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LEARNING THEORY AND INSTRUCTIONAL DESIGN USING LEARNING OBJECTS

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Instructional System Development (ISD) is a set of procedures for systematically designing and developing instruction. A solid foundation in learning theory is an essential element in the application of ISD. One question that one might ask is whether there is one best learning theory for instructional design using learning objects (LOs). Depending on the learners and the situation, different learning theories may apply. The authors do not recommended one particular theory for the design of instruction based on LOs, but rather the adoption of an eclectic approach to learning theory in the design of instruction using LOs. In this work, an overview of the ISD methodology that is based on e-learning Objects (ISD-MeLO) is given. This proposed methodology, which incorporates principles from different learning schools, is currently being tested by K-12 teachers from public schools, as well as instructional designers from private companies in Brazil.

SECTION 1

INTRODUCTION

The future of educational technology is now calling for renewing traditional instructional models (Hamel & Ryan-Jones, 2002). The basic concept lies in the possibility of reusing the same pedagogical content in different instructional contexts. Therefore, instructional content designed independently from context, similar to objects in object-oriented programming environments, can now be shared with other users, recombined with other objects, or redesigned by other instructional developers with possible time and cost savings.

In a previous work, the focus was on the structural aspects of learning objects (LOs) (Baruque, Porto, & Melo, 2003). A methodology based on ISD incorporating the LO paradigm was proposed. The concept was that there should be a systematic approach to developing instruction rather than an ad-hoc one. ISD is rooted in the Information Systems area, although it is applied to the educational arena. Similarly, the object-orientation paradigm, so important in the Information Systems area, is now being used in the educational area. This allows for modularity and reusability of educational contents. This is the *object* aspect of the LO paradigm. The other aspect—learning—is the major focus of this work. This means that an LO should have the right semantic of learning. A thorough understanding of what learning is becomes crucial. To this end, it is imperative that a methodology to design educational content based on LO be grounded in learning theories.

Depending on the context and the nature of the audience, a general approach seems to be more useful than a specific one. An eclectic approach to learning theory is proposed so that pedagogical principles from different learning schools can support the methodology. The experience with the PGL (Partnership in Global Learning) project (PGL, 2004), where the audience encompasses a variety of user profiles, reinforces the concept that an eclectic approach to theory seems to be more satisfactory. As stated in Martinez (2003), learners have different orientations: they can be transforming, performing, or conforming learners. This requires different strategies; therefore, an eclectic methodology could be considered the middle ground between standardization and personalization.

In the literature, there are many definitions of a learning object to be found. As defined in Ruttenbur, Spickler, & Lurie (2000) and as considered by many authors, an LO can be viewed as a small "chunk"of learning content that focuses on a specific learning objective. The learning objects can contain one or many components, including text, video, images, or the like. LOs may be seen as building blocks that, depending on the way they are combined, may constitute lessons, modules, or courses. In this paper, LOs are considered as structures similar to what is proposed in Cisco (2001). How they should be assembled in a collection is at the discretion of the instructional designer or the student. However, what is the basis on which these decisions should be made? Learning theories describe how learning occurs while instructional theories prescribe the best way to design instruction, in order to foster learning (Newby, Stepich, Lehman, & Russell, 1996). Different schools prescribe different strategies, but the authors believe that all have valid principles that are applicable to LOs.

This work aims at proposing an eclectic approach to learning theory in the design of instruction for e-learning modules. To this end, it shows how principles from different schools were incorporated into the ISDMeLO methodology. It is aimed at the design and development of educational content to be delivered on the Web. A top-down approach is used where pedagogical dimensions in different layers of abstraction are found. This approach is useful in showing how the methodology is grounded in sound pedagogical principles. This methodology is being developed for use by instructional designers of the PGL Project (PGL, 2004). As part of this project, a multimedia e-learning-oriented distributed database system is also being developed to serve as an LO repository in the PGL environment (Melo & Baruque, 2003).

The remainder of this paper is organized as follows. In Section 2, an overview of the fundamentals of learning theories for the design of instruction based on LOs is presented. Following this, Section 3 gives a summary of the ISDMeLO methodology with its phases, outputs, and procedures. Section 4 shows how pedagogical principles from different schools are included in the ISDMeLO methodology, thus emphasizing its eclectic nature. Section 5 shows how to apply such methodology in the design of LOs for a course on management controls. In Section 6, the results of the application of the methodology by K-12 teachers and instructional designers during a course run by PUC-Rio are reported. Finally, in Section 7, some concluding remarks are made.

SECTION 2

OVERVIEW OF LEARNING THEORIES

In this section, a brief description of three major learning schools is given and a model, which helps in the analysis of the application of pedagogical principles in the methodology, is presented. Finally, an analysis of the best theory to use is made.

The Three Learning Schools: Behaviorism, Cognitivism, and Constructivism

A learning theory encompasses principles which aim at explaining changes in human performance, providing a set of instructional strategies, tactics, and techniques from which to select, and the foundation for how and when to choose and integrate the strategies. Furthermore, it predicts the results of using the strategies (Yang, 2004).

Since the late 1800s, three learning schools have influenced education: Behaviorism, Cognitivism, and Constructivism. They represent major themes in the way learning is conceptualized and provide different practical guidelines for instructional practice. In Section 5, the use of these practical guidelines in the design of LOs is shown.

