Applying Learning Theory in the Design of Learning Objects

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PUC-RioInf.MCC19/04 June, 2004

Abstract: 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 if there is one best learning theory for instructional design using learning objects (LOs). Depending on the learners and situation, different learning theories may apply. We do not recommend one particular theory for the design of instruction based on LOs. We, rather, suggest the adoption of an eclectic approach to learning theory in the design of LOs. In this work, we give an overview of the ISDMELO methodology, which incorporates principles from different learning schools and give an example of its application. The proposed methodology is currently being experimented by K-12 teachers from public schools as well as instructional designers from private companies in Brazil.

Keywords: Instructional Design; Learning Object; Instructional Systems Development, Learning Theories

Resumo: Instructional System Development (ISD) é um conjunto de procedimentos para se projetar e desenvolver de forma sistemática a instrução. É essencial que a aplicação de ISD seja embasada em teorias de aprendizado. Uma possível pergunta a se fazer consiste em qual seria a melhor teoria de aprendizado a ser aplicada no design pedagógico usando objetos de aprendizado. Dependendo dos aprendizes e do contexto, diferentes teorias de aprendizado podem ser indicadas. Não recomendamos a aplicação de alguma teoria específica, mas sim uma abordagem eclética no uso de tais teorias, quando do projeto pedagógico usando objetos de aprendizado. . Neste trabalho, uma visão geral da metodologia ISDMeLO é apresentada, a qual incorpora princípios de várias escolas de aprendizado, e um exemplo de sua aplicação é mostrado. A metodologia proposta está sendo experimentada por professores de escolas públicas, bem como por projetistas instrucionais de empresas do setor privado no Brasil.

Palavras-chave: Design Pedagógico, Objeto de Aprendizado, Desenvolvimento de Sistemas Pedagógicos, Teorias de Aprendizado

1. INTRODUCTION

The future of educational technology is now calling for renewing traditional instructional models [1]. The basic concept lies in the possibility of reusing the same pedagogical content in different instructional contexts.. Therefore, instructional content designed independent from context in an object-oriented programming environment can now be shared with other users, recombined with other objects, or redesigned by other instructional developers with possible time and cost savings.

In our previous work we focused on the structural aspects of LO [2]. We proposed that a methodology based on ISD incorporated the LO paradigm. The idea was that we should have a systematic approach to developing instruction rather than an *ad-hoc* one. ISD is rooted in the Information Systems area, although applied to the educational arena. Similarly, the object-orientation paradigm, which also originates from 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 now the main focus of this work. This means that a LO should have the right semantic of learning. A thorough understanding of what is "learning" becomes crucial. To this end, it is imperative that a methodology to design educational contents based on LO be grounded in learning theories.

Depending on the context and the audience nature, a more general approach seems to be more useful than a specific one. We propose an eclectic approach to learning theory so that pedagogical principles from different learning schools can support the methodology. Our experience with the PGL (Partnership in Global Learning) project , where our audience encompasses a variety of profiles of users reinforces that an eclectic approach to theory seems to be more adequate**.** As stated in [3] learners have different orientations: they can be transforming, performing or conforming learners. This requires different strategies, and, therefore an eclectic methodology could be considered the middle path between standardization and personalization.

In the literature, we find many definitions of a learning object. As defined in [4] and, as considered by many authors, LO can be seen as a small "chunk" of learning content which 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, they may constitute lessons, modules or courses. In this paper we consider LOs as structures similar to what is proposed in [5]. How they should be assembled in a collection is up to the instructional designer or to the student. But on what basis these decisions should be made? Learning theories describe how learning occurs while instructional theories prescribe the best way to design instruction to foster learning [6]. Different schools prescribe different strategies, but we believe that all have valid principles, which are applicable to LO.

