Learning Object Design for Teaching Descriptive Geometry: A Study from the Perspective of Gamification and Accessibility

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Abstract. Technology has enabled significant advances in the distribution of information for education. With the Internet the information was available to the global context immediately through computer networks. To treat the contents and structure the information for education groups of researchers and developers worked to create groups of information entitled Learning Objects. This paper demonstrates the re-design of a learning object, in order to adjust it to criteria of gamification and accessibility. The methodological process consisted of: defining the project requirements and the structuring of a storyboard for the collaborative development of learning objects (Braga 2015b; Kethure 2010). Thus, the proposed interface incorporates playful elements for presentation of immersive and interactive content, so as to encourage learning also to people with disabilities, related to low vision, blind and deaf. In this sense, the objective of this paper is to present the process of developing a new interface for content learning about "Triangles and its characteristics" content, this treaty in Descriptive Geometry Course in the Graduate Graphic Design and Product. At the end of this document, we present the resulting learning object of this process, designed from gamification elements and affordability. The methodological procedure used as a base, collaboration in the development of learning objects, and includes: Concept Map, Navigational maps and Storyboard. Besides this, a Storyboard created to meet the needs of this collaborative development is presented. The paper presents a case study focusing on the use of Learning Objects to the teaching content of triangles in the university. The collaborative development process to redesign this platform featured a master's degree and two doctoral students of the Graduate Program in Design at the Federal University of Parana, and the project was prepared during the course of accessibility and gamification.

Keywords: Digital design · Gamified · Accessible learning

1 Introduction

Technology has enabled significant advances in the distribution of information for education. With the Internet, the information became available to the global context and accessed immediately through computer networks. In this context, new fields started to

be explored allowed by the maturation in research and development of learning objects and improvement of information sharing, like the gamification.

In learning objects the gamification explores the use of techniques, practices and tools that can promote information and immersion of the users. This approach may be useful to approximate the learning content of technological and digital world in which the students are insert.

This paper aims to present the process of remodeling a learning object and its contents, about the topic "Triangles and its Characteristics" subject of a lesson included in the Geometry discipline. The following sections of this document will explore the theme: Accessible and Gamified Development Process of a Learning Object (LO) for teaching geometric content. The LO was developed aiming it use by people interested in better understanding the triangles; such as regular education students and the general public; also considering, for its accessibility features, people with low vision, blind and deaf. Following is shown the LO result of this process.

The document closes, bringing considerations about the process of developing a Gamified Learning Object (GLO) proposal for learning triangles, and argues against literature review the role of LOs in the educational context and possible future developments such as the migration of these contents for mobile environments, such as phones and tablets.

Should be elucidate that will be considered in this document the learning objects only when belonging to the digital context. That statement must be clear because some authors and educational consortiums believe that learning objects can be observed both in the digital context as well in the physical, to endorse practices and teaching tools that enable reuse for educational purposes. Our focus in LO mainly comprises the digital environment with the objective to promote a better adaptation of the content for the needs of diverse users.

2   Methodology for Gamified LO Development

In the literature there is not a specific methodological approach to gamification in LO. Meanwhile, it is up to developers the best use of various tools for the design of educational elements that aims to implement aspects of games. The work of Manrique (2015), promote an overview of aspects of gamification that could be applied in the design of learning objects or other kinds of contents (Table 1).

In this document, the development of the gamified LO used as base, the INTERA Methodology presented in Braga (2015b), that integrates features of ADDIE (ADDIE - Analyze, Design, Develop, Implement), and also the set of project management knowledge (PMBOK). According to the authors, the INTERA Methodology (Intelligence, Educational Technologies and Accessible Resources) is iterative and considers the LOs development process as a project, and thus, contemplates the project life cycle.

