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A moderate constructivist e-learning instructional model evaluated on computer specialists

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ABSTRACT

This paper presents a novel instructional model for e-learning and an evaluation study to determine the effectiveness of this model for teaching Java language programming to information technology specialists working for the Spanish Public Administration. This is a general-purpose model that combines objectivist and constructivist learning theories and is based on the concept of learning objective. The purpose of the evaluation study is to find out whether the results of using this distance learning instructional model to teach this subject are comparable to learning in a traditional face-to-face classroom, with the plus of eliminating travel and maintenance expenses of the public servants attending the course and also saving time. The learners, selected at random to participate in this study, were divided into three groups depending on the type of teaching/learning they received: traditional classroom, distance learning with virtualized course contents and distance learning based on the proposed instructional model. The results indicate that the grades and satisfaction levels were similar for learners taught using the proposed instructional model and learners taught in the traditional classroom. Moreover, they were substantially better than for distance learning with virtualized contents, although the mean course learning time is greater.

1. Introduction

All the technology developed around the e-learning paradigm is beneficial for improving the quality of learning, but is useless if it is not based on psycho-pedagogical prescriptions (Alonso, López, Manrique, & Viñes, 2005). In fact, the critical element in technology-enhanced instruction is the nature of the instructional model (Tuckman, 2002), but there exists a serious dysfunction between the profusion of technological features that are put forward and the shortage of pedagogical manners and teaching principles for e-learning (Tallent-Runnels et al., 2005). Pedagogical principles are theories that govern good educational practice, and, as far as e-learning is concerned, good educational or instructional practice is implemented by the instructional design. Instructional design has evolved on a par with the development of the three basic learning theories: behaviourism (Good & Brophy, 1990), cognitivism (Anderson, 1996), and constructivism (Jonassen, 1991).

This paper presents an e-learning instructional model supported by the eclectic combination of these three learning theories and is based on the concept of the learning objective, which is composed of learning objects (Anido & Santos, 2001). The proposed model includes prescriptions and methods borrowed from different fields of knowledge. For the design and implementation of the educational contents, we have used principles based on the content performance matrix (Merrill, 1996) and multimedia principles derived from the research on information processing psychology within the field of cognitive psychology (Clark, 1998). These principles further the cognitive processes supported by the memory structures involved in learning. The educational contents (facts, concepts, procedures and principles) are structured on the basis of the concept of learning objective. A learning objective is defined as a set of learning objects that can be evaluated according to performance goals. This structure is useful for developing coherent information structures that help to build knowledge schemata in the learner's mind (Donovan, Bransford, & Pellegrino, 1999). A collaborative environment was developed, including activities designed to create a social environment that acts as a scaffold for collaborative learning and dialectical constructivism (Palloff & Pratt, 1999; Palloff & Pratt, 2003). The proposed model maps constructivist principles to the instructional design by means of a more pragmatic

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approach that focuses on the principles of moderate constructivism (Karagiorgi & Symeou, 2005; Moreno, Gonzalez, Castilla, Gonzalez, & Sigut, 2005), making use of emergent technology tools. An Instruction Aid System (IAS) has been implemented as a tool for guiding instructors through the construction of courses following the proposed instructional model.

Orthogonal to this instructional view is the learner's perspective. By learner's perspective we mean how the learning should be staged for the learner to optimally acquire the knowledge. A number of specialists in the subject advocate a blended learning solution (EL-Deghaidy & Nouby, 2008; Garrison & Kanuka, 2004; Thorne, 2003), a concept used to describe learning that mixes different activities. Accordingly, we propose a blended approach to the learning process that fits the psycho-pedagogical prescriptions defined in our instructional method for e-learning. This blended learning mixes three ingredients: self-paced learning that provides the right skills at the right time (Carman, 2004) especially with adult learners (Ellis, 2007), live e-learning in a virtual classroom where learners can collaborate (Stahl, 2005) and traditional classroom learning, which is necessary to learn management, leadership and collaborative skills (Michell, 2001).

The Spanish Public Administration has been running an information and communications technologies training programme to refresh the knowledge of public servants working in this field for more than 15 years now. As part of this programme, it regularly offers short courses and master courses. These courses cover a number of subjects related to the field of technology. Initially, these courses were taught through eight, five-hour sessions in the classroom, with a final examination at the end to assess attainment. This traditional teaching/learning method provided satisfactory results, with average grades in the final examination of 6.8 out of 10 (S.D. = 2.16), a high satisfaction level among learners and a mean learning time of 55 h (S.D. = 13.7).

The key drawback of this approach was the high cost of moving employees from all over the country to the venue where the presential classes were to be held. On top of this cost, there is the payment of per diem and accommodation expenses, and the fall in productivity due to the time learners spend away from their workplaces.