This work aims at proposing an eclectic approach to learning theory in the design of instruction for e-learning modules. To this end, we show how principles from different schools were incorporated in the Instructional Systems Development Methodology based on e-Learning Objects (ISDMELO). This methodology is aimed at the design and development of educational content to be delivered via the Web. We use a top-down-model approach where we find pedagogical dimensions in different layers of abstraction. This model is useful to show how our methodology is grounded in sound pedagogical principles. This methodology is being developed in light of the requirements of the PGL Project [7]. As part of this project, a multimedia e-learning oriented distributed database system is being developed to serve as a LO repository in the PGL environment [8].

The remainder of this paper is organized as follows. In Section 2, we mention the importance of the fundamental of learning theories for the design of instruction based on LO. Following this, Section 3 gives an overview 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. In Section 5, we show how to apply the ISDMELO methodology in the design of LOs for a business course. 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.

2. OVERVIEW OF LEARNING THEORIES

In this section we give a brief description of three major learning schools and present a top-down-model, which helps in the analysis of the application of pedagogical principles in our methodology. We conclude it with an analysis on what theory is best to use.

2.1 The Three Learning Schools: Behaviorism, Cognitivism and Constructivism

A learning theory encompasses principles which aims at explaining changes in human performance, providing a set of instructional strategies, tactics, techniques to select from and the foundation for how and when to choose and integrate the strategies. Furthermore, it predicts the results of the use of the strategies [9].

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. We will see in Section 5, the use of these practical guidelines in the design of LOs.

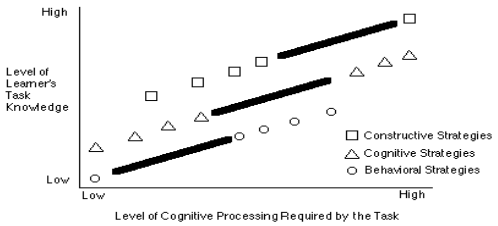
The primary focus of the *behavioral* perspective is on behavior and on how the external environment shapes the individual's behavior. As such, the primary responsibility of the instructional designer is to identify and sequence the contingencies that will help students learn. Teachers should then state the objectives of the instruction as learners' behaviors. Learning is inferred from behavior, so it is important to identify the goal behavior, what involves 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. As a consequence, the instructional designer should organize new information for presentation, carefully linking new information to previous knowledge. He/she has also to 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 [6], we find a suggestion on the application of each school principles which considers the learner's knowledge level and the complexity of the subject to be learnt.

Although Figure 1 presents some criteria for the application of learning theories, we believe they are not mutually exclusive. For example, an instructional designer may define clearly an expected behavior from a learner (*behaviorist* perspective) while she can establish 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

2.2 Learning Theories Framework

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

In [10], a top-down-model is shown in which pedagogical dimensions are imbedded in different layers of abstraction. See Figure 2. The 4th (highest) layer of abstraction is normally referred to as paradigm or as way of teaching,

learning, thinking and designing. Behaviorism, Cognitivism and Constructivism are major approaches. The 3rd layer of abstraction can be considered as a set of underlying principles. The 2nd layer of abstraction refers to instructional models and theories which are guidelines or a set of strategies. The 1st layer of abstraction contains content, practices and activities. This layer describes what is done and to be learnt as well as which resources are actually used.

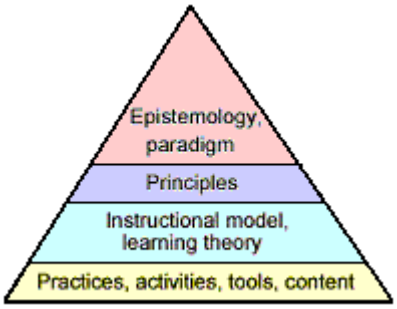


Figure 2 – Top-down-model

Based on the top-down-model, decisions which are made at a higher level of abstraction affects the more basic levels. So, our objective is to show that the instructional strategies and practices recommended by our methodology are grounded on sound pedagogical principles, following the top-down-model. In order to make it clear, the tables found in Section 4 show examples of its application. Nonetheless, in the next section we will discuss what theory is best to be used in the design of LOs.

