Constructivist Learning Models in Training Programs

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SUMMARY

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INTRODUCTION

"Real learning only happens when someone is really interested in finding out why something has caught their attention or has stumped them. It is about 'provoking' something inside each person, calling and reaching inside them".

All experts agree that behind any learning activity there is a learning model. In order to facilitate the reader's understanding of these models, we will review one of the most influential theories in education, both in terms of theoretical elaborations and in pedagogical practice itself: Constructivist Theory.

This theory will pave the way to describe models that start from the constructivist context. These models will be useful to us to design instructional strategies and techniques to facilitate learning, as well as fundamentals to select them effectively.

In this book we want to show readers different training models to discuss around some fundamental ideas:

1. The student is responsible for his own learning; This is an active process of construction rather than knowledge acquisition.

2. Elaborated contents are the motor and the support of the student's constructivist activity rather knowledge communication.

3. The teacher must create optimal conditions for the deployment of constructivist activities.

Constructivism is a fundamental part of students learning process from all educational fields and, as we will see in this work, the learning procedure is more important than the contents themselves. Constructivist models will help us design instructional strategies and techniques to facilitate learning, as well as the rationale for selecting them effectively.

CHAPTER 1

AN APPROACH TO CONSTRUCTIVISM

While a theory provides a general explanation for scientific observations, a model is a mental figure that helps us understand things we cannot see or explain directly.

Schunk[1] defined numerous learning theories can be grouped into three main models:

- *Conductivism:* This model focuses on people learning a behaviour or another from external world. Learning is seen as the association's formation between stimuli and responses. In other words, conductivism is based on observable changes in a subject's behaviour and focuses on behaviour patterns repetition.

- *Cognitive*: Cognitive models focus on the learning process that causes behaviour change. Learning new knowledge is seen as making possible these changes; These are observed to be used as indicators to understand what is going on in the learner mind. As in the previous model, it is about building reality maps[2].

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[1] Schunk, H.D. *"Learning Theories: An Educational Perspectives"*. 1999.
[2] Mergel, B. *"Diseño instruccional y teoría del aprendizaje"*. 2005.

- *Constructivists:* It is based on each person constructs their own perspective of the world, surrounding them through their own experiences and developing mental schemes.

  The constructivist model is considered the most influential in the field of science didactics. This boils down to four main sub-models[3]:

  – *Piagetian:* The different parts of the Piaget's contributions Theoretical framework.

  – *Human:* It is based on the meaningful Ausubel[4] learning proposal. To his followers are due the concept maps or the V for Gowin[5].

  – *Social*: Initially called the movement of alternative conceptions. This model uses simple messages such as students' specific conceptions about teaching contents[6].

  – *Radical*: At the beginning of the nineties promotes certain activities in the field of education more linked to speculation and philosophical confrontation than to addressing classroom issues[7].

As a summary, Table 1 shows the three models explained, different related theories and the main proponent of each of them[8]:

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[3] Marín, N.; Solano, I. & Jiménez Gómez, E. *"Tirando del hilo de la madeja constructivista. Enseñanza de las ciencias"*. 1999. Visión constructivista dinámica para la enseñanza de las ciencias. Nicolás Marín Martínez. Departamento de Didáctica de la Matemática y de las Ciencias Experimentales. Universidad de Almería. 2005.

[4] Aguirre, M.; Meza, S. & Lucero, I. *"La potencialidad de la V de Gowin en la resolución de problemas"*. Facultad de Ciencia Exactas y Naturales y Agrimensura. Corrientes. Argentina. 2005.

[5] Aguirre, M.; Meza, S. & Lucero, I. *"La potencialidad de la V de Gowin en la resolución de problemas"*. Facultad de Ciencia Exactas y Naturales y Agrimensura. Corrientes. Argentina. 2005.

[6] Driver, R. & Easley, J. *"Pupils and paradigms: A review of literature related to concept development in adolescent science students"*. Studies in Science Education. 1978.

[7] Marín, N.; Solano, I. & Jiménez Gómez, E. *"Tirando del hilo de la madeja constructivista. Enseñanza de las ciencias"*. 1999.

[8] Jáuregui, K. *"Formación a través de la tecnología en la literatura"*. IESE. 2002.

Classification	Related theories	Main bidder
Behavioral models		
	Connection between stimulus and response: Effect and exercise Law	Edward Lee Thorndike (1906)
	Classical conditioning	Ivan Petrovich Pavolv (1927)
	Conditioning without reinforcement	John B. Watson (1916)
	Conditioning through reinforcement	Clark Leonhard Hull (1920)
	Operant conditioning	Frederic Burrhus Skinner (1938)
Cognitive models		
Information processing	*Gestalt current*	Bayles, Bode, Kohler y Wertheimer (1910/30)
	Short term memory	George Miller (1956)
	Multichannel learning	Hartman (1961)
	Dual learning	Paivio (1986)
Social cognitive	Learning by expectations	Edward C. Tolman (1932)
	Social learning	Albert Bandura (1977)
Cognitive of complex tasks	Experimentation	John Dewey (1916)
	Theory of social change	Kurt Lewin (1948)
	Cognitive growth	Jerome B. Seymore (1960)
	Significant learning	Paul David Ausubel (1916)
	Solve problems	Hebert Simon (1916)
Constructivist Models		
	Cognitive development	Jean Piaget (1954)
	Action learning	Reg Revans (1963)
	Thought and language: The social environment is crucial for learning.	Lev S. Vygotsky (1978)
	Theory of action.	C. Argirys y D. Schön (1974)
	Reflection in action.	Donald Schön (1987)

Table 1. Learning Models, Related theories and Main Bidder.

Constructivist models study the learning process that causes behaviour change that, unlike cognitive models, emphasize social, culture, humanism and subjectivity as critical factors[9].

As Kemp and Smellie[10] described, there are generalizations in the different theories of learning, such as:

- *Motivation*:

  The learner must feel motivated, interested, and feel the need to learn. Instructional media and teaching aids must also be motivated in terms of the subject: presentation, typeface, legibility, etc.

- *Learning objectives:*

  The subject of learning, even if he is an adult, is interested in knowing from the beginning what he is going to learn; for this reason, any audio-visual support or teaching action should anticipate the objectives he hopes to achieve.

- *Rhythms and individual differences:*

  The figure of the individual in relation to their capacities, attitudes and abilities must be present when approaching teaching-learning situations.

- *Knowledge of the receivers and action's design:*

  A diagnosis must be established of the subjects to whom we allocate our action. It is necessary to know the group: their interests, the knowledge's level, their needs, purposes, etc. Such information will allow us to frame our actions and prepare documentation, activities, work materials, etc.

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[9] Jáuregui, K. *"Formación a través de la tecnología en la literatura"*. IESE. 2002.
[10] Kemp, J. E. & Smellie, D. C. *"Planning, producing, and using instructional media"*. New York: Harper and Row Publishers. 1989.

• *The content organization:*

The contents must be selected; They have to be relevant, meaningful and at the audience's level. These must be structured in units or blocks of complete sense. The most complex part consists in sequencing the contents, units. and blocks between them; and giving them meaning, directionality and uniformity.

• *Participation:*

The individual has to participate and commit to the action's learning development. Teaching should try to involve the student as much as possible and make him participate in that process. Participation must be frequent and qualitative.

The fundamental characteristics of a constructivist didactic model are summarized below [11]:

The constructivist vision:

– *Psychological fundamentals*: Meaningful learning related to prior knowledge

– *Epistemological fundamentals:* Reality Interpretation through Models. Reality is analysed through a theory.

– *Empirical fundamentals:* Students previous ideas that maintain despite the instruction.

Principles:

– Learn by reconstructing knowledge.

– Contents and processes are complementary.

– Teaching is promoting learning by planning and organizing.

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[11] Jimenez, M. P. *"Análisis de modelos didácticos: Didáctica de las Ciencias"*. Módulo I, Curso de Formación del Profesorado de Ciencias, MEC. 1991.

Syntax:

– Starting from students' ideas.

– Explore, restructure, and apply new ideas.

– Promote conceptual change.

– The curriculum is an activities program.

– Create learning situations in which students build their own meanings.

Social system:

– Teaching staff members are researchers; they try to select learning problems.

– Flexible. Activate student's participation.

– It is favoured working in small groups.

– Concepts, skills, procedures are evaluated, also the ability to solve new problems.

– Students' own learning control.

Support system:

– Varied resources.

– Teacher training (integration of disciplinary contents, psycho-pedagogical and science didactics).

– Materials, books, work scripts.

– Dialogue and cooperative learning.

Let us now consider some learning principles that are associated with the constructivist learning and teaching conception:

- Learning involves an internal constructive process, which is why it is considered subjective and personal.

- Learning is facilitated thanks to mediation with others, which leads to say that learning is social and cooperative.

- The degree of learning depends on the cognitive level, emotional and social development, as well as on the nature and structures of knowledge.

- Learning's beginning is the knowledge and previous experiences subject gets.

- Learning is facilitated through supports, leading to the construction of cognitive bridges between new and already known.

1.1. Piaget's constructivism

According to Piaget, constructivist theory is based on the knowledge is the result of a construction process in which people actively participates. Piaget attaches more importance to the internal reasoning process than to external manipulation. Thus, influence exerted by both, senses and reason are recognized.

Learning is an internal, active, and individual construction process. Cognitive development involves the successive acquisition of more organized and complex mental structures without excessive teacher intervention.

For Piaget, learning is an active construction process that does not depend only on external simulation, but also is determined by internal development degree. Social relationships favour learning and physical experience, and it is a necessary condition to occur.[12]

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[12] Sagales, P. Universidad Nacional de Asunción. 2001.

