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Design of Learning Activities – Pedagogy, Technology and Delivery Trends

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Abstract

There are many questions that must be addressed in the design of teaching-learning situations/scenarios. They include: how to adapt content/activities to learner´s specific needs; how to plan corrective feedback; how to fit teaching-learning-assessment techniques to a specific educational context; how to choose the educational tools more appropriate to a teaching-learning-assessment method; how to choose a language to express a pedagogical model; how to adequate the teaching-learning-assessment activities deployment to a specific educational format (distance, face-to-face or blending learning). Currently, educators, teachers included, are faced with those questions and therefore the development of teaching-learning systems is vital to help them in the design of learning situations in order to alleviate their burden in preparing lessons or teaching-learning activities. This paper presents an overview of a set of mechanisms that can help educators taking informed decisions when designing teaching-learning scenarios. To this end, a survey of the most relevant computer-based teaching-learning systems since 1960 along with developments in the learning and the instruction domains are presented. In addition, reflections on educational material design, teaching-learning activities more specifically, are also introduced. Those considerations aim at bridging the gap between relevant theoretical aspects and the teachers' daily activities in the design of teaching-learning scenarios. Finally, this paper introduces our proposed model for automatic recommendation of teaching-learning techniques to support teachers in designing of teaching-learning activities.

Keywords: computer-based teaching-learning systems, learning design scenarios, teaching-learning activities, educational tools, design tools, ontologies.
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1. Introduction

The last century was filled with huge innovations in information and computer. The invention of the microprocessor, the Internet and the World Wide Web are considered the major landmarks in the second half of 20th century and have fostered multiple scientific research paths.

Education is not an exception and it has also suffered from huge challenges in an effort to keep up with changes in learning theories and information and communication technologies.

"The promises of multimedia, simulation, computer-mediated communication and communities, and internet-based support for individual and distance learning all have the potential for revolutionary improvements in learning" [1].

In that sense, there is no question that rethinking pedagogy and learning for the digital age has become an actual theme revealing the importance in getting a proper understanding of both changes and challenges that educational environments are facing to [2]. Moreover, it is a

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straightforward thought that the traditional educational settings are no longer the unique approach to learning. This new learning pattern has emerged, to a large extent, because of the Internet and, particularly, the Web, whose potential has been widely studied [3]. Different students along with the huge set of modern digital age technologies need different approaches in educational settings. Nevertheless, as stated recurrently in the literature, the use of different educational software, media and communication technologies does not guarantee per se that students reach the expected learning goals traced by teachers. To deal with those evidences recent achievements in instruction, learning and human intelligence are considered absolutely fundamental to put in practice efficient and modern pedagogies. Until recently, the study of instruction and learning suffered from the separation between learning, as the domain of psychologists and instruction, as the domain of educators [4]. This is a crucial moment for substantial reflection and rethinking by all participants in education domain. Therefore, rethinking the design of courses, modules or even simple teaching-learning activities is becoming a mandatory step. In this regard, computer-based design tools can give a huge contribution. Such tools can be embedded with relevant mechanisms such as templates, scripts or wizards used to guide the teacher through the design process. Automatic recommendation mechanisms for different purposes are now becoming very popular as well. In the last section of this paper, we will present our proposed model of teaching-learning techniques to support teachers in the designing of teaching-learning activities.

This paper presents an overview of the evolution in educational artefacts tracing their compliance with educational environments. Next, it presents some reflections on educational material design, more specifically teaching-learning activities, that should be considered by teachers concerning reusability, sharing, adaptation and interoperability aspects. Some reflections on the design process are also presented in order to devise an operational vision of the mentioned process. In addition, it introduces our proposed model for automatic recommendation of teaching-learning techniques. Finally, the last section concludes the paper.

2. Historical development artefacts in education settings

Presently, the design of learning scenarios or 'design for learning' [5] embraces a substantial set of variables which should deserve special attention by educators.

