The Various Stages of an Instructional Systems Development Methodology for e-learning Modules

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Abstract

This paper reports the efforts which have been made towards a methodology based on e-learning objects for the development of PGL modules. The Partnership in Global Learning (PGL) Project is an international initiative to produce web-based educational modules for the corporate and academic sectors. In its earlier stages, PGL was focused on the k-12 education. A number of workshops to enable k-12 teachers in the design of e-learning modules was run as part of the PGL mission. In this work, we show the efforts towards a PGL methodology by analyzing the changes on the workshop programs along the last three years. We then describe how the ISD (Instructional Systems Development) and LO (Learning Object) technologies can be utilized for the design and development of PGL modules. The proposed methodology (ISDMELO) is grounded on sound principles from learning theories. This methodology is currently being tested at PUC-Rio by a group of k-12 teachers from public schools and instructional designers from the private sector.

1. Introduction

1.1 Motivation

Suggesting that the ISD process is no longer relevant is equivalent to suggesting that engineers forget about design drawings or that systems analysts forgo data flow and process diagrams [1]. ISD is modeled after similar systems methodologies used in professions that are based in design sciences which share the following characteristics: (1) systematic process that involves stages of planning, development and testing; (2) scientific and technical principles in the design of products and (3) products designed to be functional and appealing to users.

However, a new trend is shaping the future of educational technology [2], which calls for the revisiting of traditional instructional models. The fundamental concept is that the same instructional content may be usable in different instructional contexts. Therefore, instructional content designed as context-independent chunks in an object-oriented programming environment can be shared with other users, recombined with other objects, or redesigned by other instructional developers with reasonable expectations of time and cost savings.

There are numerous definitions of a learning object, but it is basically a small "chunk" of learning content that focuses on a specific learning objective [3]. The learning objects can contain one or many components, including text, video, images or the like. LOs may be seen as building blocks that can be combined in nearly infinite ways to construct collections that might be called lessons, modules or courses [4].

Instructional Design refers to the process of instructional program development from start to finish. Many models exist for different levels of instructional designers and for different instructional purposes; however, we will consider the general method named ADDIE, which includes the following phases: Analysis, Design, Development, Implementation and Evaluation [5]. In our methodology we show how LOs are created

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along the phases of the ADDIE model, using principles from the behaviourist, cognitivist and constructivist theories.

1.2 About PGL

The Partnership in Global Learning (PGL) is an international initiative aimed at producing technologically enhanced and distributed learning on a global scale. One of its main objective is to design and deliver state-of-the-art curricula in science and business fields in web-based format that will be distributed through state of the art technology [6].

As such, the PGL mission is to build an international university/corporate alliance to promote and share e-learning in the areas of k-12 teacher training, university teaching and research, and corporate training.

[7] The role of PGL is to form a network of educational institutions with the purpose of (1) capacity building in e-learning; (2) design and implementation of an e-learning infrastructure; (3) implementation of an e-learning infrastructure; (4) institutionalizing e-learning as a viable research teaching and training area within universities in the Latin American region; (5) establishment of a standard of production for e-learning tools and applications.

In line with PGL role, the implementation of the PGL environment will allow that content produced be stored and used/shared by all PGL users. The multimedia learning object database that is in the core of this environment will be more than distributed repositories of materials. Teachers will be able to access the system to obtain information, pictures, graphics or learning objects to fit their curriculum needs. The tools associated with the database will allow teachers to select information about topics (learning objects) in which they are interested and update and adapt this content to fit their needs. These tools will allow teachers to query the databases and fastly create web pages based upon the topics selected.

We need, however, a sound methodology that can facilitate the creation of educational contents as learning objects to be stored in the multimedia heterogeneous database for future reuse.

With this concern in mind, this paper was written to propose that a methodology based on the ISD and LO technologies be adopted by PGL users in order for them to create learning objects which satisfy the following attributes: modularity, independence, portability among applications and environments, nonsequentiality, ability to be repurposed, coherency and cohesion within a predetermined schema and ability to be adapted to audiences beyond the target audience [8].

We show in Section 2 the efforts towards a methodology that could be used for developing e-learning modules. In Section 3, we show examples on how principles from different learning theories have been incorporated into the proposed methodology, so that LOs can be generated based on an eclectic approach. Section 4 then gives an overview of the ISDMELO methodology with its phases, outputs and procedures. Section 5 presents our conclusions and indicate future work.