Many authors[13] consider that Piaget's contributions are framed within what is called a "constructivist perspective or conception."

Piaget wanted to show that learning does not occur by knowledge accumulation, because there are internal mechanisms for assimilation and accommodation.

It is necessary to establish relationships between previous and new knowledge, where accommodation is achieved by restructuring the knowledge itself.

Piaget establishes the difference between learning in the restricted sense, when new knowledge is acquired from experience, and learning in the broad sense. In this case, it refers to techniques acquisition or Knowledge instruments. between learning in the restricted sense,

For Piaget, constructivism means that the subject, through his physical and mental activity, progresses in the intellectual learning progress because knowledge for the author is not in objects or previously in us; it is the construction process result in which the person actively participates.

In this theory, more importance is given to the internal reasoning process than to external manipulation in knowledge construction. Although, it exists mutual influence between senses experience and reason, very recognized. That is, the person builds his own knowledge[14].

Knowledge construction evolves from Piaget's theories, starting from a fundamentally individual process, with a secondary teacher's role. It follows to a social

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[13] Carretero, M. *"Constructivismo y educación"*. Buenos Aires. 1993. Carretero, M. Desarrollo y aprendizaje. Buenos Aires. 1998.
Coll, C. *"Constructivismo y educación escolar: ni hablamos siempre de lo mismo ni lo hacemos siempre desde la misma perspectiva epistemológica"* en Rodrigo, M. J. & Arnay J. (Comps.): *"La construcción del conocimiento escolar"*. Barcelona: Paidós. 1997.
Coll, C. *"La teoría genética y los procesos de construcción del conocimiento en el aula",* en Castorina, J. A., Coll, C. & otros: *"Piaget en la educación. Debate en torno a sus aportaciones"*. Buenos Aires: Paidós. 1998.
Gómez Granell, C. & Coll, C. *"De qué hablamos cuando hablamos de constructivismo",* Cuadernos de Pedagogía, 221. Págs. 8 a 10. 1994.
Resnick, L. *"La educación y el aprendizaje del pensamiento"*. Buenos Aires: Aique. 1999.
[14] Bandura, Albert. *"Teoría Cognitiva Social del Aprendizaje"*. 2005.

construction where interaction with others through language are particularly important.

Piaget's thinking in relation to learning is summarized as follows:[15]:

1. It is an active construction process by the subject, which his physical and mental activity determines his reactions to environmental stimulation.

2. It does not depend only on external stimulation; it is also determined by subject development's level.

3. It is a process of reorganization cognitive process.

4. Social relations favour learning whenever it produces contradictions forcing subject to restructure their knowledge.

5. Physical experience is a necessary condition for learning to occur, but it is not sufficient; mental activity is also needed.

1.2. Constructivism and other authors

Duffy and Jonassen's[16] definition about constructivism is that world's meaning is imposed by the person and therefore, there will be many ways to structure the world and many meanings for each event. It further maintains that each student builds her own unique meaning from all events she learns.

Currently, points of view that are located under the term "constructivism" coincide in two fundamental aspects:

1. Learning is an active construction process rather than knowledge acquisition.

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[15] Piaget, Jean. *"Infancia y Aprendizaje"*. Taylor & Francis. Vol. 4, Iss. sup2,1981.
[16] Duffy, T. & Jonassen, D. *"Constructivism: New implication for instructional technology"*.
Duffy, T. & Jonassen, D. *"Constructivism and Technology of Instruction. A Conversation"*. Hillsdale, New Jersey: Lawrence Erlbaum Publishers. 1992.

2. Instruction is a process to support this construction rather than to communicate knowledge [17].

Seymour Papert developed what he called "Constructionist Learning Theory", arguing that learning occurs in better conditions when students are involved in the creation or construction of something can be shared.

This would lead us to use a working model in which an internalization process of external elements and externalization of internal elements is established by students and teachers, printing the personal stamp on creation.

Technological tools facilitate children to acquire skills allow them to explore and develop their ability to invent, build and design projects. With the development of these projects, children will acquire knowledge that, in addition to being stored in their minds, can also be apply into practice effectively.

Cesar Coll says that Knowledge incorporation will occur if specific help is provided through the student participation in intentional, planned, and systematic activities, being able to promote a constructivist mental activity.

Coll's [18] constructivist conception organizes three fundamental ideas:

1. Student is responsible for his own learning process.

2. Student constructivist mental activity is applied to contents have already a considerable degree of elaboration. It is not necessary for student, at any moment, to discover or invent school knowledge.

3. Teacher's role is linking student's construction processes with the culturally organized collective knowledge. Teacher's role is not limited to create optimal conditions for student to develop a constructive mental activity. He must orient and guide the activity explicitly.

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[17] Duffy, T. & Cunningham, D. *"Constructivism: implications for the design and delivery of instruction"*. En D. Jonassen (Eds.). *"Handbook of Research for Educational Communications and Technology"*. New York, USA: Macmillan Library Reference USA. 1996.
[18] Coll, César. *"Aprendizaje Escolar y Construcción del Conocimiento"*. 1990.

Along with Piaget's studies, Vygotsky began to study the environment impact and people around the child in learning process. He developed the theory: "Mind's social Origin"[19] and contributed to the concept about "Upcoming development's zone".

According to Vygotsky, each student can learn aspect's series he has to do with his development level. Other aspects beyond his reach can be assimilated with an adult help or more advanced peers. These stretches between what student can learn on his own and what he can learn with help, he calls "Nearest or Proximal development's zone"[20].

Vygotsky says learning is done in interaction with others and development occurs when process is internally controlled, integrating new skills into cognitive structure.

Substantial difference between Piaget's ideas and Vygotsky consists in greater emphasis that latter places on learning in development's influence. For Vygotsky, learning contributes to development, pulling it; this consideration assigns teachers and school a relevant role by granting didactic action, and the possibility of influencing a greater cognitive student's development.[21]

In 1963 Ausubel publishes "The Psychology of meaningful verbal learning." Years later, his ideas were incorporated by Novak[22] into his research programs.

Ausubel coined the concept of "meaningful learning" to distinguish it from repetitive or memorial learning. He points out the role that student's prior knowledge plays in the acquisition of new contents.[23]

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[19] Wertsch, J. V. *"Vygotsky y la formación social de la mente"*. 1988.
[20] Martín, E. *"La fundamentación psicológica del currículum de la Reforma educativa"*. Ed. Educación Abierta. Instituto de Ciencias de la Educación de la Universidad de Zaragoza. 1992.
[21] Nieda, J. & Macedo, B. *"Las fuentes del currículo"*. OEI. 2005.
[22] The importance of Prior knowledge importance had already been previously suggested by Bartlett in 1932 and Kelly in 1955, but it acquires greater prominence due to great research coincidence during the 70's. (Ausubel, 1963; Viennot, 1976; Novak, 1982).
[23] The importance of Prior knowledge importance had already been previously suggested by Bartlett in 1932 and Kelly in 1955, but it acquires greater prominence due to great research coincidence during the 70's. (Ausubel, 1963; Viennot, 1976; Novak, 1982).

This author considers learning means understanding and for this, it is an indispensable condition to consider what student already knows about what he or she wants to be taught. He proposes the need to design what he calls "prior organizers" for teaching, a kind of cognitive bridges or anchors, from which students can establish meaningful relationships with new contents.

He defends a meaningful transmission-reception didactic model that overcomes deficiencies in traditional model. This model considers a starting point for students and structure and concepts' hierarchy.

Ausubel considers what really conditions learning is quantity and quality of relevant concepts and propositional structures student possesses.

For Ausubel and Novak, the fundamental thing, therefore, is to know students' previous ideas. They propose a concept maps technique (Moreira and Novak, 1988) which can detect relationships students establish between concepts.

Ausubel defined three basic conditions for meaningful learning to occur:

1. Teaching materials are logically structured with a conceptual hierarchy, with most general, inclusive, and little differentiated at the top.

2. Teaching is organized respecting students' psychological structure, that is, their prior knowledge and learning styles.

3. Students are motivated to learn.

1.3. Jonassen constructivist's approach

According to David Jonassen[24] the objective of learning focuses on providing multiple perspectives about surrounds us, to the person who learns to build his own understanding.

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[24] Jonassen, H. D. *"Objectivism versus Constructivism: Do we need a new Philosophical paradigm?"*. Educational Research Technologhy & Development. 1991. Interview whit Jonassen. 2003.

Jonassen[25] comments that most mistaken perception of constructivism is believing each person builds a unique reality and that reality only exists in the mind who know it, so leads to an intellectual anarchy.

He also points out[26] that hypertext and hypermedia facilitate people to build their own knowledge. He affirms Internet allows exploring a large information amount and reflecting from multiple perspectives, thoughts, and worldviews, allowing the person to build his own knowledge.

In addition, network and its tools facilitate cooperative learning, allowing people to work together and discuss, thus developing their cognitive processes and building their own knowledge[27].

Jonassen[28] proposes eight characteristics to favour learning in constructivist environments. Figure 1:

- *Active:* Students' attitude should be responsible and active to engage in learning process.

- *Constructive*: New ideas integration in previous knowledge to build new meanings.

- *Collaborative*: Social support and members' contribution enhance students' work.

- *Intentional*: Students learn more if they purposefully pursue a learning goal.

- *Complex*: It is better for students to solve complex and partially posed problems rather than overly simplified problems.

