuída, focando-se especialmente no uso de redes de computadores que suportam o trabalho colaborativo dos estudantes em actividades de design e construção que são especialmente eficazes para o desenvolvimento de comunidades de aprendizagem.

Palavras-chave: Activity Theory; Discursive Psychology; Distributed Cognition; Learning Communities; Learning Environments; Situated Cognition; Construtivismo social.

Texto

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