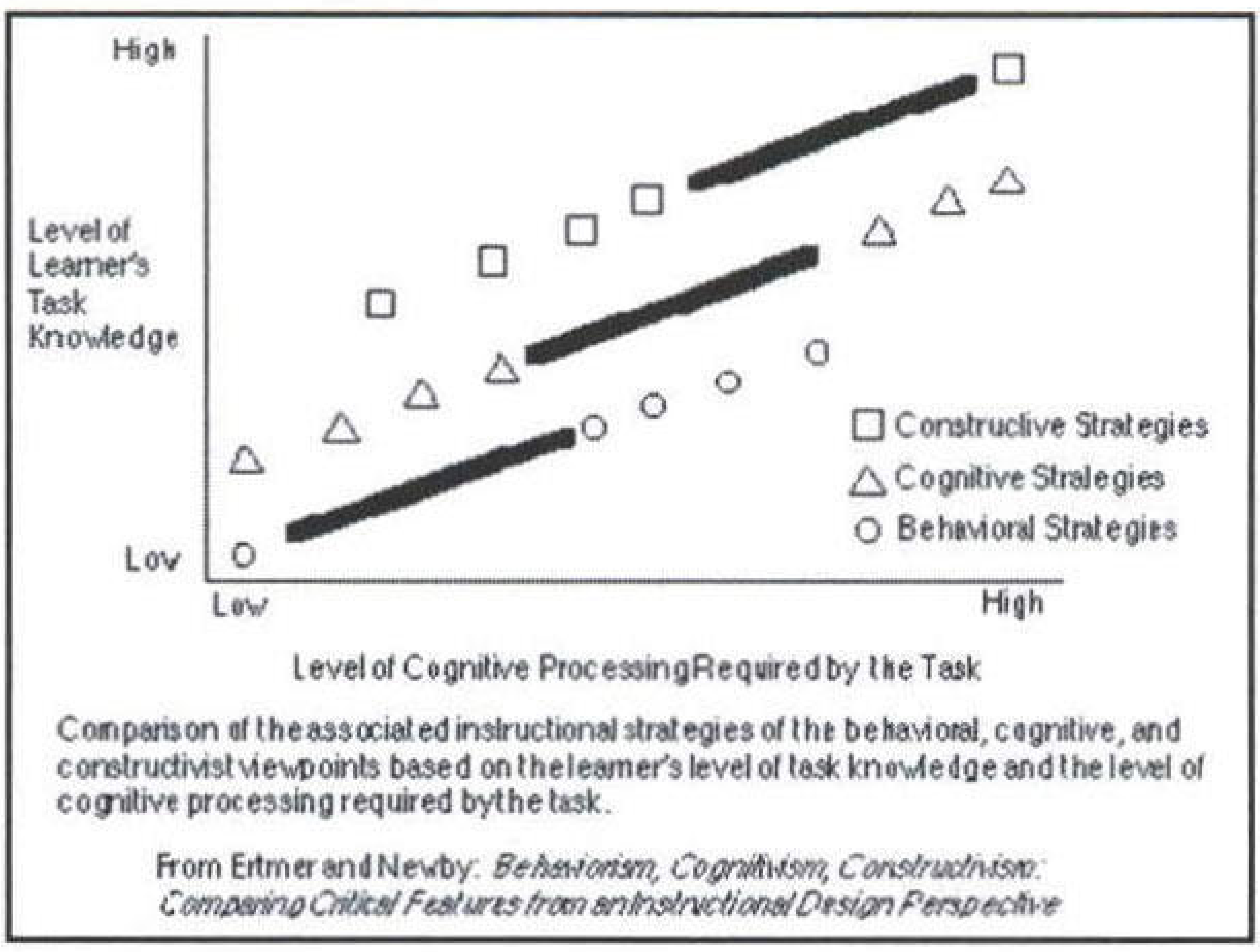
The primary focus of the behavioral perspective is on behavior and on how the external environment shapes the individual's behavior. As such, the primary responsibility of the instructional designer is to identify and sequence the contingencies that will help students learn. Teachers should then state the objectives of the instruction as learners' behaviors. Learning is inferred from behavior, so it is important to identify the goal behavior and the actions involved in breaking that goal behavior into a set of simple behaviors and arranging them in a sequence that will help students progress toward the goal.

While the behavioral perspective has an external focus, the cognitivist has an internal one. Learning is understood as a change in knowledge stored in memory. Consequently, the instructional designer should organize new information for presentation, carefully linking new information to previous knowledge. He/she must also use a variety of techniques to guide and support the mental processes of the student.

The constructivist perspective describes learning as a change in the meaning constructed from experiences. Learning is constructed by the complex interaction among students´ existing knowledge, the social context, and the problem to be solved. Thus, the instructional designer is challenged with posing good problems, creating group-learning activities, and guiding the process of knowledge construction.

In Newby, Stepich, Lehman, & Russell (1996), there is a suggestion on the application of each of the school principles that considers the learner's knowledge level and the complexity of the subject to be learned.

Although Figure 1 presents some criteria for the application of learning theories, the authors believe they are not mutually exclusive. For example, an instructional designer may clearly define an expected behavior from a learner (behaviorist perspective) while at the same time establishing a group activity or problem-based activity (constructivist perspective) where the learner will practice the knowledge acquired.



Comparison of the associated instructional strategies of the behavioral, cognitive, and constructivist viewpoints based on the learner's level of task knowledge and the level of cognitive processing required by the task.

From Ertmer and Newby: *Behaviorism, Cognitivism, Constructivism: Comparing Critical Features from an Instructional Design Perspective*

Figure 1. Application of Learning Theories

Learning Theories Framework

As mentioned before, a sound methodology for designing and developing e-learning modules should be grounded in principles from important learning theories. Similarly, the design of LOs should be based on sound principles of pedagogy.

Allert, Dhraief, & Nedjdl (2001) show a top-down model in which pedagogical dimensions are imbedded in different layers of abstraction; this is illustrated in Figure 2. The fourth (highest) layer of abstraction is normally referred to as paradigm or as a way of teaching, learning, thinking, and designing. Behaviorism, cognitivism, and constructivism are major approaches. The third layer of abstraction can be considered as a set of underlying principles. The second layer of abstraction refers to instructional models and theories that are guidelines or a set of strategies. The first layer of abstraction contains content, practices, and activities. This layer describes what is done and what is to be learned, as well as the resources actually used.