With the aim of reducing these costs, the Administration opted to introduce distance learning in the place of classroom teaching. To do this, the courses were virtualized to a digital format accessible via Internet. This approach led to a sizeable drop in the grades attained by learners and their level of satisfaction.

As a consequence of these poor results, the moderate constructivist instructional approach presented in this paper was designed. The approach has been applied satisfactorily for the last three years, with results that are comparable to those provided by the traditional classroom teaching system.

This study compares the results of these three different instructional/learning approaches (traditional classroom, distance learning with virtualized teaching contents and the moderate constructivist instructional model) in terms of grades attained by learners in the final assessment examination, learner satisfaction level and course learning time. To do this, a case study was conducted on the teaching of a Java language programming course. This course has been part of the Administration's training programme since 1997. This course is useful because it has been taught according to the three teaching options examined in this paper. Object-oriented modelling and design is part of this course, and therefore the course configurations do not have a big impact on the students' performance (Berndtsson, 2005).

2. The moderate constructivist instructional model

2.1. Learning objectives

A learning objective is the specific knowledge that the learner has to acquire about a concept or skill and the tasks to be performed. A learning objective includes several learning objects. Each learning objective will be defined by a set of interrelated learning objects that each deal with a very specific item of knowledge. These relations can be represented by means of an AND/OR graph (Fig. 1), where the nodes represent learning objects and the directed lines indicate learning sequences. AND learning occurs when two or more directed lines have the same target node: this indicates that all the source learning objects need to have been completed before starting on the target learning object. OR learning occurs when two or more lines are directed at a node: the target learning object can start to be learned when either of the source learning objects have been completed. An arrow without a source node indicates that the learning objective can start to be learned as of the learning object to which it points.

A learning objective should be composed of learning objects that contain: educational contents, a problem to be solved by a group that covers the concepts described in the educational contents (a group problem), and evaluation exercises to evaluate the knowledge acquired by learners. The knowledge state demanded for a learning objective is considered to have been attained when its evaluation exercises have been passed. A group problem is required to stimulate the exploration and reflection necessary for knowledge construction (Brooks and M. G. Brooks & Brooks, 1993). For the Java programming example, we defined a learning objective, called Object-Oriented Fundaments (OOF), with six learning objectives (Fig. 1): Class & Object, Interfaces, Inheritance and Polymorphism as educational contents, a group problem and, finally, a learning objective with evaluation exercises. The group problem used for this learning objective involves modelling a company's organisational chart based on the employed concept, where the different job types and functions have to be represented according to the business area to which they belong and their position in the hierarchy.

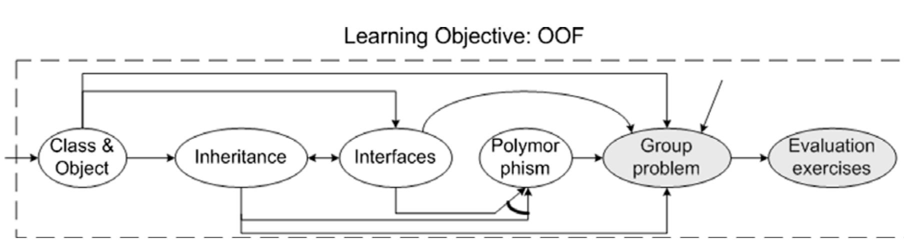

Fig. 1. AND/OR graph for the object-oriented fundamentals learning objective.

Looking at the OOF learning objective, we find that learners can start with Class & Object or directly get on with group problem solving, which is the target of an OR learning sequence. If the learner opts for the first alternative, there are three available learning sequences. This indicates that, after having learned this learning object, the learner can continue the learning process by choosing between Inheritance or Interfaces or tackle the group problem. There is an AND learning sequence from Inheritance and Interfaces to Polymorphism: the first two have to have been completed before starting on the last.

From the instructional viewpoint, learning objectives include features inspired by different learning theories. On the one hand, they cover the key characteristics of constructivism: the requirement that any learning objective should contain a problem that must be solved in a collaborative way so that learners learn through interaction with others (Tam, 2000).

On the other hand, the learning objectives include features proper to objectivism (behaviourism and cognitivism). The very term learning objective indicates that teaching is objective driven and, also, that these objectives can be evaluated, for which purpose evaluation exercises are included. These last two features overcome the most widely criticised drawbacks of using a purely constructivist philosophy, namely, the absence of specific learning objectives and outcomes, leading to an inefficient and ineffective learning process (Cey, 2001), and the notion of there not being "right" or "wrong" answers, which strikes fear into the heart of an instructor (Corich, 2004).