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[25] Jonassen, H. D. *"Tecnología del pensamiento: Hacía un modelo de diseño constructivista"*. 2005.
[26] Jonassen, H. D. & Reeves, T. *"Learning with technology: Using Computers as Cognitive Tools"*. 1996.
[27] Jonassen, H. D.; Peck, K. & Wilson, B. *"Learning with technology: A constructivist perspective"*. 1999.
[28] Duffy, T. M. & Jonassen, D. H. *"Constructivism and the technology of instruction: A conversation"*. Hillsdale, N. J.; Erlbaum; Duffy, T. M.; Lowyck, J. & Jonassen, D. H. (Eds). (1993), *"The design of constructivistic learning environments: Implications for instructional design and the use of technology"*. Heidelburg, FRG: Springer-Verlag. 1992.

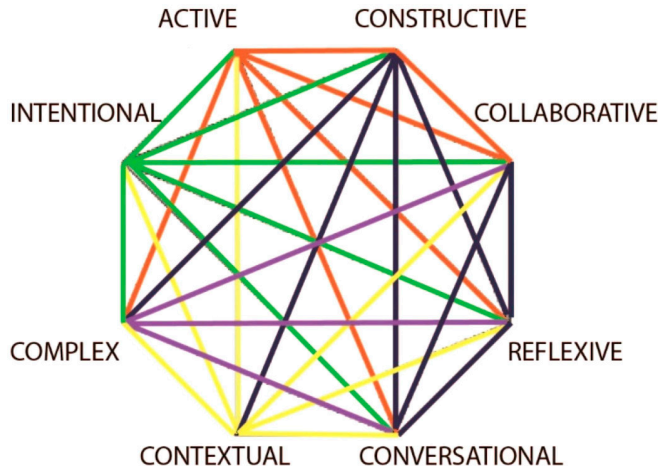

Figure 1. Characteristics favour learning in constructivist environments.

- *Contextual*: Learning activities must be in real or simulated context. Use learning' environments based on exercises and cases. Teach in real life by providing new contexts to apply knowledge.

- *Conversational:* Learning is a social process based on dialogue.

- *Reflexive*: Technology allows students to make decisions in their learning process. Control in process allows them to learn better.

1.4. Constructivist environments for learning

According to Bodner[29], Jonassen[30] and Duffy & Jonassen[31], theory about constructivism and constructivist design for learning environments arouses great interest in possibilities can student provide.

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[29] Bodner, G. M. *"Constructivism: A theory of knowledge"*. Journal of Chemical Education. 1986.
[30] Jonassen, H. D. *"Objectivism versus Constructivism: Do we need a new Philosophical paradigm?"*. Educational Research Technologhy & Development. 1991.
[31] Duffy, T. M. & Jonassen, H. D. *"Constructivism and the technology of instruction: A conversation"*. Hillsdale, N. J.: Erlbaum. 1992.

Bodner[32] says that knowledge constructivist model can be summarized in this following sentence: "Knowledge is built in student mind."

Moore, Burton and Myers[33] analysed studies by different authors. They found some of them affirming learning through interactive multimedia systems is equal to or more effective than conventional and faster; other studies determined inability to show learning with multimedia technology was more appropriate than conventional learning.

Different authors[34] affirm that multimedia application is considered an element makes it easier for the person to build their own knowledge.

In turn, Kozma[35] mentions that multimedia technology parallels mental models by forming associations between several ideas and building meaning from these relationships.

Rouet and Jarmo[36] highlight the analogy between hypertext structure and human mind concepts.

In this thought line, Vygotsky[37] emphasizes social interaction plays an important role in the learning process.

Reigeluth[38] defines two interaction's types in learning process:

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[32] Bodner, G. M. *"Constructivism: A theory of knowledge"*. Journal of Chemical Education. 1986.
[33] Moore, D. M.; Burton, J. K. & Myers, R. J. *"Multiple - Channel Communication: The Theoretical and Research Foundations of Multimedia"*. Handbook of Research of Educational Communications and Technology: A Project of the Associations for Educational Communications and Technology. 1996.
[34] Makkonen en 1998, Shohreh & Garland en 2000, Jonassen & Reeves en 1996.
[35] Kozma, R. B. *"Learning with Media"*. Review of educational research. 1991.
[36] Rouet, J. F; Levonen, J. J.; Dillon, A. P.& Spiro, R. J. *"Studying and Learning with hypertext. Empirical Studies and theirs Implications"*. Hipertext and cognitions. 1996.
[37] Vygostky, L. S. *"Mind in Societ: Development of Higher Psychological Processes"*. 1978.
[38] Reigeluth, C. M. *"Instructional Design Theories and Models. A New Paradigm of Instructional Theory"*. 1999.

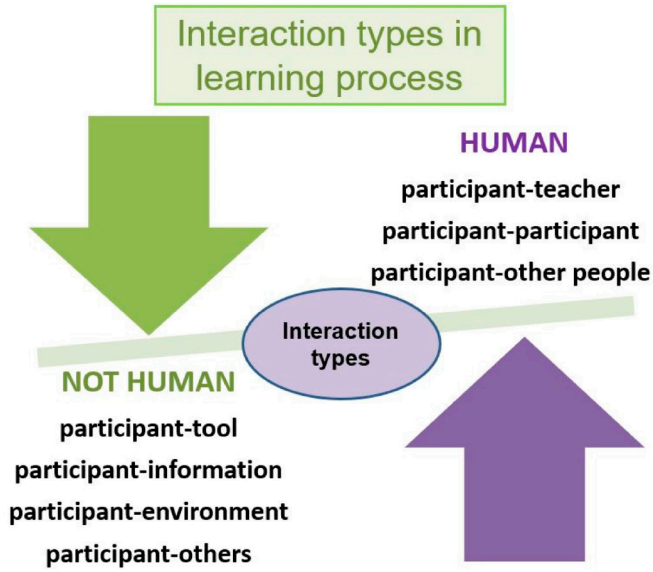

Figure 2. Interaction types in learning process.

In this way and according to Kahn and Friedman[39], constructivist learning is characterized by following principles:

1. From instruction to construction: Learning means transforming knowledge.

2. From reinforcement to interest: From a constructivist perspective, teachers involve students in learning project.

3. From obedience to autonomy: Teacher must promote responsible freedom.

4. From coercion to cooperation: Through relationships between students, equality, justice, and democracy concepts are developed and academic learning progresses.

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[39] Kahn, P. H. & Friedman, B. *"Control and power in educational computing"*. Paper presentes at the Annual Meeting of the American Educational Research Association. 1993.

Jonassen described some practical ways for designing activities and organizing information according to constructivist approach in open environments [40].

This method is known as CLE (Constructivist Learning Environments) and its main objective is promoting problem solving and conceptual development.

CLE Model consists in a proposal starting with a problem, question, or project as the environment nucleus. Many interpretation systems are offered to students and other intellectual support derived from their surroundings.

Student must solve the problem or finish the project or find the answer to questions asked.

Jonassen's model are constituted by following elements:

a) Information sources and related complementary analogies.

b) Cognitive tools.

c) Conversation / collaboration tools.

d) Social / contextual support systems.

The environment must provide student with tools to support necessary functions to elaborate the information. Cognitive tools can be computer tools whose purpose is to address and facilitate specific types of cognitive procedures.

These tools serve as:

– *Visualization tools:* they represent in a better way the problem or exercise is being carried out.

– *Knowledge modelling tools*: they help to promote her student own knowledge.

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[40] Jonassen, D. *"El diseño de entornos constructivistas de aprendizaje"*. 2000.

– *Representation support tools*: they serve to consolidate pre-existing schemes in apprentice by automating exercises at a lower level.

– *Information Gathering Tools:* They help gather relevant information needed to solve a problem.

Some tools proposed by Jonassen to create CLE are [41]:

• *Tools for representing problems and exercises:*

They are based on a mental model for understanding a situation. These tools provide congruent reasoning representations that allow students a better assimilate reality.

• *Tools for modelling static and dynamic knowledge:*

These tools allow representations to guide student in understanding phenomena. Model construction on real phenomena allows to develop mental activities related to scientific thinking such as: planning, collecting data, accessing information, visualizing data, modelling, and documenting. Databases, spreadsheets, semantic networks, expert systems, and hypermedia constructions are some tools' examples.

Model-it model is cited as a useful tool to apply on mathematics and also, as a simulation model allows observing different values of certain relationships between phenomena.

• *Performance support tools:*

They are those tools that serve to automate certain algorithms or necessary routines for certain cognitive activities. All protocols, spreadsheets allow ordering and organizing tasks, etc. would be among tools to help obtaining returns with improved time.

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[41] Jonassen, D. *"El diseño de entornos constructivistas de aprendizaje"*. 2000.

- *Tools to collect information:*

  They are tools oriented to search information, such as databases, information sources, search robots, etc.

- *Conversation and collaboration tools:*

  Learning environments supported by technology platforms use a wide communication media variety, allowing educational community collaboration. Students are actively involved in distribution' lists, emails, news services, bulletins, chats, forums, bulletin boards, MUDs [42] *(multi-user dimensions*) and MOOs (*object-oriented MUDs*).

1.5. Learning Objects

Constructivist Learning Environment helps students through using cognitive tools to carry out learning activities.

Learning objects are educational contents and procedures to help students locate and use information. Also, activities help educational institutions track student progress, report on student performance, and facilitate better interaction between systems administrative.

David Wiley[43] says learning objects are any digital resource that can be reused to support learning.

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[42] Londoño, F. C. *"Interficies de las Comunidades Virtuales"*. MUDs (Multi-UserDimension) can be described as servers provide a relationship environment between several users. Users can be robots, programs or connected people. They can converse between users, handle objects or move through virtual spaces. MOOS (MUDs Object Oriented) are multi-user environments that create images, objects and virtual spaces from textual narratives. Users are creators of their virtual worlds.