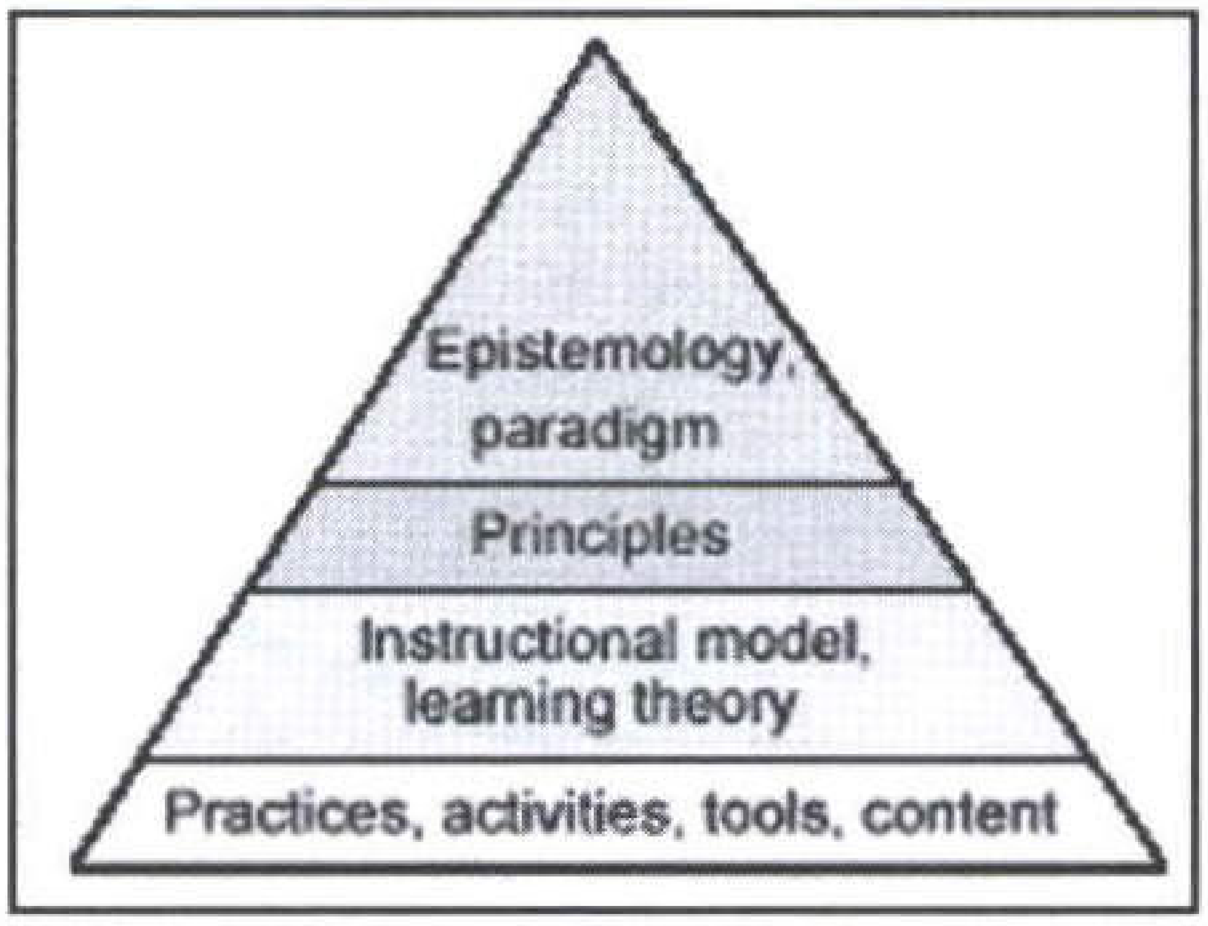


Figure 2. A Top-down model

Based on the top-down model, the decisions that are made at a higher level of abstraction affect the more basic levels. Therefore, the objective is to show that the instructional strategies and practices recommended by the methodology are grounded in sound pedagogical principles that follow this model. In order to make this clear, the tables found in Section 4 show examples of its application. Nonetheless, the next section discusses the best theory to be used in the design of LOs.

Learning Theory Most Suitable for ISD Using LOs

Similar to the behaviorist and cognitivist, the constructivist theories take on a variety of forms. The basic distinction is that while behaviorists view knowledge as an automatic reaction to external factors in the environment, and the cognitivists consider knowledge as abstract representations in one's mind, the constructivist school views knowledge as a meaning built by each learner through a learning process. Thus, knowledge cannot be transmitted from one person to another; it must be rebuilt by each person. This means that the view of knowledge differs from the objectivist view of knowledge of behaviorism and cognitivism. Constructivism is thus subjectivist. This seems to be true, however, only to radical and social constructivist approaches. In Doolittle, & Camp (2002), constructivism is described as a continuum and is classified in three broad categories: Cognitive, Radical, and Social. Cognitive constructivism focuses on the construction of mental structures that function effectively within a reality that is already known. Radical constructivism focuses on the student's personal understanding and the mental model he or she creates for the problem solving process. Social constructivism has its focus on shared social experience and social negotiation of meaning. The first is considered a weak form of constructivism, since its focus does not include the subjective nature of knowledge.

In this work, the authors analyze the learning theory underlying the curriculum and pedagogy of career and technical education. They point out that behaviorism was in place during the last century and that constructivism should be considered in preparing workers to enter an environment that demands increasingly higher orders of thinking, problem solving, and collaborative working skills. These features are not addressed by behaviorism. They examine whether constructivism could be the underlying theory of curriculum and pedagogy of career and technical education and conclude that only the Cognitive category could.

It should be noted that each school has ideas that appear to be of value for particular educational settings. Some principles may be useful in almost all situations; these include reinforcement (from the behavioral perspective), organized information (from the cognitive perspective), and learning from one another (from the constructivist perspective). However, these theoretical perspectives focus on different aspects of the learning process. Therefore, it is possible to use a combination of theoretical principles, depending on the requirements of the specific instructional situation.

As Figure 1 shows, two factors influence the selection of a learning theory: the knowledge level of learners and the amount of thought and reflection required by the learning tasks. Therefore, if the student has little knowledge of the subject, behaviorist strategies will be of most benefit to that student. As he/she acquires more knowledge, the emphasis may shift to cognitive and then constructivist principles as the better strategies. The same is true when the amount of thought and reflection, required by the learning tasks increases.

Learning orientation is another important factor that could be considered when deciding which approach to use in a particular educational setting. As mentioned in Martinez (2003), learning orientation recognizes the impact of emotions and intentions of learning. There are learners who are naturally active while others tend to be passive. Therefore, there would be no point in adopting a constructivist approach with learners who have no initiative to learn or who do not feel comfortable with autonomy. As in the case of employees, there are learners who do not need to be told what to do, while others cannot move, except if they are directed and monitored. Thus, in selecting a given strategy, one should consider the following learner orientations: Transforming (Innovators), Performing (Implementers), and Conforming (Sustainers). Transforming learners assume learning responsibility and self-manage goals, learning progress, and outcomes. He or she experiences frustration if given little learning autonomy. Performing learners assume learning responsibility in areas of interest but tend to give up control in areas of less interest. They prefer coaching and interaction to achieve goals. Conforming learners assume little responsibility, manage learning as little as possible, comply, wish to be guided, and expect reinforcement for achieving short-term goals.

Constructivism encourages and accepts learner autonomy and initiative, considers learners as individuals full of will and purpose, encourages learner inquiry, acknowledges the critical role of experience in learning etc. All of this seems to be more appropriate to a Transforming learner who is willing to take more risk and be in charge of his/her learning. On the other hand, Conforming learners need structured and low risk environments and, as such, behavioral strategies would appear to be more suitable. Finally, Performing learners prefer semi-complex, semi-structured environments that could be attended by cognitivist practices. Although it is recommended that learner orientation be considered for the adoption of a given instructional strategy, it does not mean that other factors should not be considered.

To finalize this section, we stress that these three learning schools are equally important and no single learning theory provides a complete prescription for the entire instructional design process. The authors believe that by adopting an eclectic approach, one can benefit from all learning schools and, at the same time, better meet the needs of the target audience.

SECTION 3

ISDMELO: A METHODOLOGY TO DEVELOP E-LEARNING MODULES BASED ON LOS

In this section a summary of the ISDMeLO methodology (Baruque, Porto, & Melo, 2003) is presented. This is based on the general method named ADDIE, which includes the following phases: Analysis, Design, Development, Implementation, and Evaluation (Braxton, Bronico, & Looms, 2003). It is important to mention that it is oriented to a by-hand assembly of learning objects by an instructional designer. At the end, some known good practices, which should be observed while applying the suggested methodology, are presented.

The ISDMeLO Methodology: An Iterative Process

One should note that these steps are not necessarily sequential. The inclusion of a prototyping and evaluation activity in the design phase is aimed at testing the module using an audience early in the ISD process. Based on user feedback, the design can then be revised and another prototype developed. This process is repeated until the prototype is considered satisfactory.