We have divided those variables into three threads: delivery, pedagogy and technology. Concerning delivery, we have considered the following approaches: face-to-face, distance education, online learning and e-learning mode. In respect to the pedagogical thread, we have focused mainly in both learning theories included methods/techniques and strategies to learner's adaptation of teaching-learning activities. Finally, the computer-based educational systems and the computer-based design tools for creating teaching-learning activities comprise the two types of system we have introduced in the technology thread. Those issues will be described in more detail in the following sections.

2.1. The delivery thread

As mentioned earlier, the delivery thread is justified by the diversity of approaches to carry out a course, a module, a lesson or a simple teaching-learning activity. In addition to the traditional face-to-face approach other possibilities should be considered, namely, distance education, online education, and e-learning including m-learning and b-learning.

With regard to Distance Education (DE) theme, it can be introduced as follows: "DE is teaching and planned learning in which teaching normally occurs in a different place from learning, requiring communication through technologies as well as special institution organization." [6].

DE stretches back to 1880 and from that time until today, several generations of DE can be mentioned, more exactly four according to Moore & Kearsly [6]. The first generation was characterized by the transmission of contents by postal correspondence. There was a complete separation between the teacher and the student with no type of interaction at all between them. The second generation was teaching by means of broadcast radio and television. The third generation addressed the structure and ways to organize education and it was substantiated in the Open University model. Next, in the 1980s, the teleconferencing generation followed and launched the real-time group interaction at a distance, in audio and video teleconference courses delivered by telephone, satellite, cable, and computer networks. Finally, the computer and Internet-based virtual classes generation promoted teaching and learning online, in "virtual" classes and universities. The Internet and Web, in particular, boost new ways in the organization of distance teaching. In addition to single-mode institutions (teaching at a distance mode), dual-mode institutions (face-to-face and at a distance mode) have emerged.

More important than the classification into generations, are the set of aspects on which researchers theorize namely, interaction and independence; pace / autonomy ("self paced") and group learning; blended learning ("blended") and distance learning; magnitude ("scale") and efficiency; dropouts and retention strategies; and finally learning theories. All those aspects have different magnitudes and expressions in many theories of distance education that emerged in the last two decades of the last century. Desmond Keegan was the first author presenting a systematization of theoretical thinking in the field of distance education[7].

Regarding e-learning (electronic learning), its origins go back to the 80s of the last century, appearing almost at the same time of online learning concept. Both terms are often used interchangeably despite some efforts to describe them in a more accurate way. Briefly, e-learning is characterized by the use of the Internet; the course design can be a mixed of online and face-to-face classes, sustained in synchronous

and asynchronous communications; and the interaction between learner and teacher is accomplished using all kind of tools (chat, forum, email, videoconference, among others). There are many definitions in the literature of e-learning concept. We find the following one very precise in respect to the focus of e-learning "e-Learning can cover a spectrum of activities from supporting learning, to blended learning (the combination of traditional and e-learning practices), to learning that is delivered entirely online. Whatever the technology, however, learning is the vital element." [8]. Nowadays, the e-learning community covers several domain aspects in order to overcome real challenges, namely, how to put in practice different human learning theories for adaptation purpose; the creation of high level graphical design tools; the effective use of IC technologies to enhance the teaching-learning process; the common use of specifications and standards for interoperability purpose; and the reuse and sharing of e-contents.

Online learning, in its turn, is described by most authors as a way to access learning experiences via Web. This concept can be supported by the following two definitions: "The use of the Internet to access learning materials: to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience." [9] and "online learning describes education that occurs only through the Web, that is, it does not consist of any physical learning materials issued to students or actual face to face contact. Purely online learning is essential the use of eLearning tools in a distance education mode using the Web as the sole medium for all student learning and contact." [10].

2.2. The pedagogy thread

The recognition of different ways of learning should have practical consequences in the planning of courses or teaching-learning activities. Different strategies are needed in order to adapt teaching-learning subject matters to learner's needs, interests or preferences. In addition, other skills are also considered important, as for example, collaborative and cooperative team work. This process is a very demanding task for educators. They need to consider a huge amount of information to conceive a proper pedagogical design for a teaching-learning experience. Getting the learners motivated as well as ensuring the achievements of all students both encompass a true challenge nowadays. To this end, it is important to bridge theoretical achievements in all facets of learning design with daily teachers' practices.