2.2. Developing and executing and e-learning course

The proposed e-learning instructional model provides the pragmatic level of knowledge defined within Bloom's taxonomy of educational objectives (Bloom, 1956) and the performance and action defined by Schulman (Schulman, 2002). So, it is based on the fact that training should enable learners to apply the concepts learned at their workplace and evaluate the methods, processes and tools to be used. To do so, this instructional model applies the systematic development of instruction and learning and is composed of five phases: analysis, design, implementation, execution and evaluation. The analysis and design phases are supported by IAS, the e-learning courses are implemented using an authoring tool and, finally, the learning management system platform executes and provides evaluation support for the e-learning courses.

Psychopedagogical prescriptions are taken into account in each and every one of these phases, and especially during design and implementation. The cognitive processes involved in learning and the actions taken to promote and improve it are as follows:

1. Perception. If a visual structure (format, fonts, colours, etc) is provided and maintained throughout the courses, students will be able to differentiate and identify the content type and the perception processes will be automated.
2. Attention. When designing instructional contents, methods that optimise the attention process by easing the selection of important material should be included. The use of highlighting and pointers, such as headings and boxed texts, facilitates the more unconscious task of the sensory memory. Formulating the right questions, using simple grammar and vocabulary (active voice, short sentences, no substantivisation, etc.), clearly establishing learning objectives, and addressing students personally and informally improves their conscious attention and, consequently, the effectiveness of the working memory.
3. Cognitive load. Methods should be used that reduce the foreign cognitive load not related to the content type. For example, incrusting text in pictures (principle of contiguity) reduces the effort required to retain the information presented in the text and then locate it in the picture. Distributing the information across auditory and visual media (principle of modality) reduces the effort of each processing channel. Redundant presentation should also be avoided, and care should be taken to assure that the information is coherent and to remove anything that is irrelevant and ornamental.
4. Coding. Information presented as text and illustrations can be recalled better than information that is presented as text only. The use of knowledge organisers activates any previously available schemas related to the material to be learned and improves its integration. Conceptual maps and process diagrams organise the information and improve the construction of mental models.
5. Retrieval/transfer. To improve learning, contexts with which students are familiar should be provided. As coding specificity determines the retrieval process, the examples should be as close as possible to the context to which the learning is to be transferred.
6. Metacognition. Metacognition refers to the knowledge that students have of their own thought processes. It is important to further this knowledge by means of strategies of reflection. Checklists can be used, such as: What is the objective? Do I know anything about the subject? Do I understand as I go along? Do I have difficulty with any concepts? Do I know how to correct my mistakes? and others. Forums and dialogues with tutors and fellow students also help students to check what they have learned and correct mistakes.

2.2.1. Analysis

This phase defines what to teach, and therefore analyses the learner and the educational contents to be taught. Its purpose is to detect the learner's learning characteristics and needs, and ascertain what sort of environment the learning is to take place in and what resources are available. It outputs the learning objectives with their educational contents and their interrelations. These define the knowledge and skills to be learned and the tasks to be performed to acquire the goal knowledge state. These tasks are implemented during design as learning objects with two content types: educational and exercises.

The learning objectives and their relationships are represented by means of a course knowledge graph. This is an AND/OR Graph, too. In this case, however, the arrows represent learning objectives learning sequences and the nodes are the learning objectives. The proposed model is an objective-driven instructional model with constructivist learning, giving the learner the chance to choose, subject to some constraints imposed by the content structure, the next learning objective, following the overarching idea in Ausubel's theory (Ausubel, Novak, & Hanesian, 1978).

Fig. 2 shows the course knowledge graph for the Java programming example using the IAS tool. It is composed of nine learning objectives: Basic Syntax, Methods, Sentences, OOF, Packages, Exceptions, Threads, Input/Output (I/O) and Graphical User Interface (GUI). A characteristic of this knowledge graph is that it has a great many OR learning sequences, which gives the learner greater freedom. For example, once the Basic Syntax learning objective has been achieved, the learner has the option of starting either Sentences or Methods, whereas there is an AND learning sequence from Sentences and Methods to attain the OOF learning objective.