Phase I. Analysis

This phase is aimed at analyzing the specific learning problem and determining the learner profile. Data gathered during this phase are important to ensure that personalization and customization issues will be taken into consideration. This phase generates the following outputs:

a) Learner Profile Analysis Form
b) Problem Analysis Form
c) Existing LO (if available)
d) Environmental Analysis Form

This phase encompasses the following procedures:

I.1 Specify Learner Profile: One should become familiar with the learner characteristics by analyzing the motivational, technological, and demographic profile of the LO user. Items such as age, grade, educational background etc. should be considered. The application of learning style models (Paredes, & Rodriguez, 2000) is also useful for this analysis.

I.2 Conduct Problem Analysis: It is necessary to determine why the instruction is needed. For corporations, this is normally associated with a performance gap that should be corrected. In an academic context, other variables should be taken into consideration. One important output of this step is to determine the major learning objective to be accomplished.

I.3 Search the Web or the database environment for existing LOs. If an LO is found and meets the learning needs, then one should consider its use. It may need to be repurposed or can possibly be reused as is.

I.4 Conduct an Environmental Analysis: One should consider whether an instructor should lead the instruction, if the instruction will be delivered by a learning management system (LMS), etc. Costs and administrative issues are also important.

Phase II. Design

This phase is aimed at designing the instructional content and the look-and-feel of the LO interface. This phase generates the following outputs:

a) Task Analysis Document
b) Content Analysis Document
c) Sequencing of LOs (Conceptual Map)
d) Storyboards of LO interface design

This phase encompasses the following procedures:

II.1 Conduct a Task Analysis: Based on the major learning objective established during the Analysis phase, one should now use that learning objective to create sub-objectives, generating a tree that shows pre-requisite sequences to be followed.

II.2 Conduct a Content Analysis: While the task analysis asks what the learner should be able to do (i.e., what behavior he/she should demonstrate) in order to accomplish the major learning objective, the content analysis recursively asks what the learner should know to perform the foreseen tasks. This analysis will reveal the concepts, principles, or procedures that should be learned or taught.

II.3 Identify LO structure: Based on the tree generated by the task/content analysis, one should now chunk or break the content into a structure of LOs. This chunking, which will generate a new tree of LOs, should observe the following design principles (Hamel, & Ryan-Jones, 2002): (a) LOs must be units of instruction that stand alone; (b) LOs should follow a standard instructional format; (c) LOs should be relatively small; (d) A sequence of LOs must have a context, and (e) LOs must be tagged and managed. Furthermore, it is recommended that a good sized LO should have a minimum of three and a maximum of seven components. The minimum is due to cataloguing expenses and the maximum is due to the capacity of short-term memory (Miller, 2004). In the resulting structure, the LOs at the bottom level are categorized as Atomic LOs (ALOs), as they will not be further broken down.

II.4 Establish the sequence of the Instruction: This will indicate the sequence in which the LOs will be delivered. There are a number of ways to sequence instruction, but the sequencing method prescribed by the Elaboration Theory is recommended. It uses the concepts of epitome, progressive differentiation, and reconciling integration by advocating a top-down approach (Reigeluth, 2004). The epitome should be presented first, followed by the various elaboration levels. For sequencing, the hierarchical tree should be crossed from the left to the right at each elaboration level. Because of the recommended chunking in item II.3, an LO at elaboration level n would combine between three and seven LOs from the elaboration level n+1. Some LOs will be smaller while others will be larger, since they will be composed of LOs from a higher elaboration level. It should be noted that this approach to sequencing allows learner control; this is in-line with the constructivist perspective, since the learner is not supposed to follow pre-requisite sequences that he/she may find boring.

II.5 Categorize LOs: After identifying the LOs, one should now assign a category type to them. The one proposed in Clark (1998) and Cisco (2001) is used. At the bottom level, each ALO relates to a cognitive level, such as principle, process, procedure, concept, and fact.

II.6 Specify the LOs: For each LO the following attributes should be specified: learning outcomes, content to be covered, evaluation method, example, practice, media, and instructional approach. This last item can be chosen from among the following cases: presentation, demonstration, collaborative learning, learning by discovery, problem solving, instructional games, simulation, tutorial, and drill-and-practice. At this point, it is important for the instructional designer to consider the context in which the LO will be used. If it is under the constructivist perspective, the LO should not be tied to a specific learning objective. The learner would establish his/her own goals dynamically. For example, when using an LMS, the system could hold different learning objectives from which the learner would select a specific one.

II.7 Model the user for the LO's interface design: The data gathered during the analysis phase should be useful in determining the profile of the user interface.

II.8 Implement the user task analysis: This focuses on the tasks the user will perform with the LOs.

II.9 Find a metaphor: A metaphor will make the interface more intuitive. However, one should pay attention to cultural issues.

II.10 Design the look of the interface: Colors, fonts, icons, and all visual aspects should follow sound interface design principles. Internationalization and localization issues should be considered.

II.11 Design the feel of the interface: The site topology, navigation, and interaction tasks and other interface components should be chosen following sound interface design principles. Internationalization and globalization issues should be considered.

II.12 Prototype and evaluate: Storyboards with interactive, visual, and audio aspects should be developed to specify the look-and-feel of the LO interfaces. It is important to consider the consistency of the LO interfaces when creating and combining LOs.

Phase III. Development

This phase is aimed at producing digital LOs and storing them into a repository.

This phase generates the following outputs:

a) Digital LOs
b) LOs stored in the environment database

This phase encompasses the following procedures:

III.1 Search for LOs in the environment database or on the Web: One can still mine the Web to look for possible LOs for reuse as components.

III.2 Build the LOs: LOs can be created, reused, or repurposed. LOs can be created using authoring tools, such as Dreamweaver, Photoshop etc. One should also use search engine tools, collect text, graphics, photographs, video, and audio clips to create digital files, while making sure to observe copyright laws. To reuse and repurpose LOs that are found on the Web, assembling tools are needed.

III.3 Perform quality control: This includes the review of design and editorial standards, as well as a functional review.

III.4 Store LOs in the environment database: The database is the LO repository in this case. It is necessary to comply with the policies and procedures of the environment.

Phase IV. Implementation

This phase is aimed at delivering the instruction to the user. This phase generates the following outputs:

a) LOs within an LMS or a Web page for delivery
b) Management plan for instruction delivery
c) The actual delivery of LOs to the users

This phase encompasses the following procedures:

IV.1 Select a strategy to integrate LOs into a product: One can choose among wrappers, frames, links, and templates. One could consider choosing an LMS where the LOs can be managed properly or delivering the instruction using a Web site.

IV.2 Choose the most adequate delivery mode: One should consider whether learning is best accomplished in a self-paced, collaborative, or instructor-led fashion.

IV.3 Create a management plan: One should plan for the most effective delivery of instruction. This is particularly important for instructor-led delivery. For self-paced instruction, some means of obtaining feedback should be established.

IV.4 Run the product according to the selected delivery strategy: After choosing the most adequate delivery mode, the LOs should be integrated into the proper environment and finally run.