Regard to a good pedagogical design, it is important to consider accepted theoretical foundations in order to avoid inconsistencies and undesirable results. In that sense, a careful planning must take into consideration different matters, namely, the curriculum, teaching methods, the learning environment, and assessment procedures [11].

Making a brief historical overview, the most relevant research in human learning took place throughout much of the 20th century. Most learning theories share principles that are expected to enhance learning from instruction (table 1). Nevertheless, theories/streams of learning differ in how they address critical issues namely how learning occurs, the role of memory, the role of motivation, how transfer occurs, which processes are involved in self-regulation and the implications for instruction [4].

Table 1. Shared principles in learning theories (Schunk, 2003).

Learners progress through stages/phases
Material should be organized and presented in small steps
Learners require practice, feedback, and review
Social models facilitate learning and motivation
Motivational and contextual factors influence learning

Consequently, a range of learning perspectives has emerged with important consequences for instruction. Globally, their roots are driven by the guidelines of at least one of the following broad theories: Behaviorism, Social Cognitive, Information Processing and Constructivism.

Briefly, the behaviorist perspective of human learning contends that behaviors can be described scientifically without recourse either to internal physiological events or to hypothetical constructs such as thoughts and beliefs [12]. Learning requires establishing responses to discriminative stimuli whereby environment events dominate this view of learning. In that sense, practice is needed to strengthen responses. In addition, complex skills can be established by shaping progressive, small approximations to the desired behavior. Its main influences were Ivan Pavlov, Edward L. Thorndike, John Watson and Burrhus F. Skinner.

In turn, the Social Cognitive learning theory states that individuals learn from one another, via observation, imitation, and modeling. By observing others, individuals acquire knowledge, rules, skills, strategies, beliefs, and attitudes. Moreover, individuals also learn from models the usefulness and appropriateness of behaviors and the consequences of modeled behaviors, and they act in accordance with beliefs about their capabilities and expected outcomes of their actions [4](pp.118). Its main influence was Albert Bandura.

Information Processing Theory (IPC) is a generic name applied to various theoretical perspectives dealing with the sequence and execution of cognitive events. It provided psychologists with a framework for investigating the role of a variable that behaviorism has ignored: the nature of a learner [13]. In that sense, the psychologists study closely at how, independent of the context, stimulation from the environment goes through the processes of attention, perception, and storage throughout a series of distinct memory stores [14]. This theory uses the computer metaphor focusing on what happens in between input and output. It conceives three major memory stores that are involved in cognitive processes: sensory memory, working

memory, and long-term memory. Its main influence was George A. Miller.

Constructivism, in turn, is an epistemology, or philosophical explanation about the nature of learning. Constructivist theories vary from those that postulate complete self-construction, through those that hypothesize socially mediated constructions, to those that argue that constructions match reality [4] (pp. 274). In contrast with IPC theorists, cognitive processes are situated (located) within physical and social contexts, thereby highlighting the relations between persons and situations.

Two theories from the constructivism perspective have been highly valued in instruction: the Cognitive Development theory from Jean Piaget and the Socio-cultural theory from Lev Vygotsky. Shortly, Piaget's theory postulates that children pass through a series of qualitatively different stages: sensorimotor, preoperational, concrete operational, and formal operational. Schemas, assimilation, accommodation, adaptation and equilibrium are the most prominent identifiers connected to this theory [15]. In turn, Vygotsky's sociocultural theory emphasizes the social environment as a facilitator of development and learning. The social environment influences cognition through its tools—cultural objects, language, symbols, and social institutions [16].

The implications for instruction of the above theories are of major importance for whom is responsible for planning either a curriculum of a course or a teaching-learning activity only (Table 2).

Currently, the constructivism perspective has been gained an important role in education promoting new teaching-learning pedagogical methods either in traditional classrooms or in e-learning delivery mode. The constructivist environments have the potential to engage learners in knowledge construction through collaborative activities that embed learning in a meaningful context and through reflection on what has been learned through conversation with other learners [17] (p. 13).