2.3 What learning theory is best to be applied in ISD using LO?

Just like the behaviorist and cognitivist, the constructivist theories take on a variety of forms. The basic distinction is that while behaviorists viewed knowledge as an automatic reaction to external factors in the environment, and, the cognitivists considered knowledge as abstract representations in one's mind, the constructivist school views knowledge as a meaning built by each learner through a learning process. Knowledge can thus not be transmitted from one person to another, it will have to 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, to Radical and Social Constructivism. In [11], Constructivism is described as a continuum and is classified in three broad categories: Cognitive, Radical and Social. The Cognitive Constructivism focus on the construction of mental structures that function effectively within a reality which is already known. The Radical Constructivism focus on the student's personal understanding and the mental model he or she creates for the problem solving process. The 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.

The authors make an analysis on the learning theory underlying the curriculum and pedagogy of career and technical education. They point out that that Behaviorism has been in place during the last century and that Constructivism should be considered to prepare workers to entry in an environment which demands increasingly higher order thinking, problem solving and collaborative working skills. These features are not addressed by Behaviorism. They examine if 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 conceptions which seem to be of value for particular educational settings. Some principles may be useful to almost all situations, such as 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. It is possible, therefore, 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 the learning theory: the knowledge level of learners and the amount of thought and reflection required by the learning tasks. So, if the student has little knowledge about the subject, behaviorist strategies will benefit him. As he acquires more knowledge, the emphasis may shift to cognitive

and then constructivist principles. The same is true when the amount of thought and reflection required by the learning tasks increases.

We would, however, consider another important factor when deciding which approach to use in a particular educational setting: learning orientation. As mentioned in [3], learning orientation recognizes the impact of emotions and intentions on learning. There are learners who are naturally active while others tend to be passive. So, there would be not point in adopting a constructivist approach to learners with no initiative to learn or who do not feel comfortable with autonomy. As it happens with employees, there are learners who do not need to be told what to do, while others can not move, except if a command is given and if they are monitored. So, while choosing a given strategy, one should bare in mind the following learner orientations: Transforming (Innovators), Performing (Implementers) and Conforming (Sustainers) [3]. 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 for achieving 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.

As we are aware, Constructivism encourages and accepts learner autonomy and initiative, sees 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 learning. On the other hand, Conforming learners need structured and low risk environments and, as such, behavioral strategies would appear to be more adequate. Finally, Performing learners prefer semi-complex, semi-structured environments which could be attended by cognitivist practices. Although we recommend that learner orientation be considered for the adoption of a given instructional strategy, it does not mean that other factors should not be taken into consideration.

To finalize this section, we would like to stress that these three learning schools are equally important and no single learning theory provides complete prescriptions for the entire design process. We believe that by adopting an eclectic approach, we can benefit from all learning schools and at the same time meet better the needs of our target audience.

3. A METHODOLOGY TO DEVELOP e-LEARNING MODULES BASED ON LOs: ISDMELO

In this section we present a summary of the ISDMELO methodology [2], which is based on the general method named ADDIE, which includes the following phases: Analysis, Design, Development, Implementation and Evaluation [12]. It is important to mention that it is oriented to a by-hand assembly of learning objects by an instructional designer. In the end, we present some of known good practices which should be observed while applying the suggested methodology.

3.1 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 with the audience early in the ISD process, so that based on the user feedback, the design can be revised and another prototype developed. It goes until the prototype is considered satisfactory.

Phase I. Analysis

This phase is aimed at analyzing what is the learning problem and determining the learner profile. Data gathered during this phase are important to make sure 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 be familiar with the learner characteristics by analyzing the motivational, technological, demographic profile of the LO user. Items such as age, grade, educational background, etc. should be considered. The application of learning style models [13] 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, which should be corrected. In the 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 DB environment for existing LO: If a LO is found and meets the learning needs, then one should consider to use it. It may need to be repurposed or can be reused as is.

I.4 Conduct an Environmental Analysis: One should consider if an instructor would lead the instruction, if there is a Learning Mgmt System (LMS) available 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 LOs interface.