2. Towards a PGL Methodology

We describe below the PGL efforts in searching for a standard process for the design and development of PGL modules. The first meeting held in Miami by the Administrative Committee set the tone for the production of PGL modules. The last

meeting held in the University of Florida by the instructional design team generated the last version of the PGL methodology – i.e. – the 9-Step Development Process.

2.1 PGL Administrative Meeting in Miami (August, 2000)

At this meeting, a content development strategy was established. It was agreed upon that k-12 teachers should be trained in applying a development process for the production of web-based contents. They should be able to: (1) transfer from a traditional model to an e-learning module ; (2) identify and apply the PGL process development and (3) create awareness/advocacy for e-learning/globalization benefits [9].

The idea was to promote the PGL brand which called for a common "look-and-feel" of modules, supported by advanced technology platforms, where contents would be shared observing cross-cultural issues. The modules produced during the workshops should conform to PGL standards.

While the focus was web-based content development, this should be supported by a variety of technologies, including satellite and video-conferencing. The "integrated e-learning model" developed by Lucent Technologies would have allowed to apply media selection criteria for different types of learning modules, as well as a sophisticated e-learning platform (Bitroom) which offered many interactive teaching-learning features, including voice over IP, synchronous classroom discussion, a smart whiteboard, web access etc.

Teachers should be selected for the PGL project on the basis of their computer literacy, school administrative support, interest in participating in an international e-learning program, and infrastructure support at participating schools.

The primary focus of content development was to support science and math education in secondary schools. Secondary content in the first phase of PGL included international business, business and technology in the new economy, and inter-cultural communications in global business development.

Following the workshops, attendees were supposed to finalize the module production, after approval through a request for proposal, at their schools and submit it to PGL.

In order to verify the path towards a PGL standard process, we need to refer to the workshop programs in which it is documented. From one workshop to the other, the process was reviewed and refined.

2.2 1st PGL Workshop at Unicamp (February, 2001)

The 1st PGL workshop program encompassed the following topics: (1) Training overview: PGL Goals/Objectives and PGL Brand; (2) Regionalization vs Globalization: Cross-cultural issues, language etc; (3) Technologies Media: Web based, Satellite, CD ROM, Synchronous/Asynchronous; (4) Instructional Design: Analysis (audience, needs etc), Design (Content and Measurement), Development (Techniques and Activities), Implementation (Training for Delivery) and Evaluation Techniques; (5) Course Production Standards; (6) Interactive Techniques; (7) Implementation; (8) Tools (Powerpoint, Shockwave, Flash, AdobeAcrobat, FTP, Bulletin Boards, HTML, Conversion Methods, collaborative learning environments).

Some observations on the workshop:

- too much emphasis on technologies was given at the expense of instructional design issues;
- the course was aimed at k-12 teachers but a number of procedures which apply to the corporate sector were taught;
- k-12 teachers were not able to learn fast authoring tools (such as Flash, Dreamweaver etc) to produce the modules;

- a group of instructional designers from the core universities was established to streamline the process, focusing on the design issues;
- the traditional ADDIE model was used.

2.3 2nd PGL Workshop at PUC-Rio (August, 2001)

The methodology taught at the 2nd workshop was more focused on the ADDIE phases. A number of technologies which were part of the previous program were not included here. Only four content production tools were taught at this seminar. The time devoted for producing contents was enhanced and attendees spent much more time in the lab compared with the previous workshop.

The following workshop program applies: (1) PGL Process Overview; (2) Audience Analysis, (3) Lesson Design; (4) Media Selection; (5) On-line Design; (6) Storyboarding and Web-Mapping; (7) Assessment Techniques; (8) Tools: Dreamweaver, Photoshop, Flash and (9) Review Guidelines for Module Development.

Some observations on the workshop:

- despite the time allocated to lab work, it was felt that k-12 teachers were still not able to perform as implementers of their own modules;
- a lot of emphasis was still given to media selection since sophisticated media selection tools were presented;
- storyboards were introduced as a means of specifying the module´s screens sequence and their "look-and-feel";
- the traditional ADDIE model was used.

