E-Learning Instructional Approach with Learning Objects

FERNANDO ALONSO, GENOVEVA LÓPEZ, DANIEL MANRIQUE, FRANCISCO J. SORIANO
Facultad de Informática
Universidad Politécnica de Madrid
Campus de Montegancedo, s/n. 28660 Boadilla del Monte. Madrid
SPAIN

Abstract: - This paper presents a novel e-learning instructional model and its application to teaching a Java language programming course for information technology specialists working for the Spanish public administration. This is a general-purpose instructional model, based on the concept of learning objective and composed of learning objects. Additionally, a blended approach to the learning process in web-based distance education is also presented. This approach combines self-paced learning, live e-learning and face-to-face classrooms. An evaluation has been conducted to compare the grades of students at the end of the course. The students were divided into three groups by instructional conditions: traditional face-to-face classroom, distance learning contents virtualization where videoconferencing substituted face-to-face classroom teaching, and distance learning applying the model proposed in this paper. The results indicate that the grades attained by students that took the distance learning course using the proposed instructional model are similar to the scores attained by students taught according to the traditional classroom method. Both these student groups outperformed students who took the distance learning version of the course without the instructional model.

Key-Words: - distance learning, instructional model, blended learning process, learning objective, learning object, constructivism, objectivism

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 [1]. In fact, the critical element in technology-enhanced instruction is the nature of the instructional model [2], but there exists a serious dysfunction between the profusion of technological features that are put forward and the shortage of pedagogical approaches and teaching principles for e-learning [3]. 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.

The Spanish public administration now continually offers short courses related to the area of information and communication technologies. Initially, these courses were taught by means of eight, five-hour face-to-face classroom sessions, with an examination or practical assignment at the end of the course to assess achievement. Because of the high cost of getting students to the institution where the classes were taught, it was decided to virtualize the courses in a digital format accessible over the Internet and to teach the contents via videoconferencing instead of in the physical classroom. This distance learning approach led to a sharp drop in the grades students achieved in the test taken at the end of the course.

As a result of these poor results, the instructional model that is presented in this paper was implemented to guide the development of the educational contents of any course. This e-learning instructional model is supported by the concept of learning objective, which is also presented in this paper.

The learner's perspective is also taken into account. A number of specialists advocate a blended learning solution [4], [5], which means that different activities are mixed in the learning process. Accordingly, we propose a blended approach that fits our instructional method by mixing three ingredients: self-paced learning [6], live e-learning in a virtual classroom where learners can collaborate [7] and traditional classroom training to learn collaborative skills [8].

This paper also examines the effectiveness of this model for teaching the Java language programming course. This was a forty-hour classroom course taught to an audience of information technology specialists working for the Spanish public administration. The results in terms of the grades attained by students in the test at the end of the course are compared according to the different instructional/learning approaches: traditional classroom sessions, distance learning through contents virtualization and distance learning applying the proposed instructional model.

2 The Concept of Learning Objective

Learning object refers to a generally small-sized, reusable instructional component, designed for distribution over the Internet, for use in different LMS and for access by many users [9]. Each learning object deals with a very specific item of knowledge: educational content, a "good problem" for solution through group work, or evaluation exercises, etc. Learning objects should be self-contained and can be combined to support individual instructional objectives to serve different contexts.

Learning objects have several names in the learning field. Nevertheless, the sharable content object (SCO), coined by the Sharable Content Object Reference Model (SCORM) is the most commonly accepted term with regard to learning and reuse elements.

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 is defined by a set of interrelated SCOs that each deal with a very specific item of knowledge. These relations can be represented by means of an AND/OR graph, where the nodes represent SCOs 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 SCOs need to have been completed before starting on the target SCO. OR learning occurs when two or more lines are directed at a node: the target SCO can start to be learned when either of the source SCOs have been completed. An arrow without a source node indicates that the learning objective can start to be learned as of the SCO to which it points.

A learning objective should be composed of SCOs that contain: educational contents, a "good problem" for group problem solving that covers the concepts described in the educational contents, and evaluation exercises to evaluate the knowledge acquired by learner. The knowledge state demanded for a learning objective is considered to have been attained when its evaluation exercises have been passed, for which purpose the "good problem" necessarily has to be solved. A "good problem" is required to stimulate the exploration and reflection necessary for knowledge construction. According to Brooks and Brooks [10], a "good problem" is one that requires students to make and test a prediction, can be solved with inexpensive equipment, is realistically complex, benefits from group effort and is seen as relevant and interesting by students.