This phase generates the following outputs:

a) Task Analysis Document
b) Content Analysis Document
c) Sequencing of LOs (Conceptual Map)
d) Metadata
e) Storyboards of LOs 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 decompose it into sub-objectives, in such a way that a tree is generated showing pre-requisites sequences to be followed.

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

II.3 Identify LOs structure: Based on the tree generated by the task/content analysis, one should now chunk the content into a structure of LOs. This chunking, which will generate a new tree of LOs, should observe the following design principles [1]: (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 minimum of 3 and a maximum of 7 items be combined in a given LO. The minimum is due to cataloguing expenses and the maximum is due to the capacity of short-term memory [14]. In the resulting structure the LOs at the bottom level are categorized as "Atomic LOs" (ALO), as they will not be further decomposed.

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 we recommend the one prescribed by the Elaboration Theory. It uses the concept of epitome, progressive differentiation and reconciling integration, by advocating a top-down approach [15]. 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, a LO at elaboration level ***n*** would combine between 3 and 7 LOs from the elaboration level ***n+1***. Some LOs will be smaller while others will be larger, since they will be composed by LOs from a higher elaboration level. It should be noted that this approach to sequencing allows learner control what is in line with the constructivist perspective since the learner is not supposed to follow pre-requisite sequences which may be boring to him.

II.5 Categorize LOs: After identifying the LOs, one should now assign a category type to them. We use the one proposed in [16] and [5]. At the bottom level, each LO has to do with 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 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 own goals dynamically. For example, when using a LMS, the system could hold different learning objectives from which the learner would choose a specific one.

II.7 Model the user for the LOs' interface design: The data gathered during the analysis phase should be useful to help determine the profile of the user interface.

II.8 Carry out user task analysis: This focus on the tasks the user will perform with the LOs.

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

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

II.11 Design the interface "feel": The site topology, navigation and interaction tasks and other interface components should be chosen following sound interface design principles. Internationalization and globalization 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 LOs' interfaces. It is important to consider the consistency of the LOs' 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 DB 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, observing copyright laws. To reuse and repurpose LOs 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. The policies and procedures of the environment should be complied with.

Phase IV. Implementation

This phase is aimed at delivering the instruction to the user.

This phase generates the following outputs:

a) LOs within a 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 among different LMS environments or delivery the instruction via a Web site.

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

IV.3 Create a management plan: One should plan for the most effective delivery of instruction. This is particular important for instructor-led delivery. For self-paced 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 a 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) LOs adjustments or deletion from the repository
b) Changes to specific attributes of LOs
c) Verification if 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 try out LOs on a selective group prior to their delivery and make adjustments accordingly.

V.2 Conduct *summative* evaluation: As part of LOs, there are pre and post assessments that will determine if the learner is meeting the learning goals. One should also consider the impact the instruction is having on the institution vis-à-vis its mission and strategies.

Based on the evaluation done, the LOs should be updated accordingly.

3.2 GENERIC GOOD PRACTICES

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

3.2.1 Capturing and Using Appropriate Metadata

Metadata are descriptions of data. As we are aware, LOs need to be located and retrieved in order to be reusable. That is why we need to keep records, which will allow instructional designers or students to find and use them from a repository. 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 that we consider important and were captured during the testing of the methodology by k-12 teachers are (see Section V): 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 [17]

3.2.2 Tying Instructional Goals to Business Practices

In the corporate context, one basic and very important issue, before the development of e-learning modules, is to ask whether it is the solution for a performance problem. For example, if sales of a given product have decreased, it is necessary to determine the reasons for this. By carrying out a needs analysis, one can diagnose the causes for a performance problem witch can be due to lack of motivation (e.g.: sales personnel consider that their salary and wages are low for their level of responsibility), lack of operational conditions (the information system which supports the sales are normally down) and lack of knowledge (a new product was introduced, and the sales personnel

are not acquainted with their characteristics). Only in the last case, a e-learning module will be a solution for the performance problem. Clearly, in the first two cases, the development of a e-learning module will be a waste of time and money, since the problem needs to be addressed from other perspectives. So, tying instructional goals to business practices are fundamental for the organization's success in e-learning.

