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DEVELOPING LEARNING OBJECTS USING THE GAIA METHODOLOGY: A CASE STUDY

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ABSTRACT

This paper will present the proposal of a process model for developing learning objects. It will describe in detail the entire life cycle of the proposed methodology, outlining how the pedagogical context operates into the development process. In addition, it will present a case study of a learning object to assist the skills development of spatial cognition and perception, which was developed using the proposed methodology. The developed learning object also introduces the Leap Motion®, a motion sensing technology for human-computer interaction.

KEYWORDS

Learning Object, Development Process, Project Management.

1. INTRODUCTION

Since its inception, the software has been an effective tool to assist the teaching and learning process in different fields of knowledge (Lerma, 2007). Within this context, an instructional technology called learning objects (LO) has been proved a valuable educational tool (Monteiro, 2006). According to Wiley (2000), a LO can be understood as any digital resource that can be used to support the teaching and learning process.

There are many methodologies for developing LO available in the literature (Fernandes, 2009). However, most of them are not appropriate for developing this type of instructional technology. Some methodologies present an approach more pedagogical than technical, while others approach only the technical aspects ignoring the pedagogical issues (Braga, 2012).

The development of a LO is a complex process because it involves the participation of a multidisciplinary team composed of educators, developers, testers, graphic designers and specialists of many fields of knowledge. These professionals must interact with each other in order to achieve the technical and pedagogical goals of these LO (Bond, 2008). Therefore, to develop a LO it requires the use of methodologies to organize the development process, the standardization and the communication between the stakeholders (Braga, 2012).

The structure of this paper is as follows: Section 2 presents the proposed methodology for developing LO. Section 3 shows a case study of a developed LO using the proposed methodology in order to evaluate and validate it. Finally, the Section 4 presents the conclusion and future work.

2. GAIA METHODOLOGY FOR DEVELOPING LEARNING OBJECTS

GAIA is a research project in Information and Communication Technologies (ICT) maintained by the Computing Department at Londrina State University. The research project provides a project factory services in ICT (GAIA - Solutions in ICT), in order to offers added value solutions and accumulated knowledge in ICT in the development of organizations. The research project also provides a software factory services in order to meet the internal demands of software from others departments at Londrina State University, to which a specific methodology for developing LO was created.

The GAIA methodology for developing LO is divided into four phases: inception, elaboration, construction and transition, while six processes: quality audits and configuration, treatment of nonconformity, corrective actions, change management, measurement and analysis and monitoring and controlling provide support to the project management, as can be viewed in Figure 1.