The INTERA Methodology considered the following project components: *phases, roles, steps and artifacts*. In this document, we highlight the component steps of the methodology that are:

Table 1. Extracted from Manrique (2015)

Quest; mission with concrete objectives that leads to some kind of reward.
Experience Points; points that increase the player´s level
Virtual Goods; any kind of virtual item that can be bought in the game
Special Events; time-limited events that only take place once in a while
Social Area; areas that allow further social interaction
Epic Challenge; special challenge that is only up for pro players
Tutorial; learning process that develops the player´s initial skills
Progress HUDS; any type of HUD that shows the player´s progress
Customization; allows players to customize their virtual appearance
Access Item; special item that unlocks new content
Trading System; mechanic that enables an in game market structure
Vanity Item; rare items that represent skill / status
Levels; Mechanic that displays the player´s overall and current state
Badge; Achievement to be unlocked by special conditions
Equipment; Any items our characters have
Gifting; Collaborative mechanic that increases P2P
Social Ranking; Relative ranking focused on the player´s social graph
Chat Systems; Communication channels that allow social interaction World;   where   it   all
takes place within a gamified system
Absolute Ranking; standing that shows the top players of the system
Skills / Traits; mechanics that modify the player´s characteristics
Random Rewards; rewards that are randomly given a drop rate
Free Lunch; rewards achieved with other´s actions
Ambassador; game experts that act as mentor, developers or viralizers.
Avatar; a virtual representation of the player
Fixed / Variable Reward; rewards given by any kind of fixed or variable condition
Power-up; positive but limited effect on the player´s action
Easter Eggs; special secrets that are yet to be discovered
Party / Team; the more, the merrier.
Player vs Player; mechanic that allows direct competition between players
Lifejackets; give players some rest after difficult game levels
Relative Leaderboard; it show the player´s position relative to others of a similar rank
In-Game Currency; virtual or real currency that server as in-game money
Game Constraints; rules that keep the system stable
Guilds; Association of players for common purposes

- contextualization, which presents the theoretical base to be addressed
- requirements, demonstrates the accessibility requirements
- architecture, define the general layout of the LO
- development, are presented, the navigation maps and the screens and functions tests and quality, activities of verification and adjustments in the prototype
- availability, development of delivery document for programming the LO
- evaluation, later stage programming for final alignment of LO

To promote the accessibility we observed the guidelines presented in the thesis of Macedo (2010), the author introduces elements of accessibility related in documents of various entities that discuss the web accessibility. As the author points out, the guidelines "*observe international standards for the creation of learning objects of IMS and SCORM, associated with the standards of accessibility of IMS, the W3C WCAG 1.0 and*

WCAG 2.0, with the principles of universal design applicable to the development of digitized content". Briefly the guidelines proposed can be observed in the following Table 2:

Table 2. Acessibility guidelines - extracted from Macedo (2010), translated and adapted by the authors.

TEXT
- Solid color background.
- Colors changeable, noticeable without color.
- Transformation in textual pages.
- Structure and formatting.
- Graphics or sound to text equivalents.
TABLE
- Check that the reading will be done linearly through auditory means. Screen readers read line to line, continuously or in selected sections.
- Give clear identification of the table headings, headers, rows and columns.
- Introduce summary tables.
- If you have complex tables look divide them into simple tables.
- Do not use tables as formatting, content distribution or screen layout.
GRAPHIC
- Bar graphs, line graphs, pie charts can be converted into simple table.
STATIC IMAGE
- Media alternatives to the whole image.
- High contrast.
- Scalable.
MOVING IMAGE
- Alternative media, at least one option.
- Alternative text and / or equivalent text for any video or at least for the most relevant parts.
- Title or description of the image subject.
- Possibility of monochrome display.
- Sound and image synchronized when.
- Audio, when, without background sound.
AUDIO
- Legend, caption or complete description.
- Translation in sign language.
- Visual alternative text.
- Volume control, pause, on / off all the relatives.

In this LO was not included accessibility for blind users, this restriction was due to the project scope and digital media in which this content would be displayed.