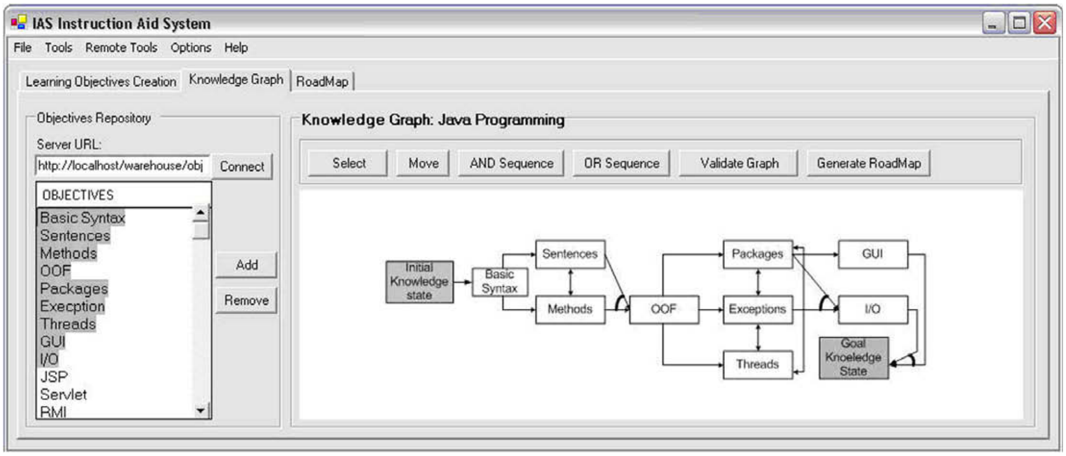

Fig. 2. IAS assisting the creation of Java programming knowledge graph.

Each learning objective is defined as a set of tasks that the learner has to do to achieve the objective. For example, the tasks to be performed to reach the learning objective called Basic Syntax are: learn variables, learn constants, learn operators and expressions learn arrays, do the group problem and do the evaluation exercises. These tasks are implemented as learning objects included within their corresponding learning objective as shown in Fig. 3.

2.2.2. Design

The design defines how to teach. Problems that have to be solved through group work are designed for each learning objective as a condition for attaining the target knowledge states. Evaluation exercises must also be set to assess what knowledge has been acquired. This phase establishes the tools, techniques and environments that are to be used in teaching: hypermedia, multimedia and the Internet to improve data gathering, collaboration and offer multiple representations of reality.

The design divides contents into five basic types – facts, concepts, processes, procedures and principles – and two performance outcomes – remember and apply. These two dimensions constitute the content performance matrix that prescribes a template for optimising learning for each content type: outcome combination.

The learner's learning process is also specified together with the educational activities that will take place within this process, standards to be used, execution criteria and achievement expected of the learner. This instructional model involves a blended learning approach to the learning process that includes three learning types: self-paced learning, live e-learning and face-to-face classroom learning.

Self-paced learning is an asynchronous interactive mode of learning over the Internet. This learning process is designed by means of a road map. The road map is a graph that represents and interrelates the learning objectives and their learning objects leading to a knowl-

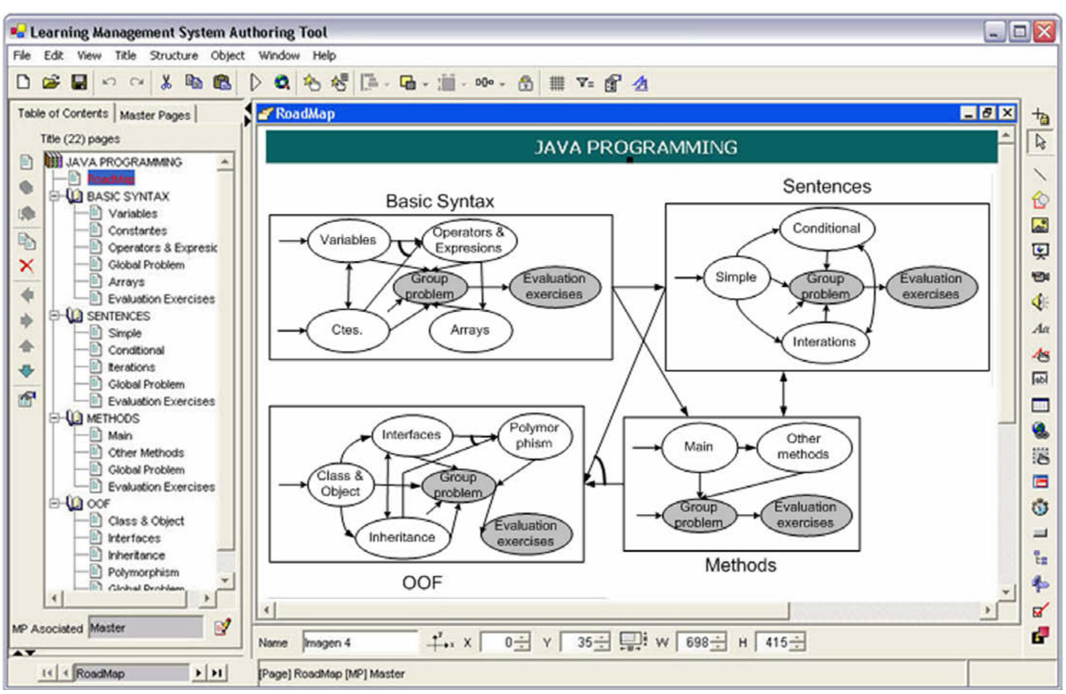

Fig. 3. Part of the road map generated by IAS for the Java programming self-paced learning process and its implementation in an authoring tool.