For the Java programming language course example, we defined a learning objective, called Object-Oriented Fundaments (OOF), with six SCOs: the educational contents of Class & Object, Interfaces, Inheritance and Polymorphism, a Good Problem and, finally, a SCO with evaluation exercises.

Fig. 1 shows the OOF learning objective designed, illustrating the interrelations between its SCOs mapped by the AND/OR graph. Looking at the graph, we find that learners can start with Class & Object or directly get on with the good problem, 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 SCO, the learner can continue the learning process by choosing between the SCOs on Inheritance or Interfaces or tackle the good 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.

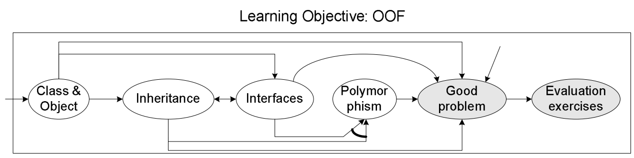

Fig. 1. The AND/OR graph for the learning objective OOF

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 "good problem", a meaningful and realistic problem, and that problem solving should be collaborative so that learners learn through interaction with others [11].

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 [12], and the notion of there being no "right" or "wrong" answers, which strikes fear into the heart of an instructor [13].

3 The Proposed Instructional Model

The proposed e-learning instructional model 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.

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 target knowledge state.

The learning objectives and their relationships are represented by means of a knowledge graph. This is an AND/OR Graph. 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.

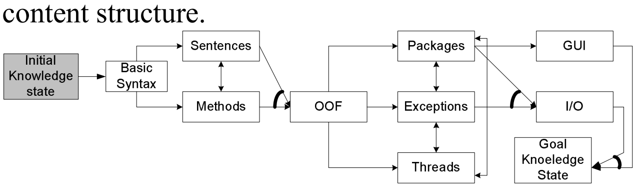

Fig. 2. The knowledge graph for the Java programming example

Fig. 2 shows the knowledge graph for the Java Programming example. 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.

2.2 Design

The design defines how to teach. The tasks to be performed in each learning objective, defined during analysis, are replaced by learning objects. 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 to teach: hypermedia, multimedia and the Internet to improve data gathering, collaboration and offer multiple representations of reality.

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 classrooms.

Self-paced learning is an asynchronous interactive mode of learning over the Internet. This 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 knowledge state. Therefore, the road map represents the set of all possible paths that go from the initial to the target knowledge state. The instructor defines and incorporates the "good problem" and the evaluation exercises for each learning objective.

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 questions of one another and of the instructor 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 not available from more traditional instruction because a group can accomplish meaningful learning and solve problems better than any individual can alone.

The face-to-face or traditional classroom is the third ingredient of blended learning. Classroom training is, despite its defects, still unbeatable for the amount of face-to-face interaction with both the instructor and classmates that is necessary to learn certain management, leadership, and other highly collaborative skills [8].

2.3 Implementation and Execution

Implementation involves building the road map into a learning management system (LMS) platform at design time.

Execution 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 hours.
5. Post-test. A face-to-face assessment is held immediately after the course has finished. The content of the examination includes questions related to real cases to which the concepts learned throughout the course have to be applied. 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.

2.4 Assessment

To determine successes and ascertain the learning product quality, information output during execution is gathered and the results are analysed on the basis of the learning objects and objectives. For the educational content learning objects and the "good 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 assessment 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 Results

The goal of the evaluation was to analyse the grades attained in the test taken at the end of the Java programming language course by students taught according to each of the three teaching modes. The face-to-face classroom course was taught in eight, five-hour sessions. For distance learning all the teaching material used in the classroom was virtualized. Students attended two face-to-face classes: one at the start of the course where they got to know each other and the teacher, and received instructions on the course; and another at the end of the course when they took the test. During the remainder of the course, they communicated with each other and with the teacher over the Internet (via videoconferencing, e-mail and chat). The teacher emulated the instructional model of the face-to-face classroom, teaching the lessons via videoconferencing and answering students' questions via chat and e-mail. The third teaching mode applied the instructional model proposed in this paper to teach the educational contents of the course.