3.2.3 Creating and Applying Success Metrics

It is important to verify the contribution the module developed is returning to the business. We find in the literature many evaluation models [18]. The Level Four of the well-known Kirkpatrick Model [19] addresses specifically the business impact of the educational program. Following the example provided above, one educational program's success metric would be to measure change in sales volume after some time the program was attended by the sales personnel.

4. THE "LEARNING" ASPECT OF LO IN THE ISDMELO METHODOLOGY

In order to understand the learning aspect of LO in the ISDMELO methodology, let´s use an example produced during the DMeLO course referred to in Section 6, which allows us to see the influence of the three basic learning schools (*Behaviorism, Cognitivism, and Constructivism*).

Our example encompasses 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, it is detected that employees are not aware of how to control operations in compliance with the rules established by the company. As such, the major learning goal 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 which will be taught at the course and which the staff should comply with. By the end of the course, the learners should be able to control the activities under their responsibility in conformance with the company´s policies and procedures.

4.1 Behaviorist Aspects

Considering the top-down-model presented above, we verify the following *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 course´s goal is to enable the learner to comply with established procedures, as prescribed by the behaviorist approach, the learning goals 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 to perform as required. This will be the basis for the content chunking into LOs. Additionally, the learning objectives will be a LO property rather than a result from the interaction between the learner and the information. However, the assessment does not need to include necessarily objective tests (such as multiple choice) to test the learner.

4.2 Cognitivist Aspects

Considering the top-down-model presented above, we verify the following *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 advance organizers • Capacity of the short and long-term memories • Content chunking into meaningful parts

Given the broad and diverse audience of the course, we will assume that it may include transforming, performing and conforming learners. Thus, the learner will be given control to follow the sequences which seem to be more appropriate to him; however, some fundamental pre-requisite requirements must be observed and the use of advance organizers, summarizers and synthesizers will help him in not getting lost. The use of analogies and metaphors will be applied to help in the assimilation of information as well as links to prior knowledge.

4.3 Constructivist Aspects

Considering the top-down-model presented above, we verify the following *constructivist* aspects:

Highest Layer	Constructivism
3rd Layer	Learning is a change in the meaning constructed from experiences
2nd Layer	Problem-Based 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

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 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 scenarium 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 made and the learner could reflect on how much he/she learnt.

In essence, eclectic LOs were designed. They were behaviorist in what 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; the learners and no rigid assessments determine the instructional direction. Bearing in mind that each particular theory will be more useful depending on the context, an eclectic approach is recommendable, such as Reigeluth´s Elaboration Theory [15] used in phase II.4 of the proposed methodology. The learner can be introduced to the main concepts of a course and then move on to more of a self directed study that is meaningful to him and his particular context, in line with a more constructivist view.

5. THE "OBJECT" ASPECT OF LO IN THE ISDMeLO METHODOLOGY

Let's now look into the "object" aspect of LO in the ISDMeLO Methodology. Following the example provided in Section 4, we will develop this section focusing on the Design phase of the methodology. Since the design of content is our focus, 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 decomposed 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**".

