Measurement of Resources and Investments to Develop Digital Learning Objects

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Abstract

The present research aims to evaluate digital learning objects architecture and build metrics – based on analyze of the financial, administrative and software engineering aspects – to define a prevision of the necessary investment to develop digital learning object. To develop some metrics it was necessary an online survey research with professionals that works with digital learning objects development. The study of the answers and some theoretical approaches of instructional design, software engineering, and learning objects characteristics turned possible create a Web application in Java that provides a prevision of the initial investment for the development of digital learning object. This program is based on the definition of a methodology that considers activities and professionals involved in the process and the execution time of each stage of digital learning object development in a dynamic way.

Keywords: learning objects, metrics, software engineering, methodology, measure investments.

Introduction

The world's economics activities did not do without investments in computer support, represented by relevant investments in technological infra-structure and software development. While the machines production have their engineer methods being implemented with constantly improves in productive process, the software industry are looking for ways to adoptee methods that make possible to foresee the necessary investment and the financial return of the project.

As a result, the impact of software in society and culture implies to develop technologies that make easy and fast the development of high quality programs. Some of these technologies are specifics, according to application, for example, the project and implementation of web pages (Pressman, 1992).

Something that has to be considered in the development of these learning objects is the measurement. Nowadays, there are some difficulties to project the resources and necessaries investments to plan and develop a learning object. Some problems are related with lack of parameters, variables, and specifications to classify the variables by its importance. In this context, looking for parameters and classify then by the attribution of weights, these variables allows more approximation of the necessary investment, getting real

values or close to them to develop the project.

According to this, the present article exposes the result of a research that was based on the identification of activities and metrics that make possible the ascertainment and analysis of the necessary investment to develop learning object in a digital format.

The document is organized as follows. The sections about learning object and measurement of elements presents the theoretician elements that are the base to the research. After this, are presented the used methods, gotten results and the analysis of them. All things considered it is exposed a proposal of application for the estimate prevision of the investments necessaries to develop a digital learning objects. Finally the last section treats about the conclusion and further works.

Learning Objects

The use of Internet makes possible the availability of different materials including learning objects in digital format. The use of learning object involves the build of small instructional components that can be reused in different educational contexts. Additionally, the learning objects can be understood like digital tool available on Internet (Wiley, 2000b).

To understand the learning object concept is necessary to understand the definition. In accordance with Rumbaugh, Blaha, Premerlani, Eddy, and Lorensen, (1991), an object is an entity of the real world that has an identity. According to this, objects can represent concrete entities (an archive in the computer, a bicycle) or conceptual entities (a game strategy, one politics of scheduling in an operational system).

Although objects have proper existence in the real world, in terms of programming language an object needs an identification mechanism. This object identification must be unique, uniform, and independent of object content. This is one of the mechanisms that allow the creation of object collections, which is also an object itself.

Besides that, one of the object-oriented's characteristic is reusability, that makes possible the use of an object in other systems and the instance of the same program without redo it.

In accordance to this definition, the object-oriented concept can be applied to learning objects when determined content or subject is divided in parts, which are equivalents the objects in the software engineering. When all these parts are joined, a course is formed (or didactic unit) equivalent to a system. These separated parts permit the reuse of objects in new courses or new systems.

Considering this, learning objects can be characterized since a simple notation in a document, figure, map, or even simulation. With the Internet, the availability of these learning objects in digital format became possible – some examples are online courses, digitalized media, and maps, among others. Learning objects are components that, separately or in set with others, form a specific material that will be used in the learning process, being able to be reused in diverse structures.

The IEEE (Institute of Electrical and Electronics Engineers) defines learning objects as *"... any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning"* (IEEE LTSC WG 12, 2003). Despite, this definition of learning objects can be more delimited when considers only digital entities (Wiley, 2000b) with content characterized by metadata.

Likewise, the learning objects, as object-oriented, has some characteristics that make possible the identification, some of them are: usability, reusability and granularity.

The usability is related with the use of the learning object developed. For examples, it is necessary to verify the consistence of graphics interfaces, colors scheme and the object presentation keeping the visual of each object consistent in each scene, giving a appropriate title to a session or page, use a limited number of colors and fonts styles (Smith, 2004). The second characteristic of a learning object is the reusability, which means the reuse of a component in different contexts without any change in the content. It predicts, for example, a reduction of the investment in the development of distance education courses. The concept that learning objects can be used in different contexts without a new investment is related with the reusability and granularity of the educational material (Downes, 2001).