[43] Wiley, D. A. *"Digital Learning Environments Research Group"*. II Utah State University. The Edumetrics Institute. Emma Eccles Jones Education 227. Logan, UT 84322-2830

Learning Technology Standards Committee (LTSC)[44] has agreed on the term "Learning Objects" due to the difference in existing criteria to describe them as "any digital or non-digital entity can be used, reused or referenced during computer-supported learning"[45].

– Some learning examples where technology intervenes are:

– Computer-based training systems.

– Interactive learning environments.

– Computer instruction systems.

– Distance training systems.

– Collaborative learning environments.

Learning object standards focus on[46]:

– *Interoperability*: defined as the possibility of communication.

– *Durability*: defined by having last updated value.

– *Administrable*: defined by enabling of values to be evaluated.

– *Reusable*: defined by use in different contextual situations.

– *Accessibility*: defined by access to contents by individuals with disabilities.

These standards focus their attention on contents. Its fundamental characteristic is reusability, that is, designers develop small training components can be used on numerous occasions and in different learning contexts.

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[44] *Learning Technology Standards Committee*. 2005.
[45] ELO. *"Entorno para la generación, integración y reutilización de objetos de aprendizaje"*. Universidad Carlos III. Madrid.
[46] Fernández, A. Coordinador Técnico de la Unidad de Virtualización Académica de la UNED. 2003.

We define some learning objects types:

– *Fundamental:* a unique digital resource, without combinations. (for example, a JPEG file).

– *Closed combination*: combined digital resources form a single object to be presented (for example, JPEG with audio).

– *Open combination*: digital resources allow dynamic combination by the computer when presenting the content (for example, text incorporation into an image in real time).

– *Presentation's generators*: resources to facilitate information's presentation, mainly learning objects with basic content, and closed combination (for example, programming models used for content's presentation).

– *Training programs' generators*: resources to generate training applications by combining other learning or presentation objects.

They allow evaluating user interactions and defining instructional strategies associated with responses (for example, Execute Instructional Transaction Shell described by Merrill in 1999), defined in its Instructional Transaction Theory (ITT) or the programming models applied in exercises, practices, or interactive activities.

Chapter 2

CONSTRUCTIVIST THEORIES FOR INSTRUCTIONAL DESIGN (IDT)

These theories refer to the way in which learning is structured, that is, steps to follow, methodology, materials, motivations, etc. Instructional design theories (IDT) attempt to provide answers to an efficient implementation and optimal instructional methods. Its objective is to analyse the way in which instructional design should be carried out, so they have great importance in instructional materials' elaboration.

IDT refers to search for optimal instructions methods providing desired changes in knowledge and students' skills. Basically, ITDs include, although not always all at once, the following elements:

– A classification of learning aims.

– A prescription how to break down general objectives into specific ones.

– A specific instructional actions' description and how to relate them to specific objectives.

– A sequence prescription of instructive actions defining an instructive strategy.

– A conditions' set for instructional strategies and actions, such as student's characteristics.

Gagne and Dick[47] say that instructional designs objective is to make explicit structural procedures for instructional process.

They specify the content and objective for each stage to be followed to ensure in maximum effectiveness in teaching / learning process.[48]

In turn, Glaser[49] analyses instructional models through four components:

- *Competent enforcement nature:*

  They are processes, knowledge' structures and capacities make up the instruction's objective and they characterize competent subjects.

- *Learner initial status:*

  Skills and possessed knowledge by learner, and they are necessary for or they facilitate instruction.

- *Learning processes*:

  Learning process' analysis as a guide to achieve proposed objectives.

- *Evaluation*:

  Check program's effectivity, and measure if procedure has been effective in achieving previously set objectives.

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[47] Gagne, R. M. & Dick, W. *"Instructional Psychology"*. In M. Rosenzweig & l. Porter (Eds.), Annual Review of Psychology. Palo Alto, CA: Annual Reviews. 1983.

[48] Los argumentos de esta hipótesis fueron refutados por Streibel (1991) y Winn (1990, 1993). A pesar de ello, el eje de la idea de la educación asistida por ordenador continúa basándose en los procedimientos tradicionales del proyecto instruccional.

[49] Glaser, R. *"Instructional psychology: Past, Present, Future"*. American Psychology. 1981.

Teaching theories [50] say that interaction nature between the student and the instruction is decisive in learning, equal or greater importance in content or the way which information is presented.

One of these expressions proponents is M. David Merrill[51] and it is based on the idea in all learning results from the interaction between the student and the program.

Merrill introduces a new term "*Instructional Component*" (ITT)[52] describing instructional transaction's theory. ITT describes the strategy and methods for using knowledge's objects, that is, presentation of knowledge components, more simply: activities carried out by students and didactic guides for their realization.

M. David Merrill, author of "*Component Display Theory*", we will describe later, proposes with ITT criteria for programming technology-based training and describes knowledge representations, training strategies and prescriptions for design. As an objective, ITT includes more effective training if learning strategies can be adapted to aims.

2.1. Learning by Doing

Learning by Doing is a learning methodology with a constructivist root, based on Roger C. Schank[53] studies. This model is aimed at solving problems and integrating knowledge in real situations.

Schank says that people don't learn by reading or listening, they only learn by doing (*Learning by Doing*). Problems must be motivating for students. The first

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[50] Casas, A.; Fíalo, L. & Maia, L. J. *"La tercera generación de la enseñanza. Ambientes inteligentes para la educación basados en realidad virtual"*. 2003.

[51] *"Instructional Transaction Theory"*. 1991 - 1993.

[52] Merrill, M. David. *"Instructional Transaction Theory (ITT): Instructional Design Based on Knowledge Objects"*. In press. Chapter 17 in C. M. Reigeluth (Ed.), Instructional-Design Theories and Models: A New Paradigm of Instructional Theory. Mahwah, NJ: Lawrence Erlbaum Associates.

[53] Schank, R. C. & otros. *"Learning by doing"*. Reigeluth (Ed.). *"Instructional-design theories and models: A new paradigm of instructional theory"*. (Vol II). (Págs. 161 a 181). Mahwah, N. J.; Lawrence Erlbaum Associates. 1999.

step is to define activity's objective and then, develop a story justifying the need to fulfil the mission. Students are given a role to participate, so they must use available operations and aids.

Schank[54] argues that computers' impact on education will not begin to be noticed until educational model changes and believes that the real challenge is to change the learning model. Computers have potential to stop being a learning medium and Schank add they do same things faster and become a way to do things in a different way, impossible in real life.

2.2. Multiple approaches to understanding

Howard Gardner's theory about Multiple intelligence suggests there are different intelligence forms for every individual, and they reside in a precise location in cerebral cortex.

Difference lies in the way each person develops each of these intelligences.

Gardner also shares some common ideas with other theories [55] and proposes next primary intelligence forms:

– *Verbal or linguistic*: Individual communicates through language.

– *Musical*: Individual creates, understands, and communicates with musical sense.

– *Logical-mathematical*: Use abstract relationships.

– *Spatial-temporal*: Individual perceives visual or spatial information and transform this information by recreating visual images from memory.

– *Kinetic-Bodily*: Use body to create products or solve problems.

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[54] Schank, R. C. is Professor of Computer Science, Psychology and Education at Northwestern University. Article appeared in the magazine Communications of the ACM *"The Computer isn't the Medium, It's the Message"*.

[55] Cronbach, L. & Snow, R. *"Aptitude-Treatment Interaction"*. 2003.

Personal:

- *Intrapersonal*: Helps individual to distinguish their own feelings, build appropriate mental models and use this knowledge in making their own decisions (for example, metacognition).

- *Interpersonal*: Allows individual to recognize and distinguish moods, intentions, motivation, and feelings from other people (for example, social skills).

– *Naturist:* Distinguish, classify, and use environment characteristics

– *Existential:* Individual uses life examples, values, etc.

According to Gardner, teaching and learning should focus on each person particular intelligences. For example, if an individual has strong spatial or musical intelligences, he should be encouraged to develop these abilities.

Gardner emphasizes cultural context of multiple intelligences where each culture tends to accentuate particular intelligences.[56]

He proposes some fundamental principles:

– Encourage students to use their preferred intelligence to learn.

– Training activities should seek and find various forms of student intelligence.

– Learning must measure multiple intelligence forms.

This theory includes these characteristics:

– Importance of having different presentation content's forms to capture student's interest.

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[56] Gardner talks about people spatial capabilities from Puluwat (Caroline Islands), who use their skills to navigate ocean in canoes and also discuss the balance of personal intelligences required in Japanese society. 1983.

– Proposal of entry points or content introducing ways to motivate students (narrative, quantitative / numerical, foundational, existential, aesthetic, manipulative and social).

– Emphasize students' work publication.

2.3. Engagement Theory

This theory [57] is born in distance education environments with telematic support from Kearsley and Shneiderman experience. It incorporates constructivist proposals and situates learning theories. It is geared towards self-training and adult learning theories (for example, *Andragogy).*

Commitment to learning means that all student activities involve active cognitive processes such as creating, problem solving, reasoning, making decisions, evaluating, etc.

Commitment theory starts from the idea of engaging students in learning activities in collaboration with other students, by creating collaborative work groups, participating in real interest projects and being teachers who guide this work.

Computers are used in collaborative learning as an aid for group learning processes, where a group learns with a communication network's help.

Collaborative learning theories suggest during learning process, students clarify and discuss their problems, and therefore, it is a solutions' facilitator.