2.4 3rd PGL Workshop at ITESM (February, 2002)

Prior to this workshop, the PGL administrative committee had decided that the next PGL workshops should be run at a distance. To this end, the instructional design team reviewed the methodology and developed a CD-Rom which was used during a pilot test in Mexico.

The workshop program encompassed the following topics: (1) The PGL Module – Analysis: Media Selection, Process, Tools and Audience Analysis/Motivational Profiles; (2) Design: Lesson Design, Pre-requisites, Learning Objectives; Module Range/Structure; Storyboards; Information Design; (3) Development: Storyboarding and Tools (Dreamweaver, Photoshop and Flash); (4) Evaluation: Summative, Diagnostic and Formative.

Some observations on the workshop:

- the CD-Rom based PGL workshop should have included more interactivity;
- tutorials were provided on authoring tools (such as Dreamweaver, Flash etc), but time has not been devoted to teach the attendees these tools;
- multimedia storyboards were introduced and the topic on interface design was removed;
- the hands-on activities were to finish with the design of multimedia storyboards;
- some module implementation was made with the help of instructional designers and specialists from the core universities;
- the traditional ADDIE model was used.

2.5 PGL Instructional Designers Meeting at UF (March, 2002)

At this meeting, PGL development process was reviewed and 9 steps were established for the design of PGL modules. It was considered that PGL modules could be a

complete lesson in itself or be used as complementary to a lesson delivered in face-to-face classroom.

The instructional design team decided not to use the ADDIE instructional systems design model and designed the steps that the PGL teachers would need to go through. The program was intended to provide an introduction to the tools and techniques required to transform content for web-based learning. It was designed to make teachers aware of the opportunities for enhancing learning on the web; it was not intended to make teachers web implementers.

[10] The 9 steps are as follows: (1) Select a suitable Topic for e-learning: Relevance, Importance, Size and Focus; (2) Define the Learner: Knowledge Levels, Learning Styles, Motivational Profiles and Computer Access; (3) Outline the Module: List content, Collect and organize content, Plan Learning Strategies, Present Content and Plan Learning Objectives and Assessments; (4) List Resources: Search Strategies and Tools; (5) Plan the sequence of activities: Writing for the Web, Designing a Site and Planning Navigation; (6) Outline the Module Sequence: Making a Web Map and Selecting Web Map Styles; (7) Prepare the Storyboards; (8) Select Implementation Tools: Software Applications and Tools Selection Criteria; (9) Plan for Implementation: Producing the online module, Obtaining more Web tools training and Integrating module into curriculum.

The CD-Rom with the last version of the PGL Development Process is still to be released.

Some observations on the proposed methodology:

- k-12 teachers were to be able to design e-learning modules and supervise its construction by a web implementer;
- attendees are supposed to know the PGL criteria for a well constructed module;
- the learner profile has been enhanced to include elements from the Silverman Model
- the methodology should incorporate the LO paradigm

2.6 PGL Administrative Committee Meeting in Miami (October, 2002)

At this meeting, [11] PUC-Rio proposed that the 9-Step Process incorporated the LO paradigm because: (a) a state-of-the-art methodology should be in line with the LO paradigm which is shaping the future of e-learning [2]; (b) the infrastructure devised for the PGL environment will be a multimedia distributed database of e-learning objects; (3) the adoption of the LO approach would allow for the reusability of PGL modules and future cost and time savings.

The analysis of the 9-Step Process vis-à-vis the LO paradigm contributed to the search of the ISDLO methodology. A reflection on the 9-Step method made us consider how to rescue the ADDIE model which was traditional in the first workshops. We verified that it could be enhanced by the practical suggestions of the 9-Sept method with a more comprehensive view of the LO approach. Most importantly, it should be grounded on sound pedagogical principles.

In the next section, we propose that the PGL methodology be grounded on eclectic pedagogical principles.

3. The Importance of Learning Theories Fundamentals

3.1 Learning Theories Framework

A sound methodology for designing and developing PGL modules should be grounded on principles from important learning theories.

In [12], a top-down-model is described in which pedagogical dimensions are imbedded in different layers of abstraction. See Figure 1. The 4th (highest) layer of abstraction is often 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, contains 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 learned as well as which resources are actually used.