edge state. Therefore, the road map represents the set of all possible paths that go from the initial to the goal knowledge state. The instructor defines and incorporates the group problem and the evaluation exercises for each learning objective using IAS, and the system automatically produces the road map from the knowledge graph. Due to the complexity of the whole diagram, Fig. 3 shows the road map generated by IAS for the Java programming example only, covering the following four learning objectives: Basic Syntax, Sentences, Methods and OOF. The course knowledge graph shown in Fig. 2 includes all these learning objectives.

Live e-learning is a synchronous process. It is a mode of collaborative learning that can be implemented by means of videoconferences, threaded discussions, online chats or virtual classrooms at a scheduled time. Learners collaborate, share information, and ask each other and the instructor questions in real time. The power of combining live e-learning and self-paced learning is augmented drastically when there is meaningful collaboration. Collaborative learning affords students enormous advantages that more traditional distance learning cannot give because a group can accomplish meaningful learning and solve problems better than any individual can alone (Brown, 1998).

The face-to-face or traditional classroom is the third ingredient of blended learning. Despite its defects, classroom training is still unbeatable for the amount of face-to-face interaction with both the instructor and classmates. This interaction is necessary to learn certain management, leadership, and other highly collaborative skills (Michell, 2001).

2.2.3. Implementation

This phase involves building the road map into a learning management system (LMS) platform at design time. Fig. 3 also shows the implementation of the Java programming example in a SCORM-compatible authoring tool. The left-hand side of this screenshot shows the content tree and the right-hand side explains to the learner what the actual self-paced learning process through the road map will be like. Hyperlinks (underlined) have been added to highlight the learning objects at which the learner can start: Variables and Constants.

2.2.4. Execution

This phase involves the learner executing the learning process. Execution provides information on the problems encountered and the knowledge acquired. The proposed instructional model implements a blended learning process, which has been adapted to a four-week course of forty learning hours executed as follows:

1. The course kicks off with a one-day face-to-face session where the learners have the chance to meet each other and the e-learning tutor. The tutor presents the learning objectives, discusses the most significant knowledge and tasks to be learned, and describes the interactions there will be through email, chat, and videoconferences.
2. One-hour interactions between learners and between learners and the instructor are held every three days via chat to consolidate and acquire knowledge. The chat is held informally, and its development is not structured.
3. Computerized videoconferences are broadcast every week. To assure that they are efficient, the subjects to be dealt with are planned and structured beforehand.
4. There is permanent email support, which should be answered within the following 24 h.
5. There is telephone support for one hour a day. Learners are encouraged to outline the subject via email previously.
6. A face-to-face assessment is held immediately after the course has finished. Students have to complete a 20-question examination requiring short answers (2 to 3 lines). These questions are related to real-life cases to which they have to apply the concepts learned throughout the course. The examination may last anything from 45 minutes to two hours. Learner evaluation takes into account the scores achieved in this test, the solution of exercises set throughout the course and the learner's participation in live e-learning sessions.

2.2.5. Evaluation

To determine successes and ascertain the learning product quality, information output during execution is gathered and the results are analyzed on the basis of the learning objects and objectives. For the educational content learning objects and the group problems, the total time each learner spends on learning an object is stored, and the interaction between learners, between learners and the tutor and the number of questions formulated by the learner are recorded. Finally, the marks that learners get in the evaluation exercises and the total time they spend on learning an objective are stored.

The content expert can analyse this information to find out whether an educational content learning object should be revised, for example, if the mean time spent studying the learning object is significantly higher than originally estimated by the content expert at design time. Similarly, it provides the instructor with statistical data about the execution of the learning objectives from which he or she will be able to ascertain whether any have been poorly designed. From this information, the instructor can draw conclusions such as: abnormally low marks or too much interaction to solve a global problem.

3. Experimental study design

The aim of the study is to analyse the evolution of the learner performance using three different teaching approaches for the Java programming language course. This course has been taught to information technology specialists as part of the Spanish Administration's training programme since 1997. Until 2001, the course was taught as eight, five-hour classroom sessions. Then, with the aim of cutting training programme costs, the course organizers opted to teach the course through distance learning. To do this, all the teaching material that was used in the classroom was virtualized. The students received two face-to-face classes: one at the start of the course, where they got to know each other and the teacher and were given instructions about the course; and another at the end of the course to take an assessment examination. During the rest of the course they communicated with each other and with the teacher over the Internet (via videoconferencing, email and chat). The teacher emulated the classroom instructional model, giving lessons via videoconferences and answering student questions via chat and email. This system remained in place until 2004, when the two teaching methods were compared in terms of learner performance in the final examination, learners' satisfaction level and subject learning time.