Collaboration increases student motivation and awakens and sustains interest in learning [58].Three basic points in this theory are [59]:

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[57] Kearsley, G. & Shneiderman, B. *"Engagement Theory: A framework for technology-based teaching and learning"*. The Virtual Professor: A Personal Case Study. 1997.
Shneiderman, B. *"Education by Engagement and Construction: Can Distance Education be Better than Face-to-Face?"* 1994.

[58] Argyro, R. *"CSCL: Computer Supported Collaborative Learning"*. 2003.

[59] Kearsley, G. & Shneiderman, B. *"Engagement theory: A framework for technology-based teaching and learning"*. 1998.

– *Engagement within the group*: group context encourages students to learn through collaborative teams.

– *Learning based on a defined project within the group*: group work is the most popular form of participation. Students learn to find solutions to project problems.

– *Contribution to society*: Students learn within society context. Learning value is making a society's contribution. For example, community organization, school, state, etc. Learning process can help students understand the world.

Group activities are summarized in *Relate-Create-Donate*:

– *Relate*: it highlights groups effort in the communication, planning, management and social skills processes. These characteristics are part of many actual professional profiles.

– *Create*: It is about carrying out creative activities. A project definition and its management allow student greater control over their learning process. This project learning orientation is known as *Problem Based Learning* (PBL)[60], used in many professional settings.

– *Contribute*: It highlights the contribution's value occurs while learning because it is about carrying out projects with real interest and with real people: from educational community itself to companies, public institutions with different nature [61], etc.

Group uses some resources to carry out projects to develop: e-mail, forums, chat, newsletters, virtual classrooms, face-to-face meetings, videoconferences, databases, groupware, audio, etc.

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[60] Barrows, H. & Tamblyn, R. *"Problem based learning: An approach to medical education"*. NY: Springer. 1980.

[61] Jacoby, B. & Associates. *"Service-Learning in Higher Education: Concepts and Practices"*. San Francisco: Jossey-Bass. 1996.

2.4. Instructional Transaction Theory

We define "Instructional Transaction" (IT) as interactions set necessary for a student to acquire knowledge or skills.

An instructional algorithm requires a set of knowledge objects related in a certain way (knowledge structure) and it contains all necessary knowledge to acquire some proposed learning objective.

Instructional transaction theory explains it is possible to develop interactive and simulation learning environments, with identification transactions, procedures' execution or interpretation, incorporating presentation strategies, practices and learning aids.

Farhad Saba[62] defines in "Integrated Telecommunications and Instructional Transaction Systems" that distance learner receives instructions through a communication channel. A differentiated feature of distance education is mediated instructional transaction, being possible by interactive communication through voice, texts, data or any information coming from a virtual continuity.

2.5. Component Display Theory

Component Display Theory [63], written by M. Merrill in 1991, describes how learning objectives and presentation models interrelate.

According to Merrill, learning objectives combine:

- *Contents*

  – *Facts:* Information pieces with their own name, date or event, symbol to designate an objects group or events.

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[62] Saba, F. *"Integrated systems of telecommunications and the transaction instructional"*. The American Journal of Distance Education. 1988.
[63] Merrill, M.D. *"Component Display Theory"*. In C. Reigeluth (ed.), Instructional Design Theories and Models. Hillsdale, NJ: Erlbaum Associates. 1983. Merrill, M.D. *"Instructional Design Theory"*. Englewood Cliffs, NJ: Educational Technology Publications. 1994.

  - *Concepts:* Objects' groups, events, or symbols with common characteristics.
  - *Procedures:* Orderly sequence of steps to achieve an objective, process, or product.
  - *Principles:* Explanations or predictions relating causes and effects.

- *Performance or development:*
  - *Remember:* In memory, previously saved information.
  - *Use:* Apply some abstraction to a specific case.
  - *Find:* Deduce or invent a new abstraction.

Merrill classifies four instruction presentation's models, based on their instructional purpose:

1. *Primary*: They are used to present information in a general way. Four primary presentation forms are specified:
   - *Rules:* general expository presentation.
   - *Examples.*
   - *Remember.*
   - *Practice:* questions about examples.
2. *Secondary*[64]: Used to facilitate information processing by student or complement specific content.

   Secondary presentation includes:
   - Prerequisites.

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[64] Merrill suggests training is more effective when it contains required primary and secondary presentations and says that there is a combination of presentation forms that provides more effective learning for each learning objective.

- Goals.
- Helps.
- Mnemonics.
- Feedback.

3. *Process*: These are presented instructions to student suggesting how to process offered information.

4. *Procedures*: Guidelines to guide student regarding how to operate with some equipment type in instructional environment.

In 1994 Merrill rewrote the "Component Presentation Theory" (CDT) to provide an answer in the field of instructional design to new developments in hardware and software. And their use generalization in educational field [65].

In this new theory a distinction is created a distinction between two instruction modes:

- *Tutorial model*: Information is presented to student in a structured way.
- *Experiential model*: Student can interact directly with presented contents in an experiential way.

2.6. Adults training

K. P. Cross[66] defined in 1991 adult training characteristics should be. The model also integrates other theoretical developments for adults, for example, Andragogy, that we will see next.

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[65] Merrill, M. D. *"Instructional Design Theory"*. Englewood Cliffs, NJ: Educational Technology Publications. 1994.
[66] Cross, K. P. *"Adults as Learners"*. San Francisco: Jossey-Bass. 1981.
Cross, K. P. *"Accent on Learning"*. San Francisco: Jossey-Bass. 1976.

Cross's model considers two variables:

– *Personal characteristics*: Personal characteristics include aging, life phases and development stages.

– *Circumstantial characteristics*: Circumstantial characteristics consist of affected learning by available time, that is, schedules, location, procedures.

Cross defined a series of principles to govern adult training:

1. Adult training programs must capitalize on participants' experience.

2. Programs must be tailored to participants age limitations.

3. Adults must progress through stages of personal development.

4. Adults should have a choice in availability and training programs organization.

2.7. Andragogy

Malcom Knowles's *Andragogy* Theory [67] is an attempt to develop a theory specifically geared towards adult learning. Malcolm Knowles states that Andragogy is the art and science for helping adults learn, based on assumptions about differences between children and adults [68].

Knowles specifies oneself must take initiative and responsibility for decisions in learning, being a fundamental aspect in adult training programs.

Knowles M. makes following observations about an adult's desire to learn:

– Adults have a need to know and, therefore, a need to learn.

– There is a need for adults to learn experimentally.

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[67] Knowles, M. *"Andragogy in Action"*. San Francisco: Jossey-Bass. 1984.
[68] Knowles, M. *"Andragogy, not Pedagogy"*. 1968.

– A good learning context is problem solving.

– Adults learn best when they can apply what they have learned immediately.

For Andragogy, adult training needs to focus more on the process and less on the content being taught.

Strategies such as case studies, roles to play, simulations, and self-assessment are the most useful.

In this case, instructors' role is providing necessary resources.

In 1980[69], Knowles exposed theoretical bases support educational process for adults, referring to process elements in "Pedagogical and Andragogical Models".

Below, Table 2 summarizes their proposals:

Table 2. Summary of M. Knowles' proposals on theoretical bases support educational process for adults, referring to process elements in "Pedagogical and Andragogical Models".

Manuel Castro Pereira delved into "Andragogic Curricular Model" development that constitutes a great effort to operationalize Andragogy as a science, and hypotheses and principles support it. This reference work is an especially important curriculum accessing, and its design in a different, flexible, innovative, and participatory way. It invites both, to observe its application and to evaluate factors that contribute to adult learning situation improvement[70].

An Andragogic model finds its dynamism in the following components:

– The adult participant.

– The andragogic.

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[69] Knowles, M. *"The modern practice of adult education: from pedagogy to andragogy"*. 1980.
[70] Castro Pereira, M. *"¿Es la andragogía una ciencia?"*. 2004.

About	Pedagogical Model	Andragogical Model
Clime-climate	Tense, unreliable. Formal, cold, distant. Guided by authority. Competitive, judgmental.	Relaxed, reliable. Mutually respectful. Informal, warm. Collaborative, supportive.
Planification	Basically, by teacher.	Mutually, by learners and facilitator.
Needs diagnosis	Basically, by teacher.	By mutual evaluation.
Goal setting	Basically, by teacher.	By mutual negotiation.
Learning plans design	Teacher content plans. Course didactic units. Logical sequence.	Learning contracts. Learning projects. Sequenced by arrangement
Learning activities	Transmission techniques. Assigned readings.	Research projects. Independent studies. Experience techniques.
Evaluation	By teacher. Referred to norms (by a curve). With grades.	By evidence gathered by learner, validated by their peers, facilitators, and experts. Referred to criteria

Table 2. Summary of M. Knowles' proposals on theoretical bases support educational process for adults, referring to process elements in "Pedagogical and Andragogical Models".

– Participants group.

– Environment.

a) The adult participant: It is the first and main resource in learning situation. Relying on his previous knowledge and experiences, participant does nothing more than continue exploitation and / or discovery his talents and capacities.

b) The andragogic: He is a recognized person as competent either in the field of learning to be done, or how it can be done, or both at the same time. As

a reference person and / or an expert person, the andragogic can and should play various roles, such as: consultant, information transmitter, facilitator, change agent, relationship agent, tutor, etc.

c) The group: Gathered adults in participants groups, constitute a set of resources due to their previous experiences and their willingness to learn. In this way, every group member becomes a learning agent, whether in terms of process content.

d) The environment: It is possible to distinguish three types of environment. First comprises the immediate environment, created to carry out learning, that is, educational activity. Second is related to educational body providing resources and human and material services. Third type includes institutions and social groups.