Since the 1990's, a large set of new learning streams has emerged much in consequence of the advances in Web technologies. Communities of practice, peer-to-peer social networks, collaborative and cooperative learning have extended the wordbook in the learning domain. This social dimension on learning has received a major boost from the gradual reconceptualization of all learning as 'situated' [18]. Situated learning is learning that is situated in a specific context and embedded within a particular social and physical environment. This view of learning focuses on the way knowledge is distributed socially, and in this regard boosting new skills and competences among the learners. Learning is not viewed as simply the transmission of abstract and decontextualized knowledge from one individual to another, but a social process whereby knowledge is co-constructed [19]. New social networking tools such as blogs, wikis, social bookmarking have truly become powerful in the educational process. Distance education and e-learning approaches, including its subcategories, have been taken major advantages in using these type of tools.

Table 2. Implications for instruction of Behaviorism, Social Cognitive, Information Processing and Constructivism learning theories (source: Schunk, 2003).

Behaviorism Theory	**Social Cognitive Theory**	**Information Processing Theory**	**Constructivism**
Instruction should have clear, measurable objectives, proceed in small steps, and deliver reinforcement. Mastery learning, computer-based instruction, and contingency contracts are useful ways to promote learning.	The use of modeling is highly recommended in instruction. The key is to begin with social influences, such as models, and gradually shift to self-influences as learners internalize skills and strategies. It is also important to determine how instruction affects not only learning but also learners' self-efficacy. Learners should be encouraged to set goals and assess goal progress. Teachers' self-efficacy affects instruction because efficacious teachers help promote student learning better. Worked examples, tutoring, and mentoring are recommended.	Information should be presented in such a way that students can relate the new information to known information (meaningfulness) and that they understand the uses for the knowledge. These points suggest that learning be structured so that it builds on existing knowledge and can be clearly comprehended by learners. Teachers also should provide advance organizers and cues that learners can use to recall information when needed and that minimize cognitive load.	Teachers need to provide the instructional support (scaffolding) that will assist learners to maximize their learning in their zone of proximal development. Lecturing and giving students answers are not recommended. Some instructional methods/approaches recommended are: discovery learning, inquiry teaching, peer-assisted learning, discussions, debates, reflective teaching, instructional scaffolding, reciprocal teaching, peer collaboration, and apprenticeships.

Besides human learning theories, human intelligence theories have also contributed significantly to the understanding how individuals learn. In this regard, the last century was very crucial. Basically, modern human intelligence theories have demystified the traditional monolithic view of human intelligence emphasizing that there are different kind of intelligences. Among such theories, we underline the Multiple Intelligences Theory [20], the Emotional Intelligence Theory [21] and the Triarchic Theory of Intelligence [22]. Their authors bring to the stage innovative reflections and explanations on why some students have great success in traditional settings and others do not.

Finally, we bring to light the learning styles concept (also referred as cognitive or intellectual styles). Learning styles can be described as stable individual differences in perceiving, organizing, processing, and remembering information or as the people's preferred ways to process information and carry out tasks [23]. That concept has been used in the design of educational systems in order to promote adaptation to learners' needs and preferences [24][25][26].

All above aspects offer several insights on the design of learning scenarios, which should be considered carefully by educators independently of the target audience or delivery mode the design of learning is intended to. Furthermore, some reflection is also needed in regard to tools for education purpose in order to promote well-informed design of learning as well as choose appropriate educational tools to support teaching-learning activities.

2.3. The technology thread

The technology thread aims at describing the significant developments over the second half of the last century until now. This includes: computer-based teaching-learning systems (hereinafter referred to educational systems) to support teaching-learning activities/contents delivery, including related educational platforms, and tools to assist educators in preparing teaching-learning scenarios.

The research in educational systems has inspired many researchers since 1960. Initial systems, dubbed under Computer-Aided Instruction (CAI) were developed for teaching in many varied domains as logic, axiomatic mathematics and foreign languages [27]. Such systems inspired a new generation of tutoring systems titled Intelligent Computer-Aided Instruction (ICAI) in the 70s, later called Intelligent Tutoring Systems (ITS) in the 80s [28]. These educational systems have highlighted the importance of reproducing in some way the human behavior in tutoring tasks. To accomplish that goal, the influence of learning theories has conducted the ITS design from the very beginning, and much research work

in this field were initially concerned devising principles in ITS design and artificial artefacts for conceiving "intelligent" computer applications [29], [30]. In that sense, ITS can carry out a wide variety of abilities depending on the instructional goals they are conceived to. Table 3 presents an important set of those abilities.