A total of 150 students were involved in the evaluation study. Half of the students attended the traditional face-to-face classroom sessions and the other half were enrolled in the distance learning version. The allocation of students to each group assured that student learning style did not affect the study results, i.e. there were approximately the same number of students with different learning styles in each group. We adopted Felder's learning style model to assess student learning style (Felder, 1993). Index of Learning Styles (ILS) questionnaires (Felder & Solomon, 2002) were used to evaluate the respondents' preferences on the five model dimensions: what type of information a student preferentially perceives, either sensory or intuitive information; how a student most effectively perceives information, either visually or verbally; a student's preferred arrangement of information, either inductive or deductive; how a student prefers to process information, actively or reflectively; and, finally, how a student progresses toward understanding the information, either sequentially or globally. The gender distribution of students in the sample was 62% male and 38% female, all of which were of the same ethnicity and of very similar ages, ranging from 38 to 43 years, to assure that these parameters did not affect the study results either. The gender distribution parameter and personally types were constant for both learner groups, and the subject was taught by the same teachers using the two teaching methods.

As a result of the study, whose results are described in the next section, it became clear that the switch from the traditional face-to-face classroom to a distance learning model without a properly defined instructional model including educational contents that complied with psychopedagogical prescriptions had failed. This led to the need to design and apply the instructional model proposed in this paper. Distance learning based on the moderate constructivist instructional model was deployed at the end of 2004 and is still in place (2007). To evaluate the goodness of the model, a second study of the three teaching methods —face-to-face classroom, distance learning with virtualized contents and distance learning with the moderate constructivist approach— was conducted this year. The study shows that the results of this instructional model are appreciably better than for distance learning with virtualized contents and are comparable with face-to-face classroom teaching; with the plus of sizeably cutting the costs of staging face-to-face classes for geographically disperse people.

The number of students involved in this second evaluation study was 235: 79 had followed the traditional classroom method, 78 took the distance course and 78 were enrolled in the course supported by the proposed instructional model. The same teachers taught the course using the three teaching methods, the age breakdown was similar to the 2004 study, learners were of the same ethnicity, ILS questionnaires were employed to select learners with different learning styles and gender distribution was also similar to 2004: 60% male and 40% female approximately.

The instructional condition served as the independent variable in both studies, with two levels in 2004: traditional classroom and distance course; and a third level added in 2007 corresponding to the inclusion of the proposed instructional model in the distance version. Three dependent variables were taken into account in both studies. Their criterion measures were: the overall course performance graded from 0 to 10, level of learners' satisfaction and the average learning time in hours needed to pass the course. Learners' satisfaction was obtained from a questionnaire administered to students at the end of the course. The questionnaire comprises two questions: Q1 ''What I have learned on the course has satisfied my training expectations for the subject" and Q2 "The training method used was good enough for me to be able to apply what I have learned in my job". Participants responded to Q1 and Q2 based on a six-point Likert scale, ranging from strongly disagree (scored as 1) to strongly agree (scored as 6).

In both studies, each learner is exposed to only one of the different instructional methodologies. This should not have an impact on the comparisons, as the subjects hold the same qualifications, perform similar jobs and have similar responsibilities. Also, as mentioned above, the sampling approach was designed to assure that there was no bias. To verify this claim empirically, learners in both studies were asked to take an examination to test their previous knowledge (pretest) and select a sample of a similar level for the study to assure that this variable did not bias the study results. To do this, analyses of variance (one-way ANOVA) were run in 2004 and 2007 to show that the differences between the average pretest scores were not significant. Again, the instructional condition serves as the independent variable with two levels in 2004 and three in 2007, whereas the dependent variable is the pretest scores graded from 0 to 10.

The results of these experiments are that the null hypothesis (the average pretest scores for each level in the independent variable are equal) cannot be rejected in either 2004 or 2007 because of the resulting F (df = 1/148) of 0.10 with a significance level of $p < 0.921$ and F (df = 2/232) of 0.214 with a significance level of $p < 0.808$, respectively. These results indicate that, as there are no statistically significant differences between mean scores for the groups, the hypothesis that all the learners selected to participate in the study of the instructional condition's impacts on overall course performance, learners' satisfaction and learning time have a similar level of learning prior to the course cannot be rejected.

One of the conditions in ANOVA is that the variances of the groups are equivalent. ANOVA is robust to this violation when the groups are of equal or near equal size, which both samples (2004 and 2007) satisfy. Even so, a Levene test of homogeneity of variances has been run. The results of this test, where a significance level of $p < 0.716$ in 2004 and of $p < 0.992$ in 2007, suggests that the homocedasticity hypothesis cannot be rejected.