IV.5 Track progress: One should monitor if the plan is being accomplished. Usually, this tracking is a standard function of an LMS.

Phase V. Evaluation

This phase is aimed at measuring the adequacy and effectiveness of the instruction delivered. This phase generates the following outputs:

a) LO adjustments or deletion from the repository
b) Changes to specific attributes of LOs
c) Verification of whether instruction is meeting learning goals

This phase encompasses the following procedures:

V.1 Conduct formative evaluation: This type of evaluation is carried out before instruction takes place. One can test LOs on a selective group prior to their delivery and make adjustments accordingly.

V.2 Conduct summative evaluation: As part of the LOs, there are pre and post assessments that will determine if the learner is meeting the learning goals. One should also consider the impact that the instruction is having on the institution in light of its mission and strategies. Based on the evaluation performed, the LOs should be updated accordingly.

Generic Good Practices

While applying the suggested methodology, the instructional designer should observe the procedures presented below.

Capturing and Using Appropriate Metadata for the LOs

Metadata are descriptions of data. LOs must be located and retrieved in order to be reusable. That is why records, which will allow instructional designers or students to find and use LOs from a repository, should be kept. As such, all data gathered during the ADDIE phases should be used to generate the metadata according to standard metadata, e.g., IEEE-LOM. Some data considered important were captured during the testing of the methodology by K-12 teachers (see Section 5): Title (1.2), Author (2.3.1), Keywords (1.5), Language (1.3), Subject (9.2.2), Summary (1.4), Location (4.3), Version Number (2.1), Status (2.2), Format (4.1), Technical Requirements (4.4), Learning Level (5.6), Age range (5.7), Description (5.10), Language (5.11), Educational Objectives (9.1), Use Time (5.9), Pedagogy (5.2), Structure (1.7), Aggregation Level (1.8), Learning Strategy (5.1), Interactivity Level (5.3), Source (7.2), Relationship (7.1), Supervision (2.3.1), Copyrights (6.2.), Price code (6.1), and Catalog identification (1.1.1). The numbers in the brackets were taken from the IEEE-LOM tree (IEEE, 2002)

Tying Instructional Goals to Business Needs

In the corporate context, one basic and very important issue, prior to the development of an e-learning module with LOs, is to ask whether it is the solution to a performance problem. For example, if sales of a given product have decreased, it is necessary to determine the reasons for the decrease. By carrying out a needs analysis, one can diagnose the causes for a performance problem; these could be due to lack of motivation (e.g., sales personnel consider that their salaries and wages are low given their levels of responsibility), lack of operational conditions (e.g., the information system that supports the sales activities is normally down), or lack of knowledge (e.g., a new product was introduced and the sales personnel are not acquainted with its features). Only in the last case would an e-learning module will be a solution for the performance problem because learning objectives can be clearly stated. Obviously, in the first two cases, the development of an e-learning module will be a waste of time and money, since the problem needs to be addressed from other perspectives. Therefore, tying instructional goals to business needs are fundamental for the organization's success in e-learning.

Creating and Applying Success Metrics

It is important to verify the contribution that the module developed is returning to the business. In the literature, many evaluation models are found (Braodbent, & Cotter, 2004). Level Four of the well-known Kirkpatrick Model (Kruse, 2004) specifically addresses the business impact of the training program. Following the example provided above, one training program's success metric would be to measure changes in sales volume some time after the sales personnel have attended the program.

SECTION 4

THE "LEARNING" ASPECT OF LOs IN THE ISDMeLO METHODOLOGY

In order to understand the learning aspect of LOs in the ISDMeLO methodology, let us use an example produced during the DMeLO course referenced in Section 6; this examples allows us to see the influence of the three basic learning schools (behaviorism, cognitivism, and constructivism) in instructional design with LOs.

The example considers a multinational company. Senior management has determined that all employees should attend a course to improve controls over the company's operations. The Human Resources department conducts an analysis to verify the gap between real performance and ideal performance. As a result of this analysis, the company discovers that employees are not aware of how to control operations such that they comply with company-established rules. As such, the major learning objective to be achieved is formulated as follows: "To establish and to maintain an effective management control system." The company has a set of control principles and procedures that will be taught at the course and with which the staff should comply. By the end of the course, the learners should be able to control the activities under their responsibility in conformity with the company's policies and procedures.

Behaviorist Aspects

Considering the top-down model presented above, the following behaviorist aspects may be applied:

Table 1
Behaviorist Aspects

Highest Layer	Behaviorism
3rd Layer	Learning is inferred from behavior; it is important to identify the goal behavior
2nd Layer	• Gagné´s Learning Hierarchies Theory
Basic Layer	• Definition of learning objectives by the teacher or instructional designer • Task/Content Analysis • Feedback • Pre and Post Assessments

Since one of the main goals of the course is to enable the learner to comply with established procedures, as prescribed by the behaviorist approach, the learning objectives will be established by the teacher or instructional designer and not by the learner. A task analysis will be carried out to describe the performance expected from the leaner and a content analysis will complement it by stating what the learner should know in order to perform as required. This will be the basis for the content chunking into LOs. Additionally, the learning objectives will be an LO property rather than a result from the interaction between the learner and the information. However, the assessment does not necessarily need to include objective tests (such as multiple choice) to test the learner.

Cognitivist Aspects

Considering the top-down model presented above, the following cognitivist aspects may be applied:

Table 2
Cognitivist Aspects

Highest Layer	Cognitivism
3rd Layer	Learning is described as a change in knowledge stored in memory
2nd Layer	• Elaboration Theory • Information Processing Theory
Basic Layer	• The use of advanced organizers • Capacity of the short and long-term memories • Content chunking into meaningful parts

Given the broad and diverse audience of the course, it is assumed that it may include transforming, performing, and conforming learners, who may also have different knowledge levels. Thus, the learner will be given control to follow the sequences that seem to be more appropriate to his/her needs; however, some fundamental pre-requisite requirements must be observed and the use of advanced organizers, summarizers, and synthesizers will help him/her in understanding the material. The use of analogies and metaphors will be applied to help in the assimilation of information as well as links to prior knowledge.

Constructivist Aspects

Considering the top-down model presented above, the following constructivist aspects may be applied:

Table 3
Constructivist Aspects

Highest Layer	Constructivism
3rd Layer	Learning is a change in the meaning constructed from experiences
2nd Layer	• Problem-Based Learning • Situated Learning
Basic Layer	• Definition of learning objectives on a dynamic way, as goals established by the learner • Learner control, since the sequencing does not force a pre-requisite sequence to be followed • Posing good problems to students • The use of collaborative activities and real world examples

The LOs defined as a result of the task/content analysis would include real examples, following the situated learning approach. That is, examples will be as close as possible to the learner's real work situation in order to foster knowledge transfer. As far as practices are concerned, collaborative and problem-based learning would be emphasized. For example, a case study would pose a problem to a group: a given scenario should be analyzed as to what risks to the company's operations are present and what controls the group would establish to minimize them in compliance with policies and procedures. As a pre-test, the learner would be asked to reflect what controls are and/or should be in place in the operations under his/her responsibility. As a post-test, the same open question would be posed and the learner could reflect on how much he/she has learned.