3 Contextualization

The context is the issue to be addressed in the LO project. This document has been selected a layer of content that deals with understanding of the triangles and their characteristics. This project used as a base reference for design and content a PUCPR (Pontifical Catholic University of Paraná) LO that was no longer in operation by changes in web browsers support of operating applets (Fig. 1).
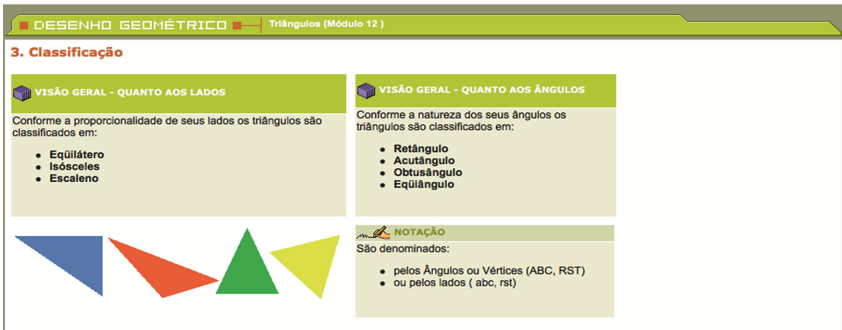
Fig. 1. Base LO – screenshot from the PUCPR repository

Through this referential base, the redesign objectives to update the contents, but also implement gamification features and accessibility to extend the range of LO. The subjects of this layer are (Fig. 2):
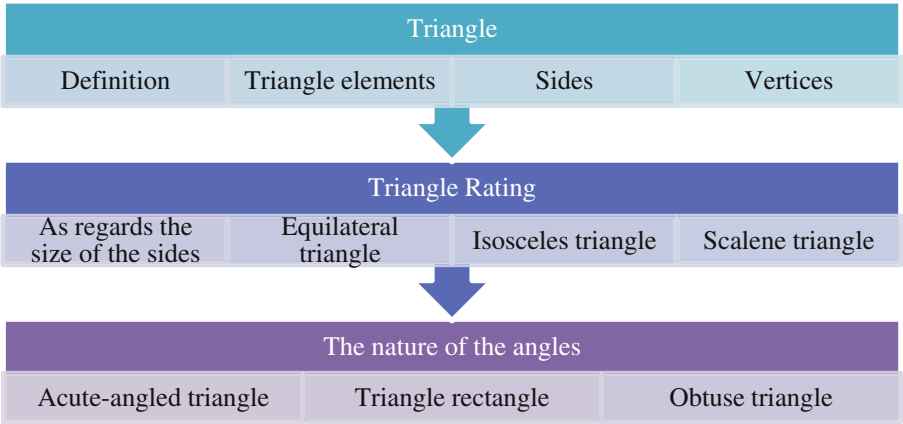

Fig. 2. The subjects of the LO - authors

4   Requirements

As general requirements for this project were defined:

– Use gamification elements to enhance learning and immersion in the content
– Use, whenever possible, accessible solutions.
– Redesign and upgrade the reference LO to make it appropriate to the context of use.

5 Architecture

According the process suggested in Kethure (2010) was developed a Concept Map and the gamified LO (GLO) Storyboard, respectively (Fig. 3).
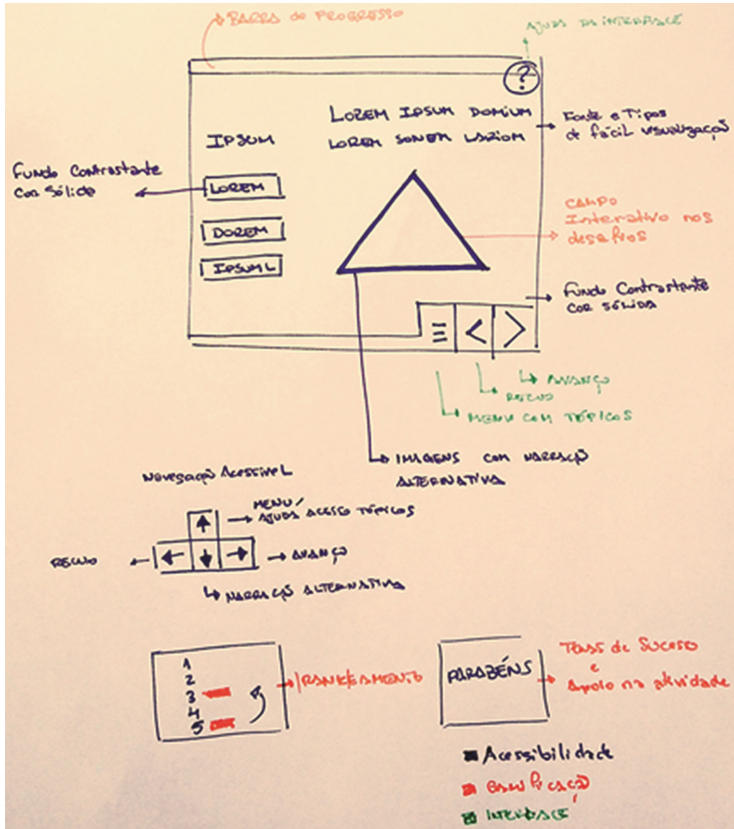