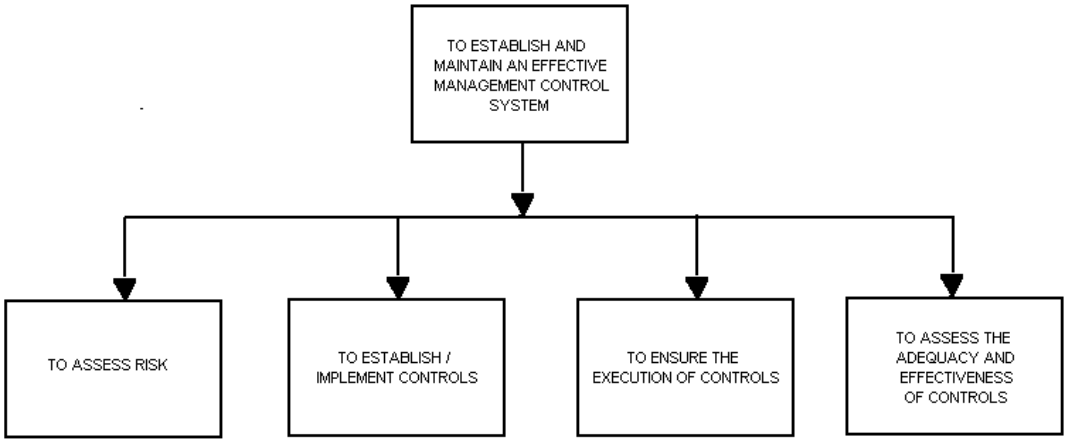


Figure 3 – Task Analysis

2. Conduct a Content Analysis: "**To Assess risk**" can be further decomposed into: "**To Identify risk**", and "**To Classify risk**". As per this analysis, the following contents should be provided to the learner: risk concept, how to identify risk, business output categories, business risk categories and risk levels. The Figure 4 illustrates this structure.