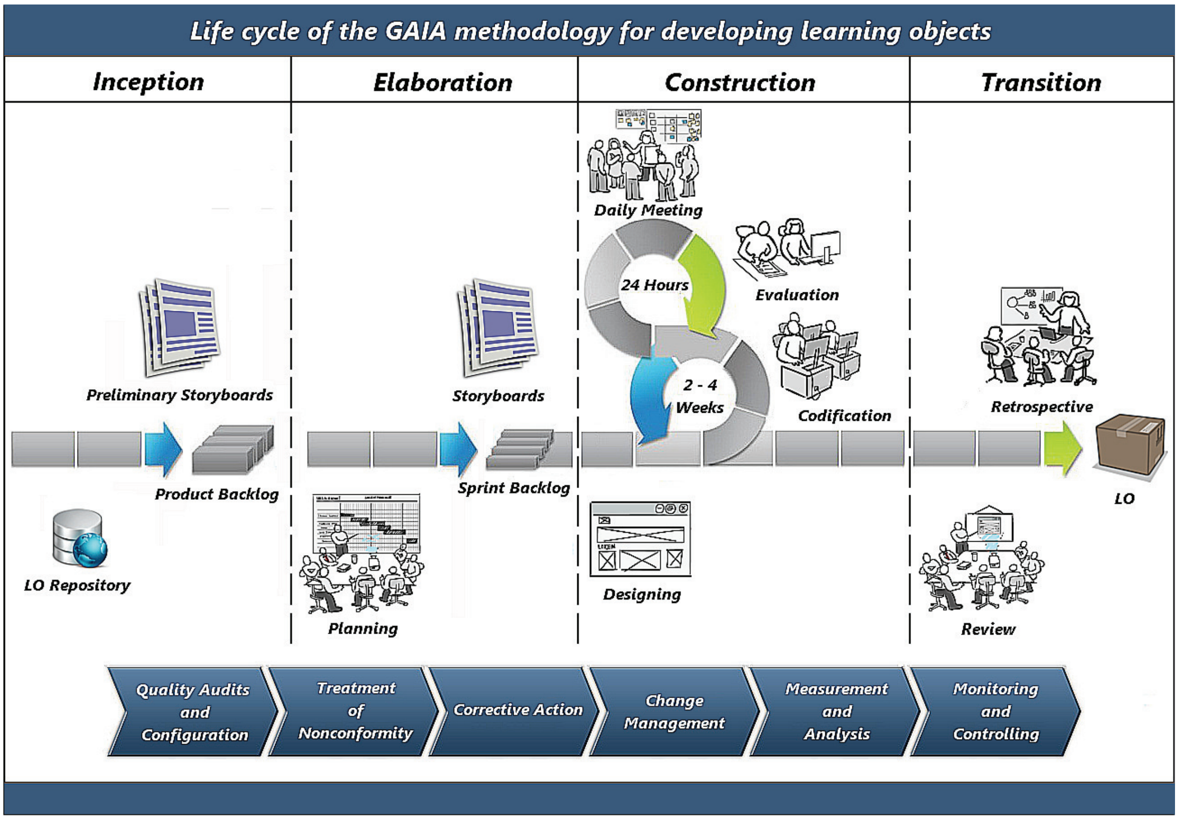

Figure 1 - Life cycle of the GAIA methodology for developing learning objects

The entire life cycle of the proposed methodology are described below:

2.1. Inception

Basically, the inception phase consists of identifying, organizing and documenting the requirements of the LO to be developed.

The first step of this phase is the identification of all requirements to develop the LO, which are based on the educational content provided by the subject-matter expert and on the problems and difficulties observed daily in classroom by all collaborators of the interdisciplinary research team. Related LO stored in repositories can also be used as part of the proposed LO or as example to assist its development only.

These requirements must be described textually or graphically in a preliminary storyboard, which will compose the product backlog. In this process, the product backlog is defined as a prioritized list, containing short descriptions of all desired functionality in the LO. However, the product backlog does not need to be entirely complete in order to start the development. The product backlog can be incremented and changed as the understanding of the LO and its target group increases.

At the end of this phase, it is expected to have a clear understanding of the problem and at least a basic understanding of the real needs of the target group in order to continue the other phases of the development process.

2.2. Elaboration

The elaboration phase consists of planning the activities of each project iteration.

During the elaboration phase the Sprint Planning Meeting occurs, when all activities of a Sprint are planned. In this process, a Sprint is defined as an iteration. Each Sprint should last from 2 to 4 weeks. At the end of each Sprint the project team should produce a potentially deliverable product increment.

In the first part of the meeting, the subject-matter expert and all collaborators of the interdisciplinary research team define the priority of the storyboards, perform the necessary adjustments in the Product Backlog, presenting their needs and what is expected from the iteration and establish a goal to the Sprint.

In the second part of the meeting, the project team breaks up the stories into tasks, estimates each of them verifying its viability of development. So, each team member selects the items (storyboards), which he/she will commit to, according to the estimates of each story.

Each day of a Sprint, the team does a brief meeting (usually in the morning), the Daily Meeting. The purpose of this brief meeting is to disseminate knowledge about what was done the day before, identifying impediments and prioritizes the work of the day about to start.

2.3. Construction

Basically, the construction phase consists of designing, codification and evaluation.