Finally, Castro Pereira states to this following conclusion: "Andragogy is one of the educational sciences aims to facilitate learning processes in adults throughout their lives."

2.8. Anchored Instruction Theory

Anchored instruction, an important paradigm for technology-based learning was developed by the *"Cognition & Technology Group at Vanderbilt"* (CTGV)[71] and John Bransford is credited with the statement and main theory contributions.

Anchored instruction theory is based on interactive tools development. These tools encourage students and teachers to pose and solve complex and realistic problems. Video sequences serve as "anchors" (macro contexts) for entire training. These stories are intended to capture interest and should be explored by students and teachers.

CTGV explains that design of these anchors is intended to be different from design of typical interactive systems design used in education. Using interactive

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[71] Bransford, J. D. y colaboradores. *"Anchored instruction: Why we need it and how technology can help"*. In D. Nix & R. Sprio (Eds), Cognition, education and multimedia. Hillsdale, N. J.: Erlbaum Associates. 1990.

multimedia technology allows students to easily explore the content. This theory is related to "situated learning" discussed below.

2.9. GOMS Model (Goals, Operators, Methods, and Selection rules)

GOMS (*Goals, Operators, Methods, and Selection rules*) is a method that allows you to describe a task and how a user should perform it in terms of objectives, operators, methods, and selection rules.

GOMS is a theory on cognitive skills related to computer tasks. It is based on memory involved types: sensory, working memory and long-term memory in cognitive processes.

S. Card, T. Moran, and A. Newell[72] proposed an original GOMS formulation and created a simplified version, KLM (Keystroke-Level Model).

John E. Bonnie developed a parallel activities' version, CPM-GOMS and David Kieras[73] a more rigorous version, NGOMSL (*Natural GOMS Language*). All these techniques are based on the same GOMS concept.

According to GOMS model, cognitive structure consists in four components:

– An objectives or goals system.

– An operators' system.

– A set of methods to achieve goals.

– A selection rules system to choose the most competent method.

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[72] Card, S; Moran, T. & Newell, A. *"The Psychology of Human-Computer Interaction"*. Hillsdale, NJ: Erlbaum. 1983.

[73] Kieras, D. E. *"Towards a practical GOMS model methodology for user interface design"*. In M. Helander (Ed.), Handbook of Human-Computer Interaction. Amsterdam: Elsevier/North Holland. 1988.

For a given task, a particular GOMS structure can be built and used to predict required time to complete the task. Additionally, model can be used to identify and predict effects on task malfunctions.

GOMS is also intended as a design methodology system. This allows designers with an interface to test used designs. GOMS model describes necessary methods to carry out objectives are desired. These methods are made up for steps user executes. When there is more than one available method to meet an objective, selection rules will allow deciding which method will be appropriate for each situation.

In other words, GOMS model is made up by methods for acquiring specific objectives. These methods compose for specific steps that a user performs at a given runtime. If an objective can be achieved by more than one method, selection rules are used to choose the appropriate method.

This model is related to Carrol's minimalist model we will see in the next section.

We describe some GOMS model principles:

1. To improve cognitive skill functioning, unnecessary operators must be eliminated from method used to do a task or use other methods.

2. Involved operators in cognitive skills are highly specific for methods used in each task.

3. Task performance can be improved by providing an error-recovery methods' set.

2.10. Minimalism

J. M. Carroll's Minimalism[74] theory (developed under Piaget's constructivism influence) is essentially intended for users training through computers.

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[74] Carroll, J. M. *"Minimalism beyond the Nurnberg Funnel"*. Cambridge, MA: MIT Press. 1998.

This theory thinks instruction should be short and should allow user their own exploration.

Minimalism is strongly centred-user, makes its objectives explicit and involves student in real tasks.

It also reduces training material's length, and explicitly supports recognition and errors correction.

Its objectives are:

– Stay motivated.

– Promote active learning.

– Make safe learning environment in sense of allowing user to experiment with the program without being frustrated when they make mistakes.

This theory suggests that:

– All tasks students learn are meaningful activities and autonomous.

– Realistic projects must be carried out as quick as possible.

– Training planning must enhance students' reasoning and their improvisation by increasing learning active activities.

– Teaching materials and activities should anticipate error and recovery.

– There must be a total relationship between training system and real system.

Minimalism theory is intended to be built on beginner experience.

Generally inexperienced users explore program's functions through trial and error.

Minimalist model assumes two important cognitive psychology principles:

1. *Constructivism*: users build their own mental models by combining their previous experiences with new information, from computer screen and documentation.

2. *Active learning*: users learn better when they are actively involved, when they do something for themselves, not just following instructions in a script manner[75].

Carroll produced a guide for documentation's development integrating constructivism and active learning[76]:

– Give opportunities to users to form their own mental models. Invite them to explore and discover for themselves instead of leading them, step by step, through an example[77].

– Do not tell everything about the program to users, omit what they already know or can infer, and omit documentation they can easily see on computer screen[78].

– Assume users will make mistakes, because in fact, they occur in any learning situation. There is a need to prevent errors, but also to find out error's types. At any given time in training help users to recognize mistakes and correct them[79].

Carroll thinks developed training on basis of other educational theories (Gagne, Merrill) are too passive, cannot exploit student's prior knowledge or use mistakes as an opportunity to learn.

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[75] Charney, D. H., Reder, L. M., & Wells, G. W. *"Studies of elaboration of instructional texts"*. En S. Doheny-Farina (ed) *"Effective Documentation: What Have We Learned from Research"*. Cambridge, MA: MIT Press. Págs. 47 a 72. 1988.

[76] Tejada, J. *"Manual impreso minimalista versus manual hipermedia: Contraste empírico de dos tipos de materiales de adiestramiento informático para usuarios inexpertos"*. Noviembre 1999.

[77] Van der Meij y Carroll, 1995.

[78] Carroll, 1990; 1998.

[79] Carroll, 1987; Lazonder & Van Der Meij, 1995 & Redish, 1998.

2.11. Situated Learning

Initially described by Jean Lave, situated learning theory[80] is based on Gibson[81] and Vygotsky[82] work. This theory[83] proposes that learning normally occurs as an activity function, context, or culture; it is called being situated.

Social interaction is critical in situated learning, students are integrated into a practices' community incorporating a set of attitudes and behaviours students gradually assume.

This theory says that knowledge is an active relationship between an agent and environment.

Learning occurs when student is actively involved in a complex and real instructional context[84].

Gibson emphasizes about learning, through perception and not memory. It argues that not only learning but also thinking is situated, and therefore should be considered from an ecological perspective[85].

Internet responds to knowledge premises located in two of its characteristics:

– Realism: It enables authentic exchanges between users from different cultural contexts, but with similar interests.

– Complexity: Unstable Internet environment nature is a stumbling block for no initiated[86].

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[80] Lave, J. *"Teoría del conocimiento situado"*. 2003.
[81] Gibson, J. *"Information Pickup Theory"*. 2003.
[82] Vygotsky, L.*"Social Development Theory"*. 2003.
[83] Lave, J. & Wenger, E. *"Situated Learning: Legitimate Peripheral Participation"*. Cambridge, UK: Cambridge University Press. 1991.
[84] Young, M. F. *"Instructional design for situated learning"*. Educational Technology Research & Development, 41,1. Pág. 43-58. 1993.
[85] Gibson, J. J. *"The ecological approach to visual perception"*. Hillsdale, N. J.: Lawrence Erlbaurn.1986.
[86] Brown, J. S.; Collins, A. & Duguid, S. *"Situated cognition and the culture of learning"*. Educational Researcher", 18(1). Págs. 32 a 42. Situated cognition and the culture of learning. 1989.

CHAPTER 3

NEW TEACHING PARADIGM

3.1. Different teaching models

In several writings (Troncoso Saracho, 1999), the statement is repeated according to that teaching does not consist in professor's teaching, but also, in students' learning. Tortajada (2009) defines the traditional teaching model (Figure 3) as one whose characteristics are:

– Primacy of the contents

– Master class as predominant methodology

– Students' passivity

– Teachers are experts in content and information transmitters

– Planning is only for teachers

– The only source of information is class notes

– A rigid evaluation system based exclusively on knowledge compilation tests.

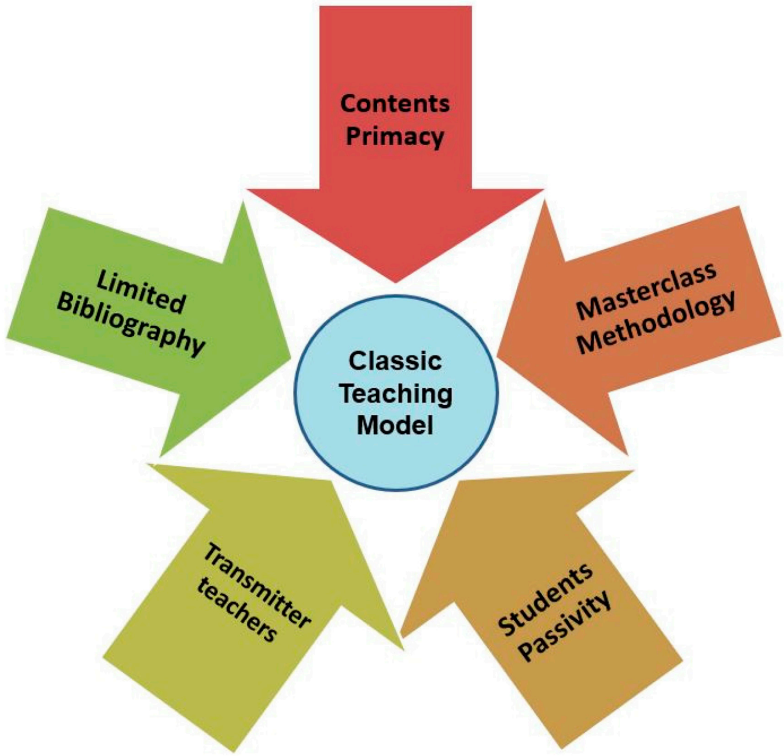

Figure 3. Classic Teaching Model.