In essence, eclectic LOs can be designed. They were behaviorist where content design is concerned, cognitivist as far as sequencing is concerned, and finally, constructivist as far as examples and practices are concerned. This shows the adaptability and flexibility of LOs.

In summary, the proposed methodology follows principles from the three basic learning schools. Behaviorism and cognitivism both support the practice of analyzing a task and breaking it down into manageable chunks, establishing objectives, and measuring performance based on those objectives. While behaviorism is highly prescriptive in nature, constructivism calls for no pre-specified content; there are no rigid assessments and the learners determine the instructional direction. Bearing in mind that each particular theory will be more or less useful depending on the context, an eclectic approach, such as Reigeluth´s Elaboration Theory (Reigeluth, 2004) used in phase II.4 of the proposed methodology, is recommended. The learner can be introduced to the main concepts of a course and then move on to a more self-directed study that is meaningful to that learner and his/her particular context, in line with a more constructivist view.

SECTION 5

THE "OBJECT" ASPECT OF LOs IN THE ISDMeLO METHODOLOGY

Let us now look into the *object* aspect of LO in the ISDMeLO methodology applied to the example provided in Section 4. This section concentrates on the Design phase of the methodology, mainly on content design, which is the major focus of this work. The other steps of this phase will not be addressed here.

1. Conduct a Task Analysis: The major learning objective, "To establish and maintain an effective management control system" as illustrated in Figure 3, is broken into the following sub-objectives: "To assess risk," "To establish/implement controls," "To ensure the execution of controls," and finally, "To assess the adequacy and effectiveness of the control system."

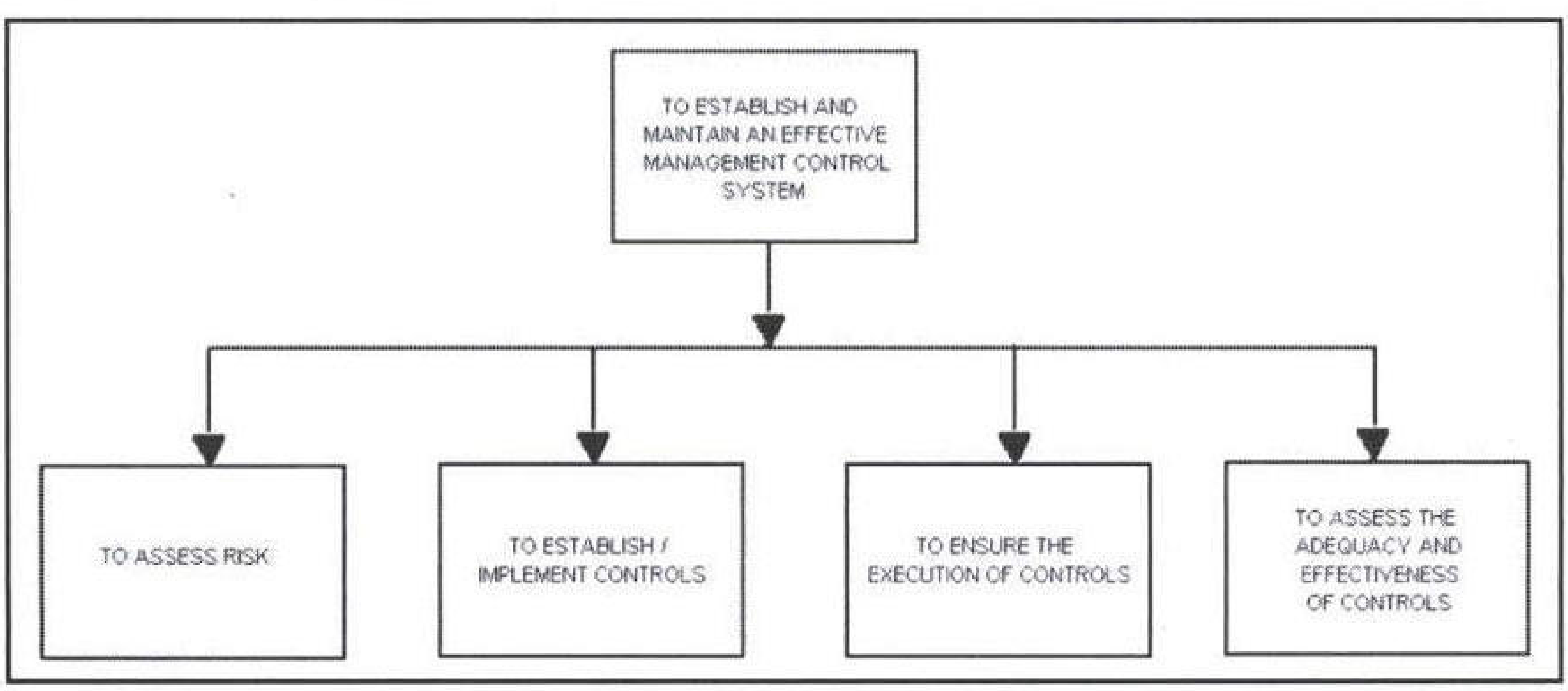


Figure 3. Task Analysis

2. Conduct a Content Analysis: "To assess risk" can be further broken down into: "To identify risk" and "To classify risk." As per this analysis, in order to perform these tasks, the following content should be provided to the learner: risk concept, how to identify risk, business output categories, business risk categories, and risk levels. Figure 4 illustrates this structure.