- **Designing:** The designing step is responsible for translate the vision of those involved in the development process into a prototype. The objective of this phase is equalizing the pedagogical and technical viewpoints, before starting the development process. During the prototype development, the designer interacts with the subject-matter expert together with all collaborators of the interdisciplinary research team to define the cognitive degree required of each activity, as well as the ergonomic factors, like usability, navigability and accessibility and with the technical team to treat technological issues of implementation.

- **Codification:** In the codification step, the development environment is prepared with all tools that best fit the needs of the project in question. After checking these items, the developers are allowed to start writing the source code based on the storyboards and prototype previously elaborated. At this level, write the source code means implementing new functionality, make adjustments or changes, fix bugs and also handle the integration between modules on the project.

- **Evaluation:** Two steps compose the evaluation process: the verification and validation tests. In the first step, we have the verification test that occurs throughout the codification of each functionality of the LO and includes the unit and integration tests, both conducted by developer, followed by the functional test conducted by test team. In the second step, we have the validation test that checks if the functionality was developed according to the didactic and pedagogical requirements previously established, considering ergonomic factors, like usability, navigability and accessibility. The validation test must be conducted by teachers and students, who will be guided by a script and also will be monitored by an evaluator that will register the reactions and acceptances of these users during this evaluation. When a bug or nonconformity is found during the evaluating steps, actions can be taken in the own iteration or be planned to the next iteration in a new story to correct them.

2.4. Transition

The transition phase is marked by the conclusion of the iteration or project. It consists of the following steps:

- **Review:** At the end of a Sprint, the team presents all functionalities of the LO that were developed in a Sprint Review Meeting. The Sprint Review is a meeting, where the team shows what has been achieved during the Sprint. During this meeting, the project is evaluated in relation to the goals of the Sprint, determined during the Sprint Planning Meeting.

- **Retrospective:** The Sprint Retrospective also occurs at the end of a Sprint. Its main purpose is evaluate what worked well during the Sprint, what could be improved and what actions will be taken to improve the next Sprint, so a continuous improvement cycle.

Still, at the end of a Sprint the team can establish that the LO was completely terminated. However, before feeding the repository with the new LO and close the project is necessary to incorporate the metadata to it.

2.5. Project Management

According to PMI (2008), the Project Management is the application of knowledge, skills, tools, and techniques to project activities in order to identifying needs, establish clear and viable objectives and balance the conflicting demands on terms of quality, scope, time and cost. Therefore, the follow six processes provide support to the project management of the proposed methodology:

- **Monitoring and Controlling:** The process of monitoring and controlling is responsible for monitoring, review and regulate the progress and performance of the project, identify all areas in which changes are required and start the corresponding changes.

- **Change Management:** The change management aims to ensure that any changes in the project are identified, registered, evaluated and communicated to all team.

- **Quality Audit and Configuration:** The quality audit and configuration process ensure that the project are adherent to policies, processes and procedures defined.

- **Treatment of nonconformity:** The treatment of nonconformity process identifies and documents items of nonconformity and ensures that they are corrected.

- **Corrective actions:** The corrective action ensures that the nonconformities are resolved.

- **Measurement and Analysis:** The measurement and analysis process involves gathering quantitative data about the product, process and project and analyzing that data to supporting actions plans and decisions in relation to the project according to organizational objectives.

3. CASE STUDY

In order to evaluate the effectiveness of the methodology presented in the previous section, a LO to assist the skills development of spatial cognition and perception was developed as pilot.

The developed LO consists in insert geometric objects with various cross-sections into fitting apertures through an object manipulation task. However, according to Örnkloo and Hofsten (2007), to fit an object into an apertures, requires understanding how the 2-dimensional aperture is related to the 3-dimensional object form. Finding this relationship requires visualizing or imagining different projections of the object. Planning the fitting action in a prospective and economical way also requires imagining how to rotate the object in order to fit it. These are rather sophisticated expressions of spatial cognition. They include mental rotation, as well as, the ability to imagine goal states and understand means-end relationships.