Learning Objects Measurement

To develop this research was used measurement engineering software techniques to determine a methodology to the development of digital learning object. The measurement can be applied to the software process to assist the estimate, the quality control, the productivity evaluation of the project resulting in a reduction of the cost and investment (Pressman, 1992).

However, these metrics cannot be considered a separate way. These metrics have to be associated to the project concept. For a project manager, it's necessary to have a real notion about the cost of the software implantation, considering also the parameters related to the total cost of the project. These parameters are inserted in a context that is represented by financial, human, technician and strategic factors that permit manage the project.

For this management, concepts related to administrative area with knowledge application, abilities, tools, techniques and strategies related with the project activities can be used to make possible reach the final result and optimize the use of resources. With these parameters is possible to integrate the process of the project management: initiation, planning, execution, monitoring, control and closing.

In this way, the processes constitute the base of the software projects management control and establishes the context that methods are applied, the work products (models, documentation, data, and reports) are produced and the elements of the control are established to assure the quality and modifications adequately (Pressman, 1992).

With this architecture is also possible to use the financial concepts to determine the fixed and variable costs related to the project. Finally, to develop a software it is necessary to use methods and processes that make possible to define the necessary activities to be executed during the product development.

According to Sommerville (2001) the software processes are related to some activities: software specification, software project and implementation, software validation, and software evolution. Amongst the existing models can be distinguished the Linear Sequential Model (Waterfall Model), Spiral Model, and ADDIE Model (applying to development of didactical materials).

The Waterfall Model (Sommerville, 2001) involves a sequence of five structured activities chained (the beginning of each activity depends on conclusion of the previous stage). Some disadvantages of this process are related to the definition of all requirements at the beginning of the project, and the development in a sequential approach.

The Spiral Model, proposed by Bohem (1988) combines some aspects of the Linear Sequential Model and Prototyping Model (Pressman, 1992) some stages of the spiral cycle are: definition of objectives, evaluation and risks reduction, development and validation, and planning. This proposal presents some advantages as the possibility of higher integration among software development stages and the improvement until finalization of the product.

According to Baruque et al. (2003) the ADDIE Model is structured with follow stages: analysis, design, development, implementation, and evaluation. The adaptation of this model to learning objects (Mustaro, Silveira, Omar, & Stump, 2007) articulate the activities because the product of each stage is used in next step and can be revised in other stage.

Methods and Results

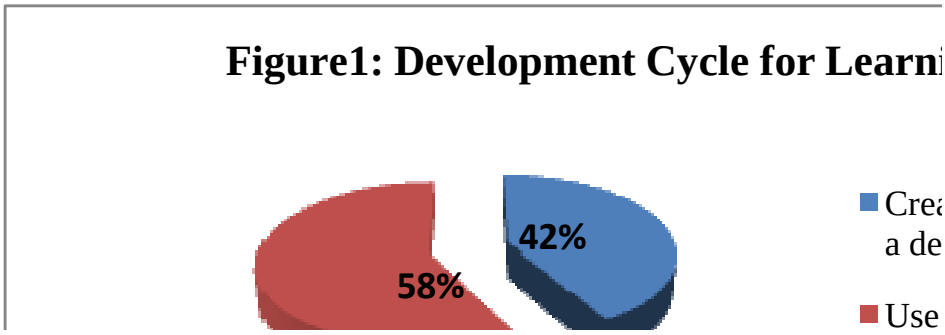
Using different areas concepts, described above, a survey was developed and sent for professionals that work with educational development. This collection instrument get, as main objective, elements that make possible define a methodology and metrics for the measurement of the investment necessary to develop a learning object.

The survey was developed in PHP and was put up in storage data server. The database used was MySQL. These tools had been chosen because are free and make possible a web implementation.

The survey was consisted of open questions that allowed the description of the methodology to develop learning object in participants' projects. The questions were formulated to help in the definition of a development cycle, activities involved in the process, execution time, the professionals necessary in the project and the models of measurement adopted.

In the period of 30 days, 20 professionals answered the questions (40% Brazilian and 60% from others countries). With the analyses of the survey's answers, it was possible to identify the necessary information to define the methodology and formula was elaborated to calculate the necessary investment of a learning object's project.