Table 3. Abilities of intelligent tutoring systems (source [31]).

Ability	Description
Generative	Generates appropriate instructional material, including problems, hints and help based on student performance.
Student Modeling	Assesses the current state of a student's knowledge and acts accordingly based on the assessment.
Expert Modeling	Models expert performance and does something instructionally useful based on knowledge of the domain.
Instructional Modeling	Changes pedagogical strategies based on the changing state of the student model, prescriptions of an expert model, or both.
Mixed-initiative	Human-computer communication in which the student or system controls the conversation or asks a question.
Self-Improving	The capacity to monitor, evaluate and improve its own teaching performance as a function of experience.

Their architecture was structured initially in three main components: domain module, pedagogical module and student module. Briefly, the domain module represents the knowledge to be learned in such a way that the computer system is able to draw inferences or solve problems in the domain. The pedagogical module is responsible for implementing strategies in order to reduce the difference between expert and student performance. In relation to the student model, it should represent the student knowledge about the domain deducing student's approximation of that knowledge [32][33].

During the ITS pathway, we have witnessed huge developments by incorporating new learning concepts, in one hand, and additional mechanisms promoting motivating interactions between the learner and the software application, on the other hand. In 1990's, the pedagogical actor concept, for example, gained an important role in tutoring systems design. This actor aimed at embodying an intelligent, reactive, instructable, adaptive and cognitive agent [34]. That agent could represent either a virtual teacher (tutor, mentor, mediator or other possible roles) or virtual students (learning companion) [35] promoting a constructivist alignment of learning.

Other step ahead was achieved at the time when educational systems first incorporated face-to-face interaction between intelligent, animated agents and the learner [36] [37] [38]. The humanlike behavior of 2D and 3D characters was capable of promoting high levels of motivation in students. In the research literature, such systems are normally referred to as Interactive or Intelligent Learning Environments (ILEs).

The contribution of ITS for education is quite considerable, and in this regard, a huge set of educational systems have been constructed from the second half of the last century [28] [27] [39] [40] [41] [42]. Despite all developments in ITS field, two huge challenges in ITS still need more research in order to make these tutoring systems more effective. These challenges are related to effective and personalized dialogue and feedback. These issues are indeed very complex to reproduce as they deal with one of the most difficult subjects in conceiving such systems, namely, how to interpret and reproduce the affective state of the learner and acting accordingly.

In addition to ITS, Adaptive Hypermedia Systems (AHSs) have also left their contributions in multiple areas of society, especially in education. Historically, the first generation of AHSs is traced back to the 90s of the 20th century. These systems aim at overcoming some limitations of hypertext systems, namely the lack of both an adaptation module and a user module [43]. According to Brusilovsky [44], AHSs are defined as "[...] all hypertext and hypermedia systems which reflect some features of the user in the user model and apply this model to adapt various visible aspects of the system to the user".

Adaptive educational hypermedia systems (AEHSs) organize what learner sees according to the learner's goals, abilities, needs, interests, preferences and knowledge of the subject, by providing both adaptive presentation and adaptive navigation (i.e. hyperlinks). These two types of adaptation are carried out by a huge set of techniques devised for that purpose [45] [46]. As an example, an AHS can provide or remove additional explanations dependent on learner's knowledge in a subject.

Even though initial objectives of AEHS were very promising, the level of reutilization is indeed low and for that reason, they are not very popular in the community of educators. In order to overcome that limitation, educators can construct their own AEH applications using available authoring tools [47]. There is no need for programming skills unless particular adaptation algorithms are intended to [26] [25].