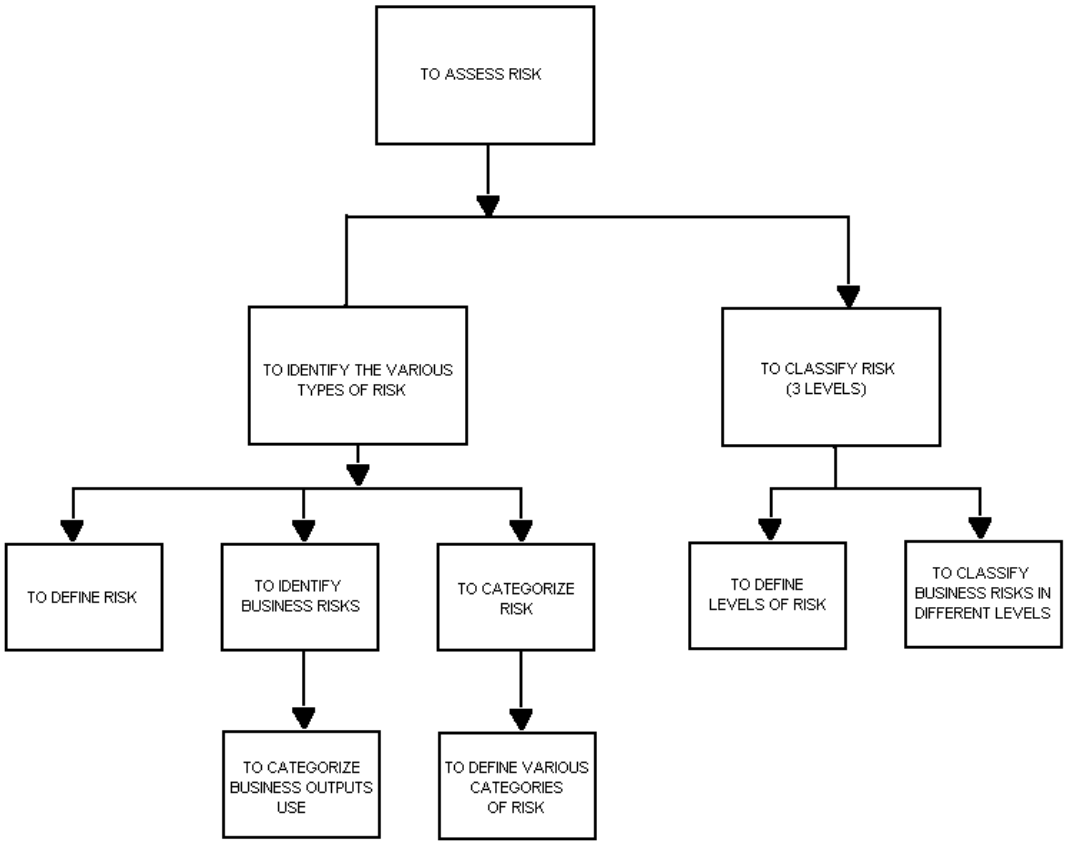


Figure 4 – Content Analysis

3. Identify the LOs structure: Once the tree of learning tasks/objectives is generated, one should follow the design principles (stated in item Section III) and generate a tree of LOs. Here one would come up with combined LOs and ALOs. It should be noted that this tree (Figure 5) is often different from the one generated in items 1 and 2. One good rule to be followed while chunking content into LOs is: How many ideas about a topic can stand on their own and can be reused in different contexts? In [23], the author stresses that conceptualization is a key phase in designing LOs in order to maximize its reusability.

Figure 5 shows the LOs and ALOs which compose the major course's objective, "**To establish and to maintain an effective management control system**". 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.