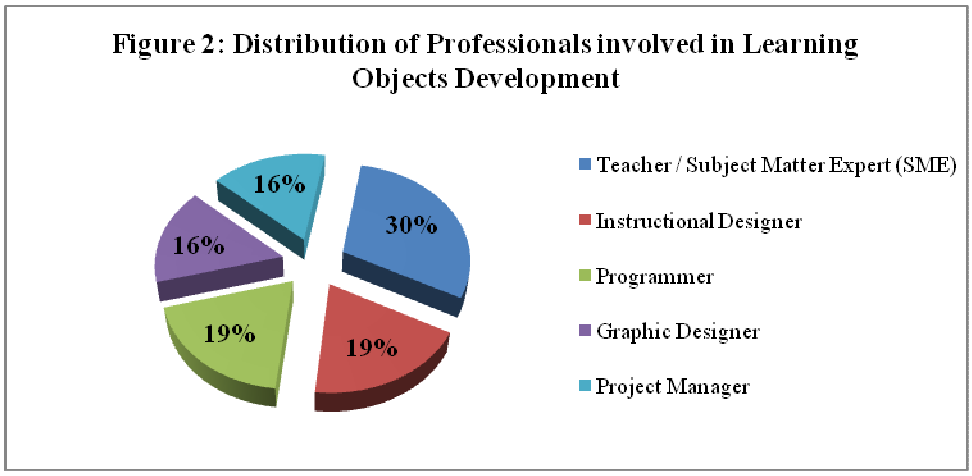
Other element observed in data analysis process was the difficulty to describe and define the necessary activities to develop a learning object. Because of that only 58% of professionals interviewed (Figure 1) had declared to use some development cycle.



Amongst the existing development cycles, the following ones had been cited in the answers: Cascade, Spiral, Prototyping, ADDIE, and RUP. In a complementary way, the professionals had to describe the essential activities in the development process of a learning object and to distribute them in the phases of the development cycle.

Beyond the activities, the survey also aimed to attainment of the execution time of the cycle development phases. In only two answers it was possible to identify a time percentage associated with the cycle phases. In both cases the percentage associate to the development stage was higher than the others, consuming around 50% of time required in development cycle.

Besides that, the survey answers also permits to collect information about tasks in each phase and professionals who are involved in development process of a learning object. The percentage of the professionals, in accordance with the answers, is presented in Figure 2.



Beyond the described professionals above, other people involved in the development process had been also cited in survey's answers: teacher education, authors, communicators, business analyst, and multimedia specialist. The data collection about professionals also referring its participation in the project activities what made possible the distribution of these in the development cycle phases of the considered model.

Finally, the last information, collected in this research, mentions the tools and languages used in the learning object development process: Macromedia Flash, C/C++, Visual Basic, HTML, PDF, Streaming Video, PHP, MySQL, XML, Java, Javascript, Photoshop, Flex, and JSP.

From the survey it was possible to verify the difficulty in getting answers related to learning object development process, especially in relation of the cost measure and getting an approach value of the necessary investment. Still thus, through the analysis of the answers, it was possible to define a development cycle to be applied to the development processes. This cycle is composed for existing elements in process ADDIE.

From this definition, the activities of each stage had been distributed, as well as the execution time, professionals and the cost/hour of these in the project development. With these variables was possible the determination of the final formula for calculation the learning object development cost.

Through the answers analysis, was verified that only 85% of the interviewed use some methodology to develop a learning object. Some of the methods described were Waterfall Cycle, Life Cycle and ADDIE.

The waterfall cycle consists in a sequence of activities well defined, being them, analysis and definition of requirements, system and software project, implementation and units' tests, integra-

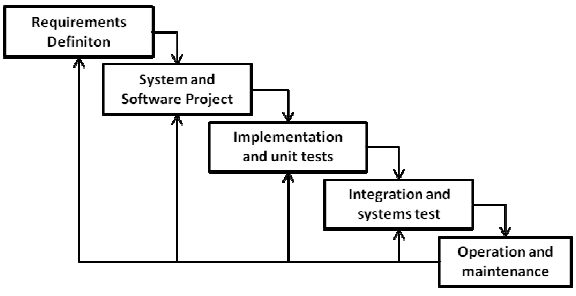


Figure 3: Waterfall model (Sommerville, 2001, p. 38)

tion and system tests, operation and maintenance to the development of the software (Sommerville, 2001). In this process, the activities are developed in a sequential way and all the system requirements have to be defined by the client in the beginning of the project (Figure 3).

The waterfall model is composed by the phases: objective definition, risks reduction and evaluation, development, validation and planning (Pressman, 1992). In this model (Figure 4), there is more integration between the phases of software development and the improvement during the stages until the final product.