Meanwhile, other types of authoring tools infrastructure have emerged for designing courses, lessons or teaching-learning activities only. These infrastructures can vary significantly in their features and facilities, even though the main goal can be resumed in producing of learning objects (LOs) and/or units of learning (UoL). Both of them enable the use of educational content online and they also have great potential for reusing and sharing facilities. Many organizations have been working collaboratively in this domain, such as ADL (Advanced Distributed Learning), IEEE-LTSC (Institute of Electrical and Electronics Engineers – Learning Technology Standards Committee), W3C (World Wide Web Consortium), ARIADNE (Alliance of Remote Instructional Authoring & Distribution Networks for Europe), DCMI (Dublin Core Metadata Initiative), AICC (Aviation Industry Computer-Based Training Committee), and IMS/GLC (IMS Learning Consortium).

Educational settings can afford a large set of available educational infrastructures for authoring, delivering and managing subject matters. Learning Management System (LMS) and Learning Content Management System (LCMS) belong to that group of infrastructures. The former is a software application that provides a comprehensive set of tools for educators to manage instructional content, administrative functions, assessments, and grading. Along with course creation, a LMS offers a range of features such as online classrooms, completed assignments, quizzes, and forums, which helps in creating a personalized and interactive learning environment. However, a LMS is not used to create course content.

A LCMS provides a multi-user environment where developers, authors, instructional designers, and subject matter experts can create, store, reuse, manage, and deliver digital content that will typically be delivered via an LMS. Users can both create and re-use e-learning content and reduce duplicated development efforts. Blackboard [48], Moodle [49] and LAMS [50] are three acknowledged examples belonging to LMS/LCMS tools group.

Besides common LCMS, other design tools have emerged for designing teaching-learning activities. They are supported by the IMS LD specification [51] mainly, and their features vary considerably in some aspects, such us the degree of user's knowledge needed to deal with metadata, available templates, scripts or wizards used to guide the teacher through the design process, interface characteristics (textual or supported by graphic-based high-level facilities). In general, these tools show appealing, intuitive, friendly user interfaces for designing teaching-learning activities. There are many examples of those tools, as for example, CopperAuthor [52], Recourse [53], COLLAGE [54], CoSMoS [55], MOT+LD [56], ASK-LDT [57] and LAMS.

In conclusion, we claim that the diversity of educational systems has its own potential in educational context and the issue is probably how to use and combine them to get students focused on learning and motivated too. In relation to design tools for designing contents/teaching-learning activities there are different concerns. Teachers should reflect on the benefits those tools can provide and then choose according to their goals. Some criteria can be, on one hand, accessibility, adaptability, interoperability, sharing and reuse of e-contents, including teaching-learning activities, and on the other hand, intuitive and friendly user interfaces along with design facilities (available templates, scripts, for example).

3. Reflections on the design of learning scenarios

The design of learning scenarios it is neither a linear nor an easy activity for teachers to accomplish. The preparation of teaching and learning activities is a common and consuming task for teachers whatever degree of education those activities are intended for. Moreover, it could be very complicated, and sometimes not feasible, if teachers want to put in practice different teaching and learning methods/techniques. Collaborative techniques, for example, are normally very difficult to implement in traditional learning settings and therefore it is quite common teachers to find that is a great responsibility to take that risk.

Two important issues can contribute to reduce those problems. On one hand, the information and communication technology tools, and on the other hand, the learning design supported by proper languages and specifications. The former embraces the use of tools to support the design/authoring and delivery of learning [58]. The latter is twofold: to diversify teaching and learning methods in order to respond to a larger student population as well as to provide different learning experiences, and reusing of learning scenarios in different teaching-learning contexts. All those aspects can be caught in the learning design frame.

3.1. Learning design

Learning design can be introduced as follows: "it aims at providing teachers with a framework capable to bridge the gap between rich, descriptive models and technologies, and the everyday practice and understanding of teachers" [59]. According to Koper [60], learning design is described: "as the application of learning design knowledge when developing a concrete unit of learning (UOL), e.g. a course, a lesson, a curriculum, a learning event".

Learning design has the potential to go beyond the learning content creation itself and proceeding to the "process". In other words, learning design helps to bring to the stage the learning issue while the technological aspects come after. In turn, the contributions of the new technologies to the learning design need also to be underlined once usual teaching-learning methods and pedagogies that were previously taken for granted can now be reconsidered [58]. Learning design is used to describe a learning experience supported by tasks to which students should be engaged to. For example, students may be formed into groups and required to discuss the relations between two given topics; or they may be asked to gather some information about a given theme and write a report afterwards.