4. Results and discussion

Starting from the samples described in the last section, we present the results for each of the three instructional conditions (independent variable) applied to the teaching of the Java programming course: traditional classroom method, and distance course for the study run in 2004, and the third level added in the 2007 study corresponding to the inclusion of the proposed instructional model.

Tables 1–3, respectively, show the descriptive statistics and analysis of variance for each of the three dependent variables that have been taken into account: overall course performance, learners' satisfaction and the average learning time. Table 1 shows the results of both studies, 2004 and 2007, where we find that the mean and standard deviation are similar in both years for the same instructional conditions. As the same applies to the other two dependent variables —learners' satisfaction and average learning time—, Tables 2 and 3 show the results for 2007 only. As the homocedasticity hypothesis cannot be rejected in any case, an analysis of variance has also been run for each dependent variable to show what differences are significant.

The overall course performance variable (Table 1) corresponds to the post-test score: the grades attained by the learners that attended the course taught using any of the three methods of instruction. In all three cases, we used a face-to-face final assessment, held immediately after the course had finished. Students were asked to complete a 20-question examination requiring short answers. These questions were related to real-life cases including Java programming. Analysing each table, we find that the null hypothesis (the mean scores are

Table 1
Descriptive statistics and ANOVA for post-test scores in 2004 and 2007.

	N	Mean	Standard deviation
2004			
Traditional classroom	75	6.7660	2.16208
Distance learning	75	5.6949	2.29104
Total	150	6.2305	2.28410
Levene statistic: 0.246	df1: 1	df2: 148	Sig.: 0.621
ANOVA: *F*(df = 1/148)	8.670		Sig. < 0.01
2007			
Traditional classroom	79	6.9038	1.97740
Distance learning	78	5.6496	2.39410
Instructional model	78	6.5987	2.01897
Total	235	6.3863	2.19480
Levene statistic: 1.553	df1: 2	df2: 232	Sig.: 0.214
ANOVA: *F*(df = 2/232)	7.331		Sig. < 0.01

Table 2
Descriptive statistics and ANOVA for learners' satisfaction in 2007.

	N	Mean	Standard deviation
2007			
Traditional classroom: Q1	79	4.1266	1.34324
Traditional classroom: Q2	79	4.4177	1.31664
Distance learning: Q1	78	3.2308	1.37627
Distance learning: Q2	78	3.4231	1.33406
Instructional model: Q1	78	4.3718	1.42436
Instructional model: Q2	78	4.7179	1.19411
Levene statistic:1.190	df1:5	df2:464	Sig.:0.313
ANOVA: *F*(df = 5/464)	15.416		Sig. < 0.01

Table 3
Descriptive statistics and ANOVA for average time to study in 2007.

	N	Mean	Standard deviation
2007			
Traditional classroom	79	55.0380	13.66958
Distance learning	78	71.3718	11.88157
Instructional model	78	79.1154	14.80258
Total	235	68.4511	16.80280
Levene statistic:1.852	df1:2	df2:232	Sig.:0.159
ANOVA: *F*(df = 2/232)	65.101		Sig. < 0.01

equal) can be rejected because of the resulting F (df = 1 /148) of 8.670, $p < 0.01$, in 2004; and F (df = 2/232) of 7.331, $p < 0.01$, in 2007. This indicates that the post-test scores achieved by learners depend on the instructional condition.

The results of the study run in 2004 provide statistical evidence that the switch from a traditional teaching method based on face-to-face classes to distance learning that was not based on an instructional model and did not apply pyschopedagogical prescriptions to the educational contents was a failure. Numerically, the mean post-test score fell from 6.77 in face-to-face classroom teaching to 5.7 in distance learning. The difference between the means is about one grade point out of 10.

Additionally, the results of the analysis of variance run in 2007 also show that there are statistically significant differences between the grades attained by learners that took the Java course taught according to the three different types of instruction. The results of the post-hoc tests run to find out where the differences between the types of instruction are to be found are shown in Table 4 and discussed later.

The learners' satisfaction variable (Table 2) represents learners' responses to the questionnaire administered at the end of the course with the two questions marked as Q1 and Q2. As for overall course performance, the null hypothesis (responses to the questions Q1 and Q2 are the same for each of the three instructional conditions) is rejected, as F (df = 5/464) of 15.416, $p < 0.01$.

The average learning time variable (Table 3) represents the total time, measured in hours, that the learner spends on the course. On top of self study of the subject by the learner, it includes doing exercises, class attendance if so required by the type of instruction followed, collaborative activities and all sorts of actions targeting the learning of the course's educational contents and aimed at improving performance. Again, the null hypothesis (in this case, the average learning time) can be rejected because of the resulting F (df = 2 /232) of 65.101, $p < 0.01$. This indicates that the instructional condition also influences the time the learner has to spend on the course.