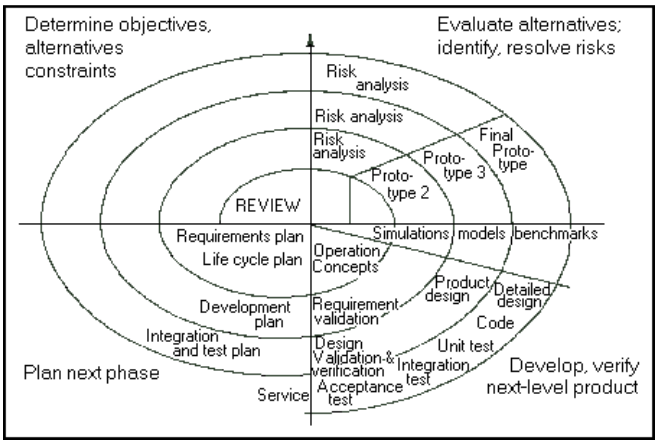


Figure 4: Life cycle model (Sommerville, 2001, p. 45)

The ADDIE model is composed by the phases: analysis, design, development, implementation and evaluation. In the following picture, it's presented an adaptation of this structure considering the learning objects feature.

Figure 5: ADDIE Methodology for Learning Objects Development (Mustaro et al., 2007, p. 268)

Analyzing the cycles described below, it was defined that the ADDIE model would be used as base to define the activities of learning object development process. This model was chosen because it is used in the instructional development and allow that the activities could be developed in a sequential or iterative way. All the product of one stage is used in the next phase or also can be sent to previous phase.

After this definition, were associate activities and essentials professionals in each stage of the development cycle. The Analyses phase means the definition of the learning object that will be de-

veloped. The activities identified in this stage are related to the subject, target public, goals of the learning object, definition of requisites, implantation plan, tests' specifications and the managements of the planning, resources and the project costs.

The design (Project) phase is related to the definition of all learning object characteristics that will be developed. In this phase, was identified the activities related to the content definition, creation of storyboards, scenes and screens, learning object prototypes and the elaboration of tests planning, medias definition and evaluation of the digressions and the revision of the project planning.

The development phase is related to the construction of the learning object using the definitions foreseen in the project. In this phase, it must be defined the activities related to the interface elaboration, media elements production, individuals tests and evaluation of the digressions and the revision of the project planning.

The implementation consists in turn available the learning object. In this phase the activities are: metadata addition, turn available de object in a repository, objects integration, integration testing and evaluation of the project.

Finally, the evolution – originally called in Mustaro et al. (2007) as evaluation – is related to the evaluation of the final product developed. The activities defined in this stage are: verify the requirements accomplishment, update the content, refinement of the architecture, tests verification, project costs evaluation, return of investments (ROI), and identification of improvements.

After the definition of these activities, it was proposal the professional allocation that have to participate in each stage of the project. According to Lopes and Casanova (2005), exist three teams involved in the project: Pedagogical (Pedagogical Coordinator, Instructional Designer), Technological (Computer Coordinator, Media Producer, Programmer), and Managemental (Project Manager). Considering this groups, the professionals defined for all the development cycle of learning objects was: Pedagogical Coordinator, Instructional Designer, Subject Matter Expert (SME), Programmer, Graphic Designer, Media Producer, Editor, Tester, and Project Manager. The Project Manager is the only Professional that integrates all the learning objects development cycle, being responsible for the project manage, planning the steps, the stages that will be involved in the development process, the time, resources and finally, identifying the costs and analyzes the final project.

With the definition of a development cycle and the activities involved in the process, it was also possible determine an effort percentage in each stage and the weight of each of them in the activi-

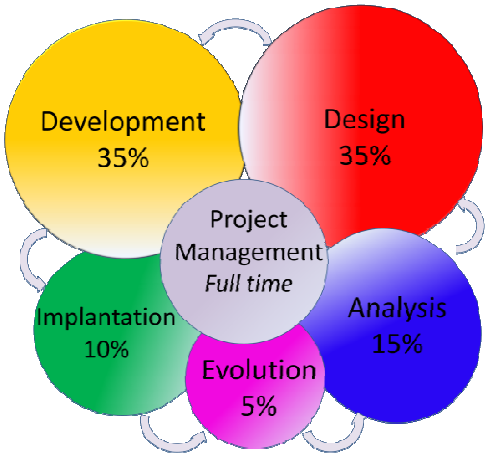


Figure 6: Effort distribution in the activities cycle

ties cycle (Figure 6). In this way, was defined that the design and development phases its necessary 70% of the time and professionals using in the project. In the analyze phase, 15% of the effort have to be used. To the last two stages, the implantation and evolution, the percentage are 10% and 5% respectively.