Fig. 3. Concept map - authors

From the user name insertion, encoding occur, resulting in a fictitious name, some sort of triangle (equilateral, for example), this name would be as the user in the context of navigation. The adoption of this code would serve as the first user immersion element in the context of the GLO. In sequence, some elements of gamification received a first draft on the project (Fig. 4).

This scheme, structured the information area and user interaction; it shows the progress bar that provides real-time feedback on user interface about their situation. Has been added a help button on all splints, which when activated displays the navigation keys that help the user to understand the working mechanics of the GLO, determining the user how you can interact with the platform.

Fig. 4. Information architecture sketch - authors

The storyboard included the organization of GLO screens, prioritizing an accessibility screen that would be an introductory screen, where the user could control if you would like to activate or not the accessibility mode (Fig. 5).

Fig. 5. Storyboard – authors

In a second stage were idealized the menus, the presentation of content and the content of fixation exercises, presented to the user in the form of challenges along their learning. The exercises would be applied at the end of each content block and served to

better learning and memory, and were classified in: Challenge 1 - Identification of different types of triangles; Challenge 2 - Classification of triangles; Challenge 3 - Straight and angles.

Subsequently, was studied the module to display and insertion of the user's name. From the user name insertion, encoding occur, resulting in a fictitious name, some sort of triangle (equilateral, for example), this name would be as the user in the context of navigation. The adoption of this code would serve as the first user immersion element in the context of the GLO, extracted precept of gamification.

6 Development

Were developed two navigation maps for this application. The first includes a handy navigation for users with low vision or blind, and does not address fixing activities whose user interaction request the viewing screen elements. This mode presents the information through voice over and may include additional information through simplified access the directional keys on the keyboard (Fig. 6).
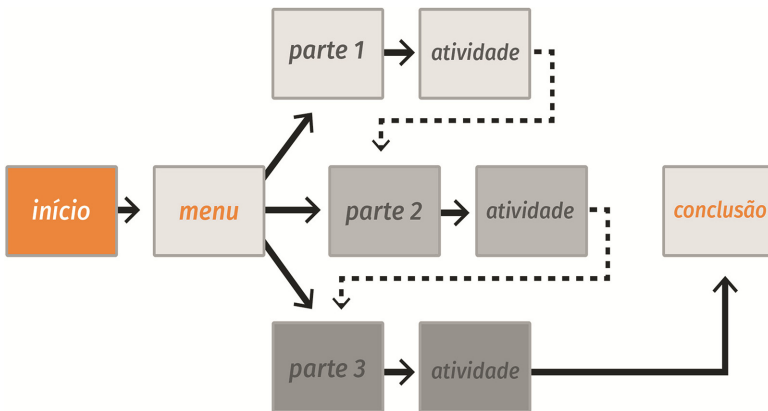
Fig. 6. The GLO paths - authors