As in the 2007 there are sizeable differences study between the three dependent variables with respect to the instructional model, the Tukey HSD test was used to make post hoc comparisons to demonstrate where we can find out the statistically significant differences between the three instructional conditions. Table 4 shows the significance level for these multiple comparisons, taking into account that the significance level for the mean difference is $p < 0.05$, which has been marked with an asterisk.

From this table, it is clear that, for the overall course performance and learners' satisfaction (same results for Q1 and Q2), there are significant differences between teaching in the traditional classroom and distance learning without an instructional model, and between distance learning with and without an instructional model, whereas there are no differences between the traditional classroom and distance

Table 4
Tukey HSD post hoc comparisons. Samples of 2007.

Instructional condition a	Instructional condition b	Mean difference: a–b	Sig.
Dependent variable: Post-test score			
Traditional classroom	Distance learning	1.25418*	0.001*
Traditional classroom	Instructional model	0.30508	0.645
Distance learning	Instructional model	−0.94910*	0.017*
Dependent variable: Learners satisfaction			
Traditional class. Q1	Distance learn. Q1	0.89581*	<0.001*
Traditional class. Q1	Instruc. model Q1	−0.2451	0.859
Distance learning Q1	Instruc. model Q1	−1.14103*	<0.001*
Traditional class. Q2	Distance learn. Q2	0.99464*	<0.001*
Traditional class. Q2	Instruc. model Q2	−0.30023	0.721
Distance learning Q2	Instruc. model Q2	−1.29487*	<0.001*
Dependent variable: Time to study			
Traditional classroom	Distance learning	−16.33382*	<0.001*
Traditional classroom	Instructional model	−24.07741*	<0.001*
Distance learning	Instructional model	−7.74359*	0.001*

* means that there are significant differences between means.

learning based on an instructional model. In the case of the average learning time variable, significant differences are identified between all three instructional conditions. Along the lines of the earlier studies, we have statistically calculated, as a function of the mean, the homogeneous subsets for alpha 0.05 to group the three instructional conditions applied. The result for overall course performance and learners' satisfaction (taking into account the two questions, Q1 and Q2, separately) was the same: a subset formed exclusively by distance learning with virtualized contents and another subset containing the traditional classroom, plus distance learning with the proposed instructional model. There are three subsets for the learning time variable: one for each instructional condition.

In view of the above results, it can be said that, as far as the overall course performance variable is concerned, statistically speaking, learners attain the same grades when they take the Java Programming course taught according to the traditional face-to-face classroom method as well they follow the e-learning version of the same course supported by the proposed moderate constructivist instructional approach. Consequently, the instructional model designed for e-learning can be said to allow learners to attain a level of knowledge comparable to the traditional classroom method, with the plus of considerably cutting the costs of the Public Administration's training programme.

A similar thing applies to the case of the learners' satisfaction variable. There are no significant differences between learners taking the course taught according to the traditional classroom method and learners enrolled for the distance learning course with the proposed instructional model for either Q1 or Q2. Additionally, the values obtained are, statistically, greater than for learners responding to the questionnaire after taking the distance course without an adequate instructional underpinning.

Finally, note that the distance course with the proposed instructional method requires a bigger effort (learning time) on the part of the learner than the other two instructional conditions: 55 h for the traditional classroom method, 71 h for distance learning with virtualized contents (which is a considerable increase on the above) and 79 h for the case of distance learning with the proposed instructional model.

5. Conclusions

This article presents what is classed as a moderate constructivist instructional model, since it maps constructivist principles to the instructional design by means of a more pragmatic approach. This general-purpose instructional model is now being applied as part of the information and communications technologies programme to teach distance learning courses for Spanish Public Administration employees.

We have presented the results in terms of overall performance, learners' satisfaction and learning time for the Java programming language course, as this is one of the most representative courses. However, the results are similar for the other courses making up the training programme. These results correspond to two time frames: 2004 and 2007.

The 2004 results compare face-to-face classroom instruction with a distance learning format confined to the virtualization of course contents. These results reflect the mistake of not taking into account psychopedagogical prescriptions on teaching/learning and doing without an instructional model.

As a result of this failure, the proposed instructional model was designed. Another study was conducted in 2007, comparing face-to-face classes with distance learning with and without the instructional model. The results indicate that, while it is true that the effort required on the part of the learner in terms of learning time is higher for distance learning with the proposed instructional model, the overall performance and level of learner satisfaction is similar to courses taught face-to-face in a classroom, whereas it has the advantage of cutting costs considerably.

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