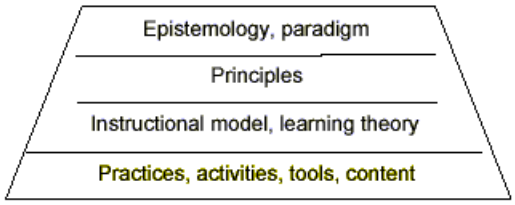

Figure 1 – Top-down-model

The top-down-model makes it clear that any decision which is 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 table below shows examples of its application.

3.2 How the proposed methodology incorporates pedagogical principles

Following the top-down-model presented above, the ISDMELO methodology contains the following elements, for example:

Highest Layer	Behaviorism	Cognitivism	Constructivism
3rd Layer	Learning is inferred from behavior; it is important to identify the goal behavior	Learning is described as a change in knowledge stored in memory	Learning is a change in the meaning constructed from experiences
2nd Layer	Gagné´s Learning Hierarchies Theory	Elaboration Theory	Problem Based Learning
Basic Layer	Task Analysis	The use of advance organizers	To pose good problems to students

We believe that each school has valid contributions and, as much as possible, principles from each of them can be combined in creating successful learning objects. As we find in [13], students have different learning orientations. For example, Conforming Learners prefer to follow and try to achieve simple, task-oriented goals assigned by others. As such, learner control, which is advocated by constructivists, would not be necessarily effective. So, preferred learning styles are also of relevance for choosing an instructional approach. Therefore, we propose that PGL adopts an eclectic approach.

The next section gives an overview of the ISDMELO.

4. An Overview of the ISDMELO Methodology

We present below the ISDMELO´s phases and outputs [14]. It is important to mention that it is oriented to a by-hand assembly of learning objects by an instructional designer.

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
e) Metadata

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 [15] are 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.
- **I.5 Keep Metadata**: All data gathered during this phase should be used to generate the metadata according to standard metadata, e.g. IEEE-LOM.

Phase II. Design

This phase is aimed at designing the instructional content and the "look-and-feel" of the LOs´s 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´s 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 should observe the following principle: After defining the hierarchical tree of learning objectives, it is recommended that a minimum of 3 and a maximum of 7 items be presented at each elaboration level for a given aspect of the epitome. The minimum is due to cataloguing expenses and the maximum is due to the capacity of short term memory [16]. Therefore, 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.
- **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 [17]. 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.
- **II.5 Categorize LOs**: After identifying the LOs, one should now assign a category type to them. We use the one proposed in [18] and [19]. 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.
- **II.7 Keep metadata on content design**: All data generated during this phase should be used to create the metadata according to standards, such as the IEEE-LOM
- **II.8 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.9 Carry out user task analysis**: This focus on the tasks the user will perform with the LOs.
- **II.10 Find a metaphor**: A metaphor will make the interface more intuitive. One should however pay attention to cultural issues.
- **II.11 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.12 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.13 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.
- **II.14 Keep metadata on interface design**: All data generated during this phase should be used to create standard metadata, e.g. IEEE-LOM

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.
- **III.5 Keep metadata**: Metadata on technical aspects will be issued in accordance standard metadata, such as the IEEE-LOM

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.

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. One should consider whether learning is best accomplished in a self-paced or collaborative or instructor-led fashion.

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

5. Conclusion

In this paper we showed the various stages the PGL development process went through during the last three years. The lessons learnt from each workshop have provided valuable input for the last version composed of 9 steps. As for the last PGL methodology version, the ADDIE model was abandoned. With the ISDMELO methodology we not only rescued the ADDIE model but we also revisited it to incorporate the LO paradigm and sound pedagogical principles.

We believe the following contributions were made by the present work:

1) it serves as a memory of the efforts towards a PGL methodology for the design and development of e-learning modules;
2) it proposes that an eclectic approach should be used for the design of e-learning modules;
3) it suggests that the ISDMELO methodology, which was summarized here, be used as the next PGL methodology, in light of the future of the PGL environment envisioned by the recent PGL researches.

The ISDMELO methodology is currently being tested by a group of k-12 teachers and instructional designers from the private sector. As future work, we intend to refine the methodology based on the results of this experiment. This work, which is a contribution to the PGL Project, is still underway in the Database Technology Lab (TecBD) at PUC-Rio.

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