The LO was developed using the Autodesk® Maya® 3D tool for modeling all 3-dimensional components of the scene with the Game Engine Unity® 3D for the construction of the scenario, control and animation of the components on scene.

Using a device called Leap Motion® allows us interact with all components on the scene, using hands and fingers only. The Leap Motion® is a motion sensing technology for human-computer interaction. With two cameras and three infrared LEDs to capture detailed information, the sensor observes an area approximately hemispherical up about 1 meter with an accuracy of approximately 0.01 mm. The device detects the individual movements of the hand and fingers independently, while cruising the area observed.

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The Leap Motion® device can be viewed in Figure 2.

Figure 2 – Leap Motion®

The LO is basically composed by a circular transparent box with three apertures on the surface (circular, square and triangular), which can be viewed in Figure 3 and by three distinct geometric objects (cylinder, elongated block with a square cross section and block with an equilateral triangular cross section), which can be viewed in Figure 4. In order to avoid spatial variables, all geometric objects have equal length with the longitudinal axis distinctly larger than the cross-sections and their dimensions are 1 mm smaller than their respective apertures, precisely to allow its passage. Soon, each geometric object can be fitted in its corresponding aperture.

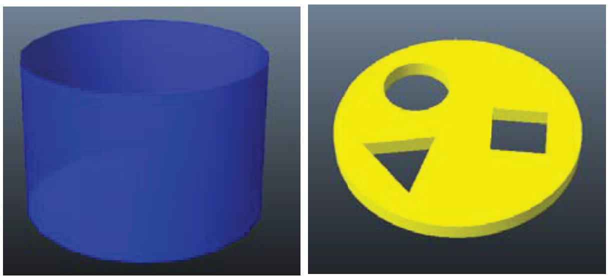

Figure 3 - The circular transparent box with tree apertures on the surface

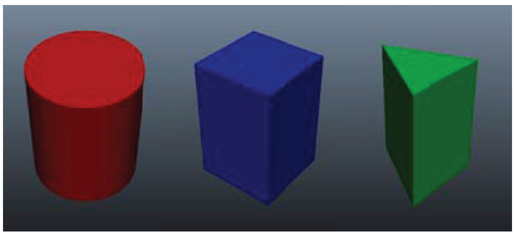

Figure 4 - The three distinct geometric objects

The cylinder can be fitted in every possible way in each of the two vertical orientations. While the elongated block with a square cross section can be fitted in four different ways in each of the two vertical orientations. And finally, the block with an equilateral triangular cross section can be fitted in three different ways in each of the two vertical orientations.

The fully developed LO can be viewed in Figure 5.