Associates with the activities and professionals necessaries to develop a learning object is the execution time, and the number of professionals in each phase, being able to be modified as the complexity of the project.

To calculate the final cost, beyond the value of these variables described below, it was determined using some market research (Luca, 2007), the average wage of the professionals. With this value it is possible to calculate, in each activity, the professional cost. This is gotten by the relation between the number of each professional, the quantity hours associate with the activity and the cost by work hour.

This calculates allows an estimate of the necessary investment for each phase of development cycle that added they generate an estimate value of the project.

Application for Learning Object Measurement

With the elaboration of this methodology, it was developed a Web application using Java that allows an approached forecast of the necessary investment to develop a learning object. Java was the language select to this application because presents portability, being able to be executed in any platform or equipment.

The Web application was developed with J2EE standards (Hurst, 2002). These standards divide the application in five layers: Customer Layer (User Interface), Presentation Layer (Getting User Solicitations), Business Layer (Application Logic Definition), Integration Layer (for access the Data Layer), and Data Layer (Application Database). The use of these standards represents advantages in the application modeling, allowing reduction of the implementation time, a better visualization of software functionalities, integration between the layers and information that are processed.

This application (Figure 7) was developed in a dynamic way, becoming possible the user modify the hours amount value to the realization of each activity, the amount of professional and costs

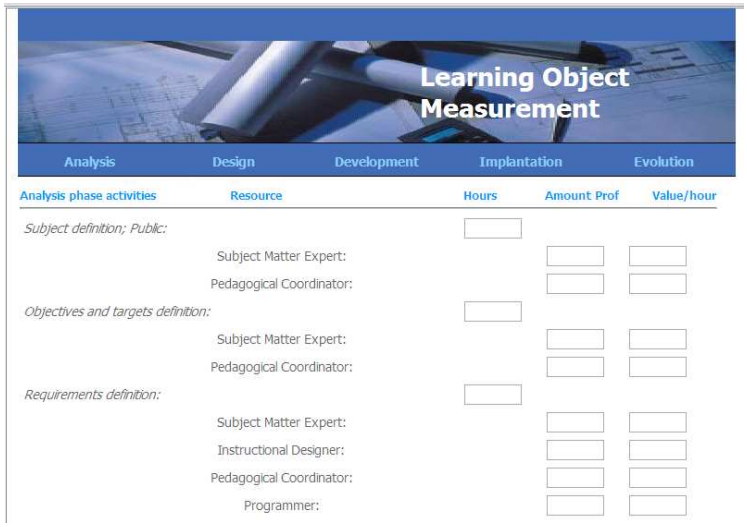


Figure 7: Application to measurement of investments for learning object development

associated, identifying the better distribution of the resources and time, getting a reductions of the costs involved in the project.

The user has to select the activity that wants to get the cost value and indicate the total time for the project execution. The calculation executed is the division of this total of hours in a percentage of execution time in the stages and activities relates to the development cycle.

Moreover the calculation, the use of this application allows identify a methodology of learning object development, related with the activities involved in the process, the time necessary for the execution and the professionals that have to be used in the development process.

Conclusions and Further Works

It was verified that the establishment of activities, methodologies, time execution, professionals involved and cost-hour to the final calculation of the investment necessary to develop a learning objects depends on the measurement of variables identified in different knowledge areas (software engineering, administrative, financial, and pedagogical). Associate with variables there is the also the weight concept that makes possible the dynamic adequacy of the calculation to allow the evaluation of different types of learning objects.

In a complementary way, the survey used in research had not only allowed the identification of some processes used by professionals related to development of educational software or tools but contributes to identify the professional difficulties to describe the process and attribute cost variables as a result of measure parameters lack.

Further works includes the survey of parameters related to the complexity of a learning object to complement the cost of the project. With the definition of a complexity table, the cost will be determined based on the object characteristics. In this way, will be possible the identification of different activities and professionals for each type of learning object. Another pertinent perspective is the aggregation of others variables in the project cost. These variables can be: materials used in the development process, software licenses, used energy, equipments, space, and so on.

With this research expects to contribute for the institution of methodologies that cannot only make possible the measurement of the investments related to a development of learning object, but also presents the professionals and resources involved in this process.

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Biographies

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