Faced this model, new technologies are significantly changing the teaching way; while traditional teaching follows artisanal work methods, it is necessary to propose and rethink objectives, content, and methodologies (Álvarez Peñín, 2000).

There is a belief that teaching occupies a secondary level in teacher's activity, dedicated strongly to research. For this reason, a teaching adaptation to social reality is needed.

It is perceived that there is a great teachers' interest in learning and applying new methods to improve teaching quality; for this reason, it is necessary that support tools are presented in specialized teaching conferences, so that this new teaching-learning model contributes an added value to teaching.

Rather than promoting the point of view of technological innovation, it is necessary to use this technology to achieve objectives in a better efficient way (Sangrà, 2001).

To improve teaching, different alternatives are proposed. Some authors (Herrero de Lucas, 2008) highlight the advantages of coordination between teaching staff who teach in the same university degree, both with respect to the content, and different teaching methodologies used. It is proposed to coordinate teaching in different knowledge's areas to alleviate the excessive division in academic knowledge.

For others (Pallisera Díaz, 2008) it is essential to provide teachers with sufficient information and training to initiate innovative processes in teaching. For others (Bermúdez Rodríguez, 2000), Information and Communication Technologies (ICT) can be a powerful aid to teaching to maintain quality area level and adapt to new dedications set in study plans.

It seems clear that ICT will significantly influence teaching in a way that will inexorably lead to a new paradigm shift. Computer tools not only pose a change in applying teaching way but also in contents. Other authors (Marín Granados, 2000) propose a teaching model combining lectures, tutoring and a computer-assisted teaching system.

The solution to increase teaching efficiency, understood as a greater amount of knowledge imparted in less time, is in computer-assisted animation. Although it highlights that this didactic medium cannot be used alone, nor independently from the rest.

Martín Gutiérrez (2006), identifies three change's factors in teaching: the new educational model designed by the European Higher Education Area (EHEA-EEES), the social demand for the incorporation of new information and communication technologies to university and the need to improve university quality.

As solutions for teaching improvement, it is proposed:

– Mechanize part of teaching work, especially regarding the management and exercises' correction using new tools based on ICT (Álvarez Peñín, 2000).

– Virtual platforms use allows to increase teaching's quality, both at the level of demand and results (Zurita de la Vega, 2008).

– The improvement of teaching efficiency through a methodological proposal based on the results obtained by the students in the exams. All to know causes

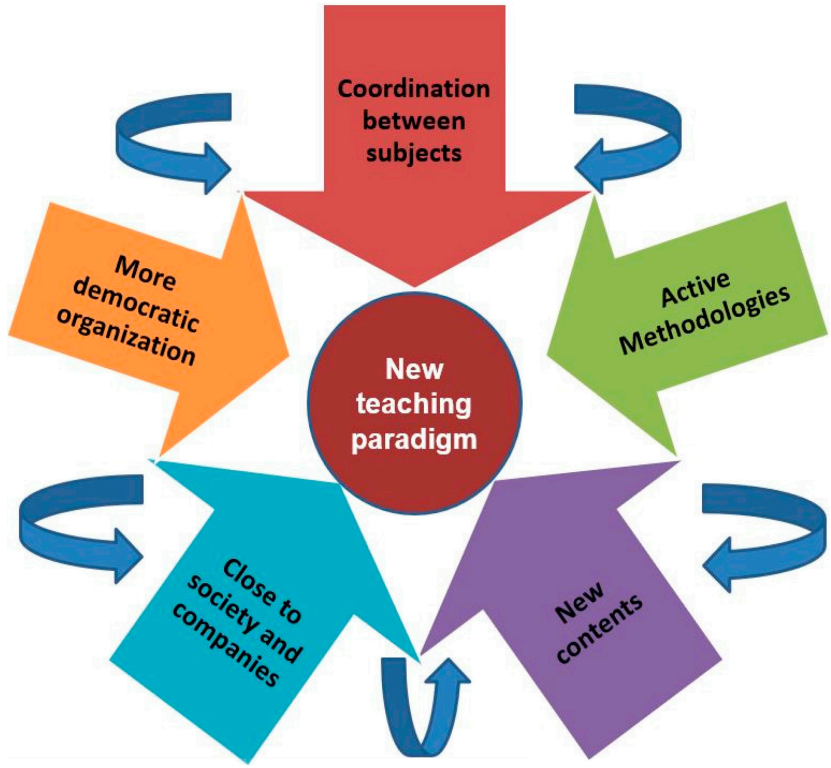

Figure 4. New teaching paradigm.

provoking a high degree of difficulty (Methodology based on the Rasch model) (Rebollo Castillo, 2009)

It is important that change in teaching paradigm from teaching to learning does not imply a decrease in teaching quality. Figure 4 shows us the new teaching paradigm.

3.2. Virtual learning

Virtual learning origins (Pellejero, 2000) are largely based on the design of virtual practices allowing students to develop an interactive learning type. Virtual learning is the result of a historical evolutionary process in which several stages are distinguished: printed material's use, teaching based on analogy material, computer tools' incorporation and use of digital technology through Internet.

Facilitate tools for virtual reality development have experienced a great advance, so, technological equipment necessary to execute these applications is simple and standard, thanks in part to new web-based scenario, and this allows an explosion of learning experiences virtual.

There is confidence that, in the future, virtual laboratories will become integrated elements in learning processes; there are even authors (Cruz, 2006) who affirm that virtual learning will facilitate the European convergence of university teaching programs.

One proposal is to influence learning from teachers' side, through the creation of thematic virtual learning portals for collaborative work on different subjects.

With integration into EHEA- EEES, some technology-based teaching methodologies incorporate virtual learning environments complementing face-to-face activities, facilitating publication, communication and group work so that didactic model becomes blended.

The new virtual learning environment provides students the possibility of intervening in their own learning process as an element for teaching improvement. For Zulueta (2009) a virtual classroom idea takes shape as a support tool for face-to-face teaching, not as a resource with which to develop knowledge, but as a vehicle for exchanging relevant information and improving learning.

Creating a virtual environment has the following objectives:

– Introduce the subject in a work environment based on new technologies.

– Promote work planning in a remote way.

– Provide tools for document management.

– Encourage use of new office automation and multimedia integration techniques.

Main characteristics of a virtual classroom can be seen in Figure 5.

Figure 5. Virtual classroom characteristics.

There is unanimity (Moreno, 2000) in defining a virtual classroom as a new teaching medium that entails great advantages: teaching flexibility time and place, adaptation to student's learning rhythm, non-linear learning, and interactivity between teaching agents; but also, with its limitations, especially in security matters.

Hernández (2003), presents two types of virtual learning environments: open and closed.

In general, closed virtual environments are identified as systems that are well planned and have greater efficiency: subjects' content has been created and reviewed by experts, great easer use, elements' coherence composing it. Student monitoring is a task shared with a coordinator who ensures uniformity.

On the contrary, open systems, despite not having the same efficiency than closed ones, stand out for: planning is freer, investment in material 's generation

is much lower, material used is easier to prepare and there is a much greater dependence on teacher training and their experience in developing material. Figure 6 summarizes the above.

It seems logical to think that analysis and evaluation perspectives about virtual teaching may be different from face-to-face or presential teaching.

The most significant difference between face-to-face and virtual education resides in "environment change". We cannot do the same in two different media. Although our purpose is the same (students understand what they are taught), we cannot travel the same path.

Learning process is a global approach that is specified in different ways depending on the medium it is used. Virtual classes benefit from creative net possibilities.

According to Sangrà (2001), there are two types of differential elements in educational processes in virtual environments: methodological and organizational.

For this author, educational methodology for virtual learning environments must *"be student-centred"*. It is about adapting methodology to a student profile, with time difficulties to attend university.

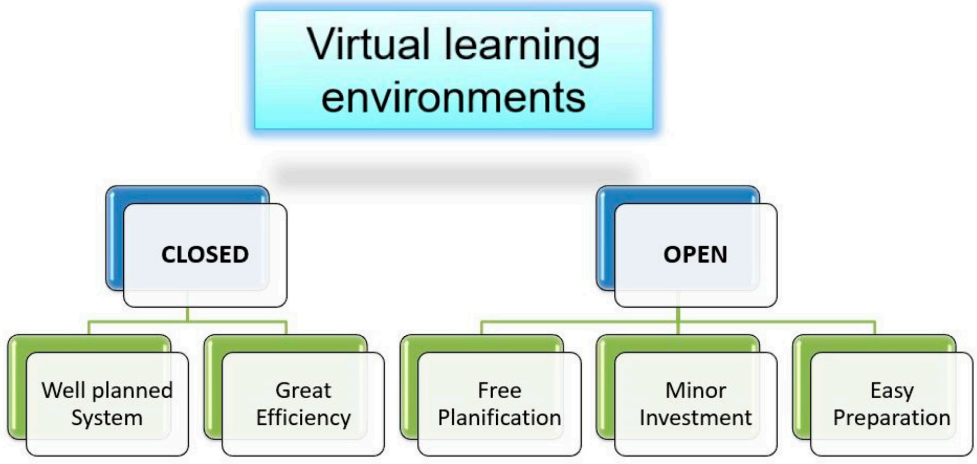

Figure 6. Virtual learning environments.