The meaning of learning design knowledge is transmitted by a series of prescriptive rules with the following format: "if situation, then method". The left-hand side of the rule is the learning situation which accommodates the situational factors. The main objectives of these factors are twofold – firstly, they may represent the requirements that any new learning design method has to meet – secondly, they can be seen as descriptors of the situation in which an existing learning design method has been applied. The term situational factors are justified by the assumption that one method may behave best in a particular situation whereas another method may work best in a different one. Learning outcomes and learning conditions are two subclasses of situational factors. The former is related to the level of effectiveness, efficiency, attractiveness and accessibility of the learning design method. The latter is related to the characteristics of some elements, such as the learning objective (knowledge, skill, attitude, competence), the learners (pre-knowledge, motivation, situational circumstances), the setting (individual and/or group work, work at school and/or work and/or home) and the media (bandwidth, synchronous/asynchronous, linear/ interactive, media types) [60].

To develop reusable, interoperable and adaptive learning designs the need of formal languages capable to be understandable by machines it is more and more a mandatory prerequisite. As previous mentioned, the IEEE Learning Object Metadata (LOM) and the IMS LD specification, for example, are two relevant examples of communication languages. Their use promotes the development of new technical architectures in addition to enable the move towards a service-oriented approach for the development of software and true interoperability purpose [61]. As a more complex concept, the IMS LD is a standard published by IMS consortium based on the Educational Modelling language (EML) developed by the Dutch Open University (OUNL) [62]. IMS LD describes several components, namely metadata, roles, plays, acts, environment, role-parts, sequence of activities and conditions. This structure is comparable to a theatrical play where actors (students, teachers among other participants/roles) perform as expected by the script (that is, tasks to be performed during a learning activity episode).

In this research domain, the learning activity concept takes a central role. There is no single definition concerning this concept. We introduced the following definition as a good example to frame this issue: learning activity is "a specific interaction of learner(s) with other(s) using specific tools and resources, orientated towards specific outcomes" [58]. Four components are associated to a learning activity:

- Learner(s): This component combines identities (preferences, needs, motivations), competences (skills, knowledge, abilities) and roles (approaches and modes of participation).
- Learning Environment: The focus is tools, resources and services.
- Learning outcomes: It comprises new knowledge, academic and social skills, and abilities.

- Other(s): Other people involved and the specific role they play in the interaction, e.g. support, mediate, challenge, tutor and guide.

The range of pedagogical approaches used in the learning design process should be of a large spectrum promoting, therefore, different perspectives on learning. The Associative, the Constructivist (individual and/or social focus) and Situative perspectives are considered a helpful support to create and sequence learning activities [18]. The learning outcomes to be achieved underpin the pedagogical decisions that educators should reflect carefully on. A taxonomy of learning activities is presented in [18] which can form an important basis to help teachers in the design of teaching-learning activities.

All mentioned aspects in learning design are now summarized (see figure 1). It can be point out a set of design principles that educators should reflect on. Those principles could be divided into two main layers of issues, the educational context layer and the design context layer. The educational context layer embraces three threads (Delivery, Pedagogy and Technology one) along with two other components: teaching-learning activities and resources. Teaching-learning activities represent the sequence of tasks that students need to perform to get the teaching-learning activity completed whereas resources are related to objects like files or services needed to support teaching and learning materials.

With regard to the design context, the main idea is thinking about the tools that teachers should use to design learning scenarios as already introduced in section 2.3. This decision has several consequences in the short and long terms. Some basic criteria to consider are accessibility, adaptability, interoperability, sharing and reuse of e-contents, including teaching-learning activities. Online repositories of educational resources are an important means of promoting sharing and reuse facilities [63].

3.2. Embedding advanced features in design tools

Design tools are a powerful means to support teachers in designing learning scenarios. The more special features are incorporated into those tools more efficient and useful they can be. In this respect, we consider that automatic recommendation mechanisms represent one useful feature to be added to design tools. Such mechanisms can, for instance, guide teachers in designing teaching-learning contents/activities.