Access for users with visual impairment does not include the first two activities that have focused on visual user interaction with the LO through the mouse. These activities are represented with dotted lines and are only in the complete GLO. The full mode, displays the information and interactive activities through the human computer interface using as main peripheral access the mouse or touchscreen. This mode also provides information through voice over and may contemplate additional information help through simplified access by LO navigation interface. A map screen-to-screen was then developed contemplating the entire route that the user can access on the LO. An excerpt of this map can be see illustrated in the following (Fig. 7).
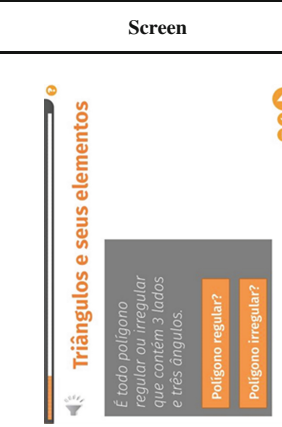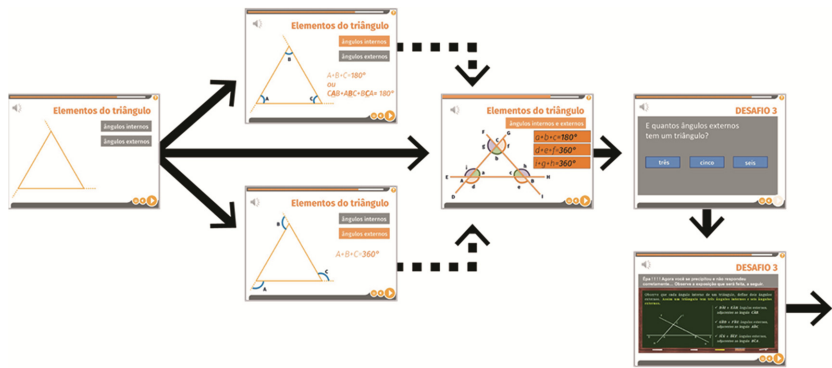
Fig. 7. Excerpt map screen-to-screen - authors

As an additional tool to the navigation map, a table explain every screen and functions to be developed by programmers. Table 3 depicts the screen, the description of the screen and account items, as well as physical and virtual function buttons. Such data include the description of each of the screens, stories suggested for the comprehensive and affordable navigation, functions applied to each of the available buttons and operation information, screens and challenge.

Table 3. Excerpt descriptions and functions – authors

Screen	Description	Functions
Screen 4 - triangles and its elements	It presents the theme: Triangles and its elements. Voice Over 1: Triangles and its elements. Triangle is all regular or irregular polygon containing three sides and three angles. VO 2 through the lower directional: (repeats screen audio description: VO 1) Adds: Polygons are closed figures formed by line segments, being characterized by the following elements: angles, corners, diagonal and sides. According to the number of sides in the figure is named.	Directional physical buttons: right (advances to Regular Polygon screen), left (returns the previously accessed screen), higher (access menu), lower (repeat description screen audio). Navigation buttons per click: advance (advances to next screen), decrease (returns the previously accessed screen) menu (LO access the menu). Regular Polygon button - Opens explanation Irregular Polygon button - Opens explanation

Many of the features are included in the developed prototype and can be experienced by programmers for better understanding.

7   Availability

Developed documents, as well as figures, text and slide presentations, will be available in conjunction with this document to dealings by pedagogues and LO programmers. The prototype can be accessed by the link: https://goo.gl/2iKeAQ.

Developed in public and federal level, the Learning Object is licensed under a Creative Commons License - Attribution 4.0 International.

8   Evaluation

Throughout the development of the previously demonstrated screens the project team made several checks on the functionality and quality of available information. Thus, it should be noted that the screens and logistical shown here are the result of work cycles to better match the GLO, and occurred throughout the project. In this project by limiting its scope, and development time were not understanding of tests with users focus gamified LO. These tests should be conducted to analyze the collection of information for general users, visually impaired and blind. The data should be used to increase and improve the proposal.

9   Final Considerations

This paper aimed to present the process of instructional GLO re-design for teaching content of triangles based on LO descriptive geometry course at the Catholic University of Paraná. For this purpose, the presented process of digital design, taking into account the establishment of design requirements set to the accessibility of gamification.

The platform digital design left the following guiding questions of project: How to structure the development of GLO? How to promote the memorization, learning, content retrieval and enable accessibility in the digital environment?

Given these problems, it was established that would also be used gamification concepts on the platform, to establish interaction, involvement and immersion of the user