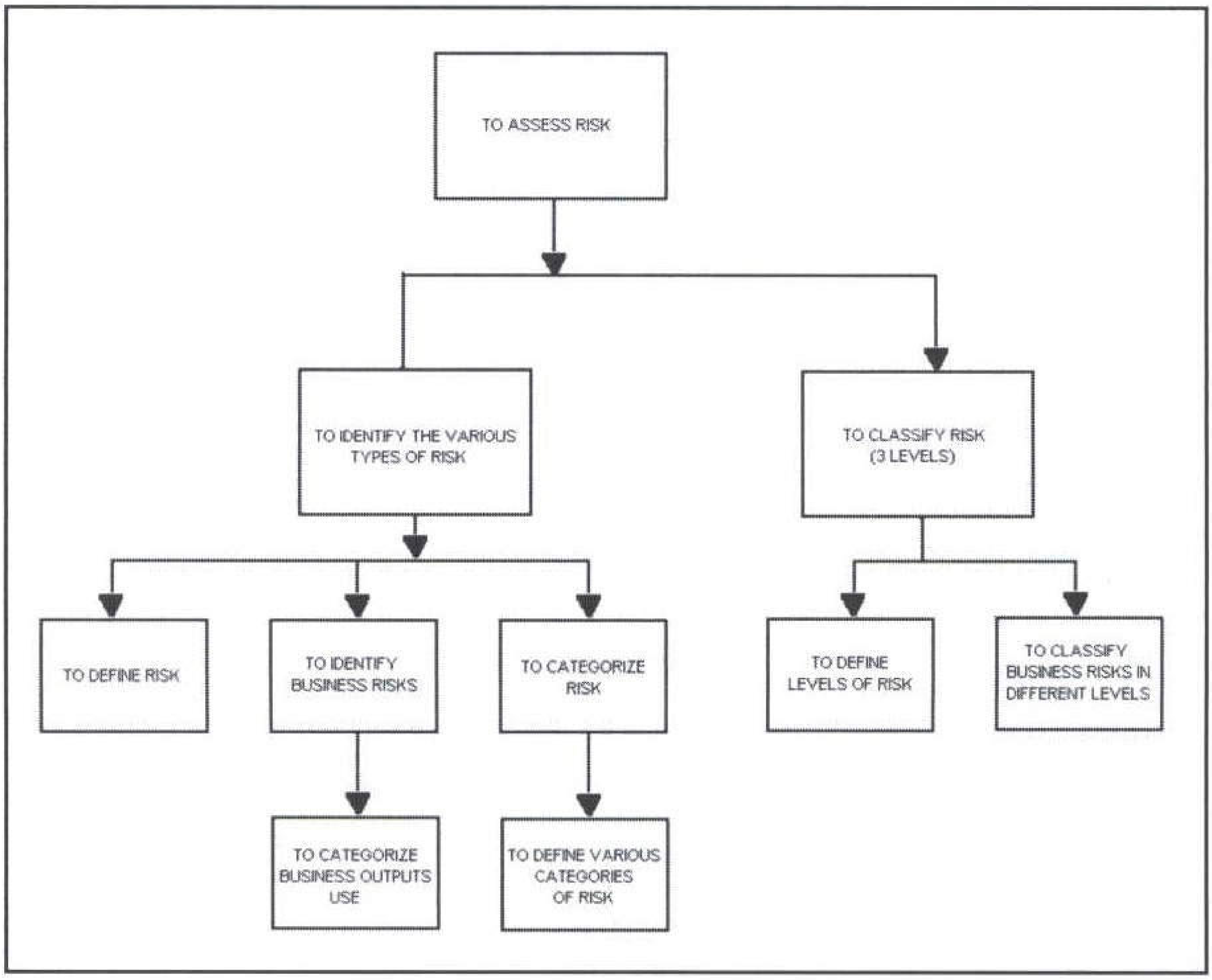


Figure 4. Content Analysis

3. Identify the LO structure: Once the tree of learning tasks/objectives is generated, one should follow the design principles (stated in item Section 3) and generate a tree of LOs. At this point one would come up with combined LOs and ALOs. It should be noted that this tree (Figure 5), although similar, is often different from the one generated in items 1 and 2. One good rule to follow while chunking content into LOs is: How many ideas about a topic can stand on their own and can be reused in different contexts? Polsani (2003) stresses that conceptualization is a key phase in designing LOs in order to maximize reusability.

Figure 5 shows the LOs and ALOs, which together address the major objective of the course: "To establish and to maintain an effective management control system" and its sub-objectives. The ALOs are those numbered LO 1.1.1.1 and LO 1.1.2.1 and LO 1.2.1 and LO 1.2.2.

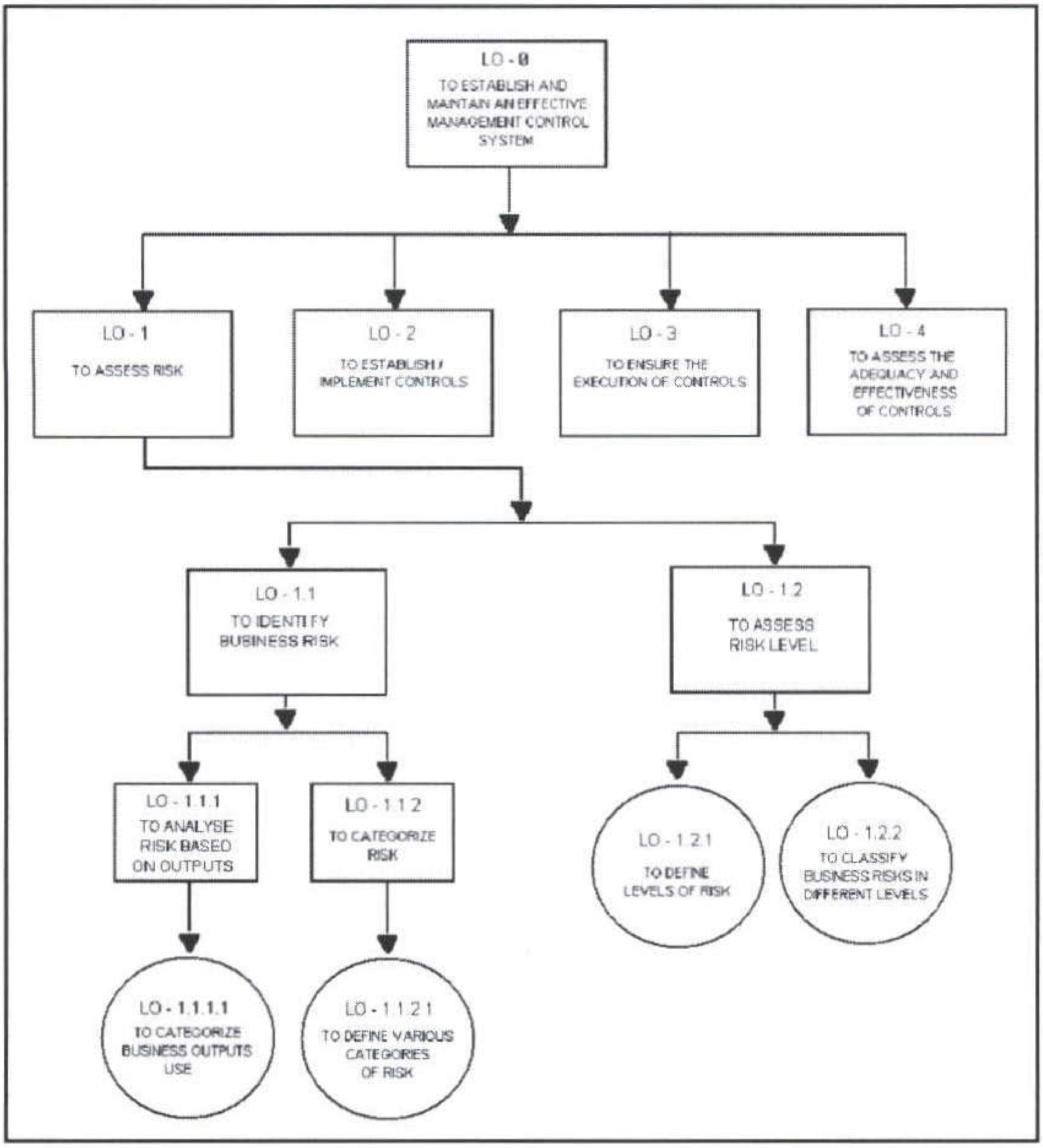


Figure 5. LO Tree

4. Establish the sequence of instruction: Since Elaboration Theory is followed, it means that an epitome would be presented first to the learner. Therefore, it would give an overview of the four major sub-objectives, including a practice. Then, at each elaboration level, more details of a sub-objective would be presented. Instead of following a behaviorist approach in which the first box—to assess risk—would be presented in detail and only

then could the learner go to the second and so forth, he/she could choose different paths. This means that the student can learn how to "To establish/ implement controls," "To ensure the execution of controls," and finally, "To assess the adequacy and effectiveness of the control system" at a general level, before going into all details of the "To Assess Risk Level" sub-objective, for example.