To this end, we propose a model, titled OTILIA (Ontology of Techniques for teachIng, LearnIng and Assessment purpose) for recommending teaching-learning techniques. Our motivation for the development of this model is derived from the scarcity of tools for that purpose [64].

An ontological approach is being used to model the teaching-learning techniques knowledge.

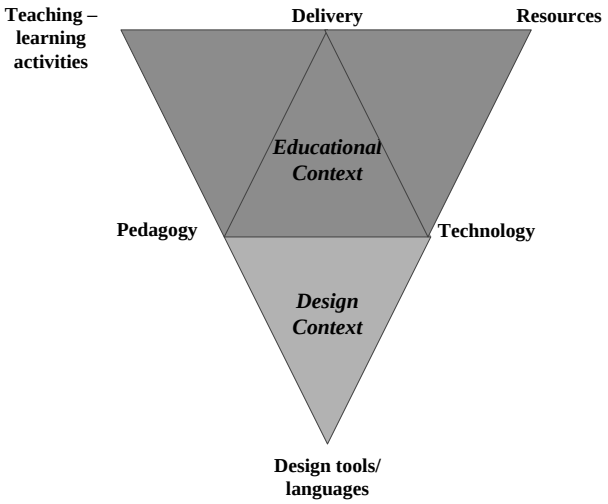

Figure 1. Diagram describing the main principles in the design of teaching-learning activities.

The ontology scope embraces competency questions, such as:

- What kind of teaching-learning technique(s) will be better to engage not motivated students in productive tasks?
- What kind of teaching-learning techniques promote better results in a traditional (face-to-face) class of students which are not very participative?
- What are the teaching-learning techniques that help students in critiquing tasks?

Briefly, a technique is a module which can be divided into a sequence of phases and, in turn, each phase is composed by a set of learning and/or support tasks. Each of them is described by the following main attributes:

- Role: The participant who is going to carry out the task;
- Description: The task description;
- Resource: The type of resource needed to support the task. It can be either a digital content or a service;
- Type: The type of the task.

In relation to the type attribute, we use a taxonomy based on DialogPlus [65].

There are four main actors in the proposed model: the educational psychologist, the scholar psychologist, the ontology engineer and the teacher. Briefly, the educational psychologist contributes with the high level knowledge in order to describe teaching-learning techniques along with the rules to be applied in real educational contexts. The scholar psychologist, and can exist several of them, is responsible for the instantiation of teaching-learning techniques. In turn, the ontology engineer needs to implement and maintain the ontology in collaboration with the scholar psychologist. Finally, the teacher describes the teaching-learning activity to be given to students. That task includes several data, namely

learning objectives, target population, and learning context variables. The recommendation algorithm, in turn, questions the ontology in order to get the techniques that best fit to the teaching-learning activities description, more specifically, compares the learning objectives, among other variables that were defined by the teacher, with the techniques instantiations created by the scholar psychologist. The proposed model is being implemented now.

4. Conclusions

Currently, there are many questions that must be addressed in the design of teaching-learning situations/scenarios. First, the recognition of different ways of learning obviously has practical consequences in planning courses or teaching-learning activities only. In this sense, different strategies are needed in order to adapt teaching-learning contents/activities to learner's needs, interests or preferences. Second, both educational systems and design tools are recognized as having an important role in education settings, however much work need to be done in order to include intuitive, practical and useful features into those systems/tools.

To conclude, we presented in this paper a survey of the most relevant computer-based teaching-learning systems since 1960 including high level design tools (authoring tools) along with a description of the learning design paradigm. In addition, we brought to the stage some reflections on educational material design and tools needed for that purpose. The choice of such tools by teachers has consequences in many aspects, namely accessibility, adaptability, interoperability, reusability and the implementation of different pedagogical models. All those considerations aim at bridging the gap between relevant theoretical learning achievements and the design of well-informed teaching-learning experiences. Finally, we introduced our ontological approach for automatic recommendation of teaching-learning techniques. The main purpose is to create different strategies for teaching-learning activities depending on learning objectives and other learning context variables.

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