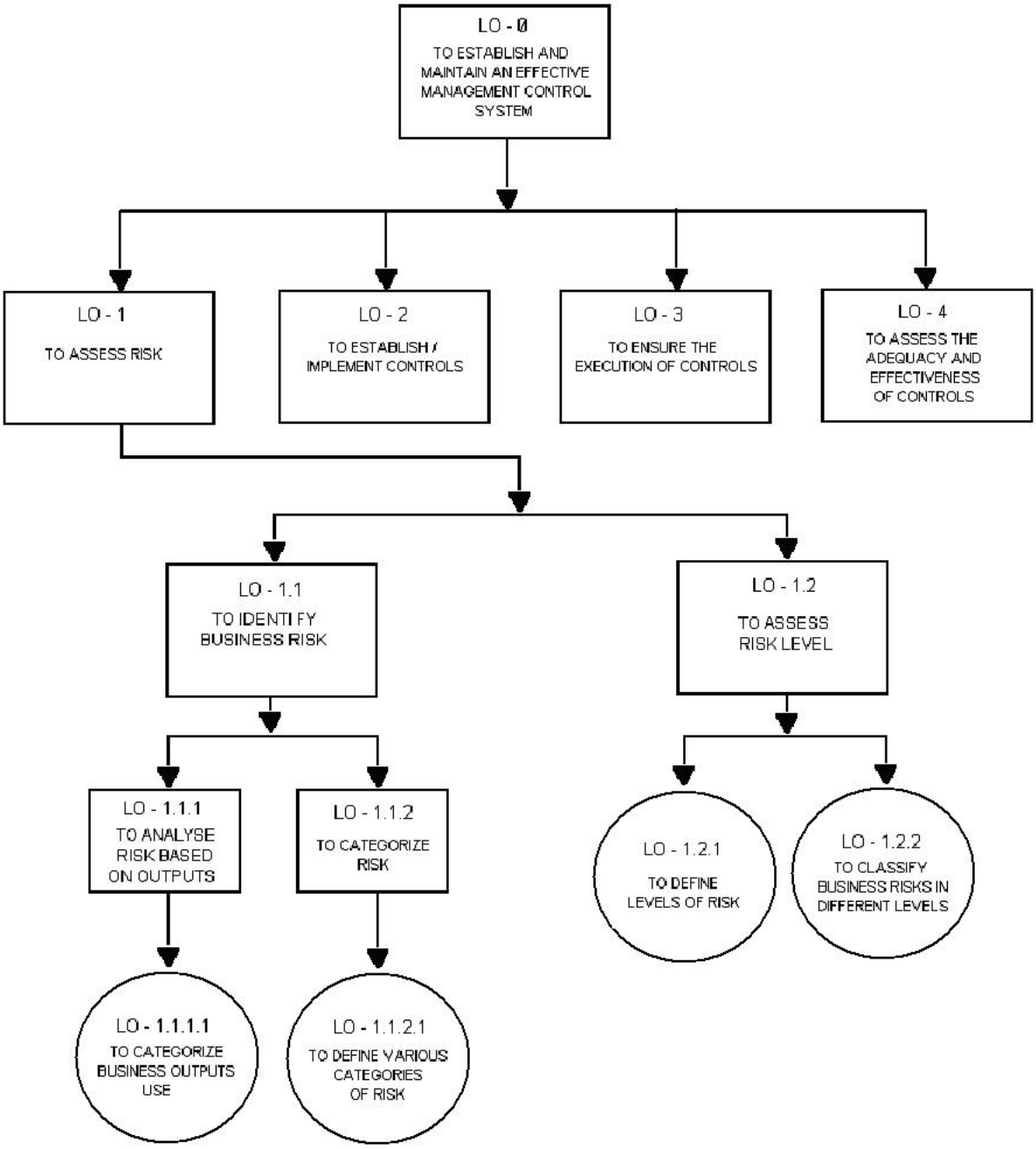


Figure 5 – LOs Tree

4. Establish the sequence of instruction: Since we are following the Elaboration Theory, it means that an epitome would be presented first to the learner. So, it would give an overview of the 4 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 would be presented and only then the second one, more details and further complexities will be presented as we go to higher elaboration levels. 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 he goes 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: We will take as an example, LO 1.1.2, "To Categorize Risk", which will have the following attributes:

- **Learning outcomes:** The student should be aware of the company's business risk categories and classify each situation 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, learner reflection;
- **Example:** Examples were provided based on real or authentic situations within the company;
- **Practice:** A case study was used 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, problem solving

6. EXPERIMENTING THE METHODOLOGY – CASE STUDIES

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

The methodology proposed in this paper enhances the first version mainly with the emphasis on the LO paradigm. This new version was tested in another course – DMeLO [20] - given to K-12 teachers and employees from the human resources department of private companies. They produced 5 modules as follows:

- Controls Awareness Program (used as example in Sections 4 and 5)
- Water shortage
- Urban Trash
- Air Pollution
- Hydreletrical Factory

In order to facilitate their work, a Html template was made available. The complete documentation is kept on-line following the steps given by the methodology. The LOs 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 a very useful tool to plan instruction. The great majority was willing to present it to the Board of their schools in order for them to adopt it. Although each teacher may have his or her own style, they found that, a method to systematically plan instruction is really helpful to guarantee that learning needs are met. They 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 more training from them. In general, they considered that it was relatively easy to follow the methodology but they were a bit confused about using the metadata standards to describe the LOs that they produced during the course. They are now looking forward to integrate the LOs produced during the course into their daily activities.

For future work, we are planning to make a more formal and quantitative evaluation on the methodology´s use to help improve and enhance it.

7. CONCLUSION

In this paper we focused on the "learning aspect" when including the LO paradigm in an ISD-based methodology for the design of e-learning instruction. Our concern was related to the LO semantic which is better expressed when the design of instruction is grounded on sound pedagogical principles.

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

We proposed that an eclectic approach to learning theory be used when designing LOs, so that valid principles from each school can be taken advantage of in face of a broad target audience.

We also showed, using a top-down-model, how the different pedagogical dimensions are embedded in the proposed ISDMeLO methodology. The idea 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 a second plane. It is important to note, however, that all theories have a place and their prescriptions can be complimentary rather than mutually exclusive. That is why we 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 [11], five important criticisms are made to social and radical constructivism: (a) knowledge does not have to be, necessarily, obtained through active "discovery" learning; (b) not all knowledge is contextualized as constructivists promote; useful knowledge is often abstract and decontextualized; (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 along the last century. After all, what would have happened to mankind if the previous researchers had not contributed their ideas to the learning process? By taking advantage of all the schools´ principles, we advocate a middle path approach to design instructionally sound LOs. In line with [21] "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".

Finally, we believe that the main value added by our 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 data available on the public Internet are learning contents that do not easily fit into automated systems [22]. In order to achieve a greater educational impact with LOs, we have to consider their manual reuse. The aim of our methodology is to guide instructional designers in the production of e-learning contents 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 PUC-Rio.

ACKNOWLEDGEMENT

The authors would like to thank the TecBD people at PUC-Rio who actively participated in the discussions. This paper was partially supported by CNPq Brazil – Brazilian National Research Council and the PGL Project.

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