A total of 225 students were randomly chosen to take part in this study. Of these 75 attended the traditional face-to-face classroom sessions, 75 enrolled in the distance learning version and the other 75 took the course supported by the proposed instructional model. The same teachers taught all three versions of the course to assure that this parameter did not bias the results. The instructional conditions served as the independent variable. This variable had three levels: (a) traditional classroom, (b) distance course emulating classroom teaching and (c) distance learning including the proposed instructional model. The dependent variable was the test score, graded from 0 to 10.

Table 1 shows the descriptive statistics of this study. An analysis of variance (one-way ANOVA) was run for the test score to show that there were meaningful differences depending on the type of instructional conditions under which the student took

Table 1. Descriptive Statistics

Test Score

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum scores	Maximum scores
					Lower Bound	Upper Bound		
Traditional Classroom	75	6.4076	2.21038	.25523	5.8990	6.9162	-.55	9.75
Distance Learning	75	5.0771	2.38602	.27551	4.5281	5.6260	.08	8.42
Instructional Model	75	6.1172	2.02420	.23373	5.6515	6.5829	.17	9.60
Total	225	5.8673	2.27512	.15167	5.5684	6.1662	-.55	9.75

the course. One condition of the ANOVA is that the group variances should be equivalent. ANOVA is robust to this violation when the groups are of equal or near equal size, which is in the case in our sample. Even so, a Levene test of homogeneity of variances was run. Table 2 shows the results of this test, where the significance level $p>0.05$ indicates that the hypothesis of homocedasticity cannot be rejected.

The results of the ANOVA for this study are that the null hypothesis (the average test scores for each level of the independent variable are equal) can be rejected because the resulting F (df = 2/222) is 7.503 at a significance level of $p<0.001$. This indicates that the test scores achieved by learners depend on the instructional conditions.

Table 2. Test of Homogeneity of Variances

Test Score

Levene Statistic	df1	df2	Sig.
1,407	2	222	,247

As there are sizeable differences and we have three different levels for the dependent variable, the Tukey HSD test was used to make post hoc comparisons and demonstrate where the statistically significant differences between the three instructional conditions were to be found. Table 3 shows the confidence level for these multiple comparisons, taking into account that the significance level for the mean difference is $p<0.05$. This has been marked with an asterisk. It is clear from Table 3 that there are significant differences between the traditional classroom method and distance learning, and between learning with the instructional model and distance learning; although there are no differences between the traditional classroom and learning with the instructional model. We also calculated statistically the homogeneous subsets for alpha 0.05 into which the three applied types of instruction can be divided as a function of the mean. The result was as follows: one subset formed exclusively by distance learning and another subset formed by traditional classroom and learning with the instructional model.

The fact that there are no significant differences between the average test scores attained by students taking the face-to-face classroom course or distance learning course with the proposed instructional model indicates that we have managed to design an instructional model that is comparable to the traditional face-to-face classroom method, but has the advantage of doing away with the travel and maintenance expenses associated with face-to-face instruction.

4 Conclusion

This paper presents an e-learning instructional model based on the concept of learning objective. A learning objective represents a knowledge state that can be evaluated through evaluation exercises. Accordingly, this instructional model is objective driven. However,

Table 3. Post hoc tests. Tukey HSD. Multiple Comparisons

Dependent Variable: Test Score

(I) Instructional Condition	(J) Instructional Condition	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Traditional Classroom	Distance Learning	1.33053(*)	.36119	.001	.4783	2.1828
	Instructional Model	.29040	.36119	.701	-.5618	1.1426
Distance Learning	Traditional Classroom	-1.33053(*)	.36119	.001	-2.1828	-.4783
	Instructional Model	-1.04013(*)	.36119	.012	-1.8924	-.1879
Instructional Model	Traditional Classroom	-.29040	.36119	.701	-1.1426	.5618
	Distance Learning	1.04013(*)	.36119	.012	.1879	1.8924

* The mean difference is significant at the level of .05.

it also permits learners to choose their learning paths, according to predefined rules. Therefore, this instructional model has the feature of mixing ideas borrowed from the objectivist and constructivist approaches.

The statistical results after applying the proposed instructional model to a Java programming distance learning course indicate that the average test scores (all learners take an assessment exam after finishing the course) are statistically comparable to the grades attained by students taught by the traditional classroom method. These are on average 1.04 and 1.33 respectively, higher than the grades of the students who took the distance learning course that emulated classroom teaching through the virtualization of the educational contents but was not based on any instructional model.

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