5. Categorize LOs: The LOs are in essence procedural, except for LO 1.1.2, which can be classified as Conceptual.

6. Specify the LOs: As an example, the LO 1.1.2, "To Categorize Risk," is used, which will have the following attributes:

- Learning outcomes: The student should be aware of the company's business risk categories and classify each risk scenario according to this list; in a constructivist approach, no pre-determined list of risk categories would be given and the students would come up with their own risk categories list;
- Content to be covered: Definition of Risk Categories;
- Evaluation method: Pre and Post tests with learner reflection;
- Example: Examples based on real or authentic situations within the company;
- Practice: A case study posing a problem which should be addressed by a group of students;
- Media: Text-based or multimedia tools for shared synchronous or asynchronous communication, tools for collaborative work (shared screens);
- Instructional approach: Collaborative learning and problem solving.

SECTION 6

TESTING THE METHODOLOGY: CASE STUDIES

The first version of the methodology without the LO approach was used in a course given to about 40 employees of a Brazilian public company. They were organized into 10 groups; each group had to design and implement an e-learning module. They had no difficulty in applying the principles and procedures prescribed by the methodology and monolithic modules of good quality were produced.

The methodology, proposed in this paper, enhances the first version with the main emphasis on the LO paradigm. This new version was tested in another course, DMeLO (PUC-Rio, 2003), which was given to K-12 teachers and employees from the human resources departments of private companies. They produced five modules named as follows:

- Controls Awareness Program (used as an example in Sections 4 and 5)
- Water Shortage (about the shortage of water in the near future on this planet)
- Urban Trash (on how to cope with urban trash)
- Air Pollution (on the consequences of air pollution)
- Hydroelectricity (on the generation of electricity in hydroelectric power plants)

In order to facilitate their work, an HTML template was made available for the implementation of the LOs. The complete documentation was kept online following the steps of the methodology. The LO metadata that was produced also followed a standardized template. These LOs will be included in the PGL DB environment in the near future.

The following reactions were observed from the course's participants: They considered the documentation template provided to them to be a very useful tool to plan instruction. The great majority were willing to present it to the boards of their schools for adoption. Although each teacher may have his/her own style, this group found that a method to systematically plan instruction is helpful to guarantee that learning needs are met. Participants also realized that the possibility of repurposing and contextualizing LOs was extremely important. They found no difficulty in applying the procedures proposed by the methodology, except for the use of authoring tools, such as Flash and Photoshop, to create the contents of LOs. They found that this skill would require additional training. In general, they considered it relatively easy to follow the methodology but they complained about the lack of good tools to describe the LOs that they produced during the course of using the proposed metadata standards (IEEE-LOM). They are now looking forward to integrating the LOs produced during the course into their daily activities.

As for the future, a more formal and quantitative evaluation of the methodology's use is planned to help in improving and enhancing it.

SECTION 7

CONCLUSION

This paper focused on the learning aspect of including the LO paradigm in an ISD-based methodology for the design of e-learning instruction. The major concern was with the LO semantic, which is better expressed when the design of instruction is grounded in sound pedagogical principles.

The proposed methodology does not follow a constructivist perspective *only*, but does incorporate elements from this school. For example, it is flexible, so that an LO may have, as an attribute, a behaviorist learning objective or a constructivist goal dynamically established by the learner. It also permits some learner control on the sequence of instruction and the use of collaborative and problem-based practices.

An eclectic approach to learning theory was proposed for designing LOs, so that valid principles from each school can be taken advantage of in the face of a broad target audience.

It was shown that how, using a top-down model, the different pedagogical dimensions are embedded in the proposed ISDMeLO methodology. The concept is that principles from each of the major learning schools (behaviorist, cognitivist, and constructivist) can be combined in creating and sequencing successful e-learning modules based on LOs.

Surprisingly, many researchers consider that constructivism is the solution for learning, relegating behaviorism and cognitivism to second place. It is important to note, however, that all theories have a place and their usage can be complimentary rather than mutually exclusive. That is why the authors believe that an eclectic approach is better than just assuming that constructivism, as advocated by recent researchers in education, is always the preferable solution to learning. As stated in Doolittle, & Camp (2002), five important criticisms are made relative to social and radical constructivism: (a) knowledge does not have to necessarily be obtained through active *discovery* learning; (b) not all knowledge is contextualized as constructivists promote; useful knowledge is often abstract and de-contextualized; (c) direct practice, although regarded by constructivists as artificial and non-motivational, is actually beneficial to skill acquisition; (d) whole and authentic activities are not always necessary for knowledge construction, as constructivists consider, rather practicing a part of the whole may be more beneficial to knowledge construction; (e) not all learning must take place in social situations.

This indicates that there is a need for diligence in applying constructivist approaches. Disappointingly, some radical researchers assume that constructivism can be applied to every educational situation, disregarding its context and ignoring the historical success and the contributions that the previous schools have made to learning in the last century. After all, what would have happened to mankind if previous researchers had not contributed their ideas to the learning process? By taking advantage of all the schools´ principles, the authors advocate a middle ground approach to designing instructionally sound LOs. As stated by Marti, "People are not machines and do not live in isolation from the real world. Neither can students be left entirely on their own to haphazardly find/not find what is important to grasp in a particular learning situation. Guidance is still needed" (Marti, 1997): Learning Theories: Constructivism and Behaviorism. Arizona State University [Online]. Available:

http://seamonkey.ed.asu.edu/~mcisaac/emc503/assignments/assign4/marti.html (was retrieved in January 2004).

Finally, the authors believe that the main value of this work relates to the human assembly of learning objects. Many researches in the literature are oriented to the LO automated assembly. However, the majority of the data available on the public Internet is learning content that does not easily fit into automated systems (USU, 2004). In order to achieve a greater educational impact using LOs, one must consider their manual reuse. The aim of this methodology is to guide instructional designers in the production of e-learning content while reusing available LOs and generating new LOs to be reused by others.

This work, which is also a contribution to the PGL Project, is underway in the Database Technology Lab (TecBD) at Pontificia Universidade Catolica do Rio de Janeiro (PUC-Rio).

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