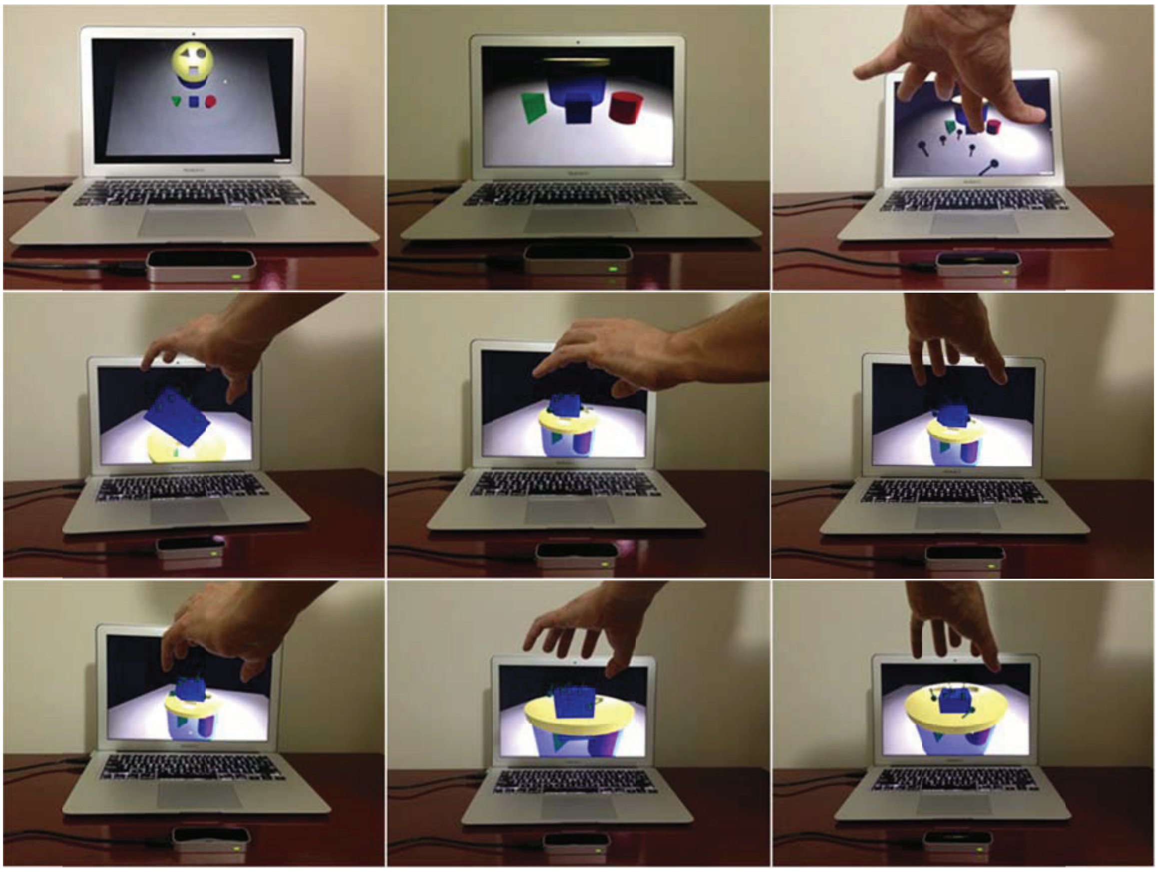

Figure 5 - The fully developed learning object

3.1. Data Analysis

Three items were chosen as metrics to evaluate the effectiveness of the methodology presented in the previous section through the developed LO. These metrics can be viewed in Table 1.

Table 6. Quantitative data analysis

Iteration	***Stories***				***Reworks***
	Planned	**Finished**	**Approved**	**Rejected**	
1	4	3	3	-	3
2	3	3	2	1	1
3	1	1	1	-	2

- **The effectiveness of the iteration planning:** This metric consists in assessing how much was finished from the planning in order to evaluate the effectiveness of the iteration planning. It is a way of measuring the success rate of the planning of each project iteration.

- **Percentage of approval of the iteration:** This metric consists in assessing how much of what was delivered was approved in order to evaluate the effectiveness of the iteration. It is a way of measuring the quality of each project iteration.

- **The rework average:** This metric consists in assessing the average of corrective actions to fix the nonconformities and bugs.

Analyzing the presented data, in the first iteration 75% of the planned stories were finished and approved, while in the second iteration 100% of the planned stories were finished but only 75% of them were approved requiring a third iteration in order to finish 100% of all stories.

In respect to the average amount of corrective actions were 2 by iteration.

4. CONCLUSION

The proposed methodology incorporates the basic concepts of the prescriptive methodologies with the best practices of the agile methodologies and also implements a set of practices in project management to ensure the consistency and standardization of the development process in order to increase the quality of the LO produced.

The case study allows us to evaluate the effectiveness of the proposed methodology through a quantitative data analyses, which indicate that the development process is constantly monitored and controlled, allowing a constant analysis of the progress and performance of the project in order to answer quickly to any deviation signal detected with corrective actions.

As future work, we plan to adapt the proposed methodology to the quality process model MPS.BR (Brazilian Improvement Software Process), that is the Brazilian solution compatible with the CMMI (Capability Maturity Model Integration).

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