It is about *"bringing university to each student home"*. But there are other models in which technology does not change teaching itself, but rather, it must be an added value to teaching tasks. On the other hand, if there must always be a certain understanding in teaching, in non-face-to-face teaching. Students must always know what is going to be required from them; this implies a certain negotiation just when starting a non-face-to-face teaching course.

For Gisbert (2002) there are two clearly defined application areas, one local (which works through a classroom) and other global (Internet).

Learning with technology is different, it involves students and forces them to be active in learning. Technology first complicates our lives (since learning is different for students, but also for teachers), but over time it becomes much more simplified.

Gisbert proposes organize non presential teaching, following some precious steps:

– Plan the subject.

– Design and develop the subject.

– Design process implementation.

– Propose a guide for students.

– Plan different content blocks.

– Develop training materials.

– Organize concept maps.

– Create other evaluation materials.

Teaching organization in virtual environments must put ICT possibilities at student service. ICT should not be an end on itself, but only a media with a certain added value. In this organization, different learning materials (debates, forums, messages, links ...) must allow interaction and collective construction of knowledge. Particular structure in a virtual education organization has to manage, in

addition to academic and teaching processes, production and editing of educational materials.

But… What is virtual teaching? Is it a new paradigm, or is it simply the evolution of traditional teaching? According to Charles Wedemeyer (1981), there is not an authentic virtual learning theory, although this author refers to traditional distance learning by conventional mail (UNED Model).

Other authors, on the contrary, come to define different theories from their own for distance education: "The theory of student autonomy and independence" (Delling, 1987), "The theory based on the process of education industrialization" (Peters, 2002) and the "Theory based on interaction and communication" (Holmberg, 1987), but whatever the theory studied, they all identify three fundamental elements for virtual teaching:

- The student (a specific student' type for these studies)
- The teacher (the relationship established with the student)
- Resources (allowing interaction)

The relationship established by these three elements at stake is what makes a new paradigm in non-face-to-face teaching possible.

3.3. Blended learning

For Rajadell (2000), blended studies are justified based on three major advantages:

1. Complete the offer for face-to-face studies,
2. Expand the geographical scope of the campuses and,
3. Allow studies' compatibility with job responsibilities.

For others (Jiménez, 2008) its main advantage lies in it allows a progressive introduction to distance teaching, where semi-simplicity is only an intermediate

step. In this line, it is manifested (Griful, 2002) that it exposes teaching model change from face-to-face to blended attendance and has no more motivation than teaching quality improvement. It also stands out as an advantageous element (Lapaz Castillo, 2002) that semi-simplicity allows flexibility and individualization for student learning.

The success of blended teaching lies in getting students to achieve most of the tools available for their learning, basing it on an intensive use of ICT. The use of virtual learning environments in a blended mode is emerging as a strategy with great possibilities in ICT incorporation, especially in technical studies.

Tools incorporate virtual environments allow favouring a project-based learning methodology, group work and personalized advice.

Blended presented studies always follow the same Study Plan as the face-to-face ones, but generally with a different subjects' distribution between compulsory, elective and free choice, and extending the credit load in more semesters or courses.

3.4. Distance education models

Distance education has existed for many years before Internet appearance, but with other teaching models. It has been a society need to be able to satisfy citizens' learning who for reasons of time and / or space could not attend to university, also if they had a desire to improve their knowledge.

Taylor, J. C. (2001) analysed four models about distance education have been surpassed in time and space (there are countries where distance education is in more ancient models than others). These models are based on useful technology according to its historical application moment, which has allowed them certain applications in some cases.

Taylor highlights that just when the fourth model is being applied, a fifth is appearing, basically derived from the previous one, but exploiting all Internet capabilities. These models are:

- *First generation-model based on correspondence.* Technology uses paper. This model offers flexibility in time and space. Student can study and do exercises when

she wants and where he wants, and then send them by post. There is no interactivity.

- *Second generation-Multimedia model.* In addition to paper, use audio and video. This model offers flexibility in time and space. There is no interactivity.

- *Third generation-telelearning model.* Technology uses videoconferencing, and television and radio broadcasts. This model has lost all flexibility in time and space, since you must be in a certain place where there is a television to attend the program broadcast that interests us and also at a certain time.

- *Fourth generation-flexible learning model.* Use interactive multimedia technology online and Internet. This model offers flexibility in time and space and, also interactivity. It adds the advantages from First, Second and Third Generation, without any of its limitations.

- *Fifth generation-smart flexible learning model.* Use interactive multimedia technology online, Internet and virtual campus. This model offers all the advantages of previous ones and significantly reduces the teaching cost, approaching it to zero.

Not all authors fully agree in these five generations. Suárez Quirós (2002) recognizes only four stages in distance education models: 1. Use of printed material, 2. Teaching based on analogy material, 3. Computer tools incorporation and 4. Use of digital technology through Internet mainly. In any case, the scheme is very similar, and in all cases, it stands out there has been an evolution in distance learning, always based on skilful technology at each historical moment, regardless of whether there are four or five models.

The application for full ICT potential in distance learning leads to the emergence of a new learning model. It is increasingly efficient and cheap, with full intercommunication and it involves a new virtual campus model, although it can be implemented in different successive phases.

The potential Internet offers as a teaching tool extends to various perspectives: as a complement to face-to-face teaching through websites development containing useful work materials for students; as management support through tools that facilitate both teaching and administrative tasks. At the end, as an effective

virtual classroom, creating an infrastructure on the network capable of integrating all teaching elements usually used in university education.

3.5. New virtual university settings

Two possible scenarios are proposed towards which university education organization could evolve: the local scenario and the multinational one.

The local scenario, which has been developing since the 1990s, consists in an explosion in the number of universities that are increasingly physically close to student. A priori, it is a completely illogical model with ICT explosion. It is not necessary to bring universities to each student's home door since ICTs allow distance learning. But in this scenario, what prevails is not an existing technology but politics, in which each region (and even city) wants "its" university.

The global scenario, on the contrary, foresees fewer and fewer universities, since student will be able to choose the university that best meets their needs, regardless on physical distance from the school, thanks to ICT. In this way, only "best" universities will be able to survive since they will have a sufficient critical mass of students to defray costs of implementing new technologies.

But there is a third scenario, not an intermediate one, but a mixture of both. Universities proliferation in cities with little demographic, economic and / or technological weight has encouraged these institutions to develop full ICT potential, in order to attract students to them, not physically, but through Internet. In this way, what is being carried out is a network of universities' network (generally from the same region), sharing services series. It has started with what is easier from a bureaucratic point of view, free choice subjects.

The most paradigmatic example is Intercampus project, sponsored by Universities Department, Research and Information Society from Generalitat de Catalunya.

Intecampus project aims to exchange free-choice subjects that are taught on Internet. Participating universities are: UAB, UB, UdG, UdLL, UOC, UPC, UPF, and URV. Universities facilitate communication and simplify bureaucracy, but it is a first step.

This will be followed by other logics such as the increase in subjects not only free choice, the sharing of more and more information, and territorial expansion (if teaching is based on ICT, what is the point of Intercampus being from Catalan universities and other Spanish, Latin American, or other institutions in the world cannot join the project). In this way, we will have reached a global scenario based on local universities.

Intercampus project is in fact part of a larger approach, Digital University of Catalonia, which aims (in addition to connecting the non-face-to-face free-choice subjects from Catalan universities):

- Create a platform to produce and manage educational material. Share multimedia teaching materials and teacher-student methodologies.

- Build an Internet platform based on publishing houses from Catalan universities.

- Design a doctoral thesis server. Create a virtual consortium with all Catalan universities, the CBUC.

- To promote Catalan university Internet connectivity at international level, especially with US.

Chapter 4

CONCLUSIONS

Learning theories are grouped into three main models: Behavioural, Cognitive and Constructivist. Constructivist model is the most influential in educational science didactics field and is reduced to four main sub-models as described in this book, Piagetian constructivism, Human, Alternative conceptions' s movement (social) and Radical sub model.

Constructivism is an essential part in training students process, while interaction's nature between it and teaching is decisive in learning. Learning procedure is often with greater importance than content itself or even the way information is presented.

Constructivist hypothesis is one of the most influential theories in education, both in terms of theoretical elaborations, and because its pedagogical practice. Constructivist models are useful for designing instructional strategies and techniques to facilitate learning, as well as to select them effectively.

Constructivist models are based on three basic premises: First is that student is responsible for their own learning, since it is an active construction process rather than knowledge acquisition. Second fundamental idea highlights that contents are the engine for student's learning activity rather than communicating knowledge. Both, two previous basic ideas do not apply if teacher does not know how

to create optimal conditions for constructivist activities' deployment. This is the third premise necessary for constructivist models success.

Instructional design theories seek to analyse the way which learning is structured. They are especially important in instructional materials' development. Elements in these theories are based on a learning objectives classification and the prescription of how to decompose general objectives into specific ones. Also, it is based on specific and instructive active description, a sequence prescription of instructive actions defining the strategy, and finally, a set of conditions for instructive actions and strategies themselves.

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With more than 25 years of university teaching in technical careers behind them, book's authors have been observing for a long time Constructivism. It is an essential part in training students process and how interaction between them and Instruction are decisive in learning, being equal or greater importance than the content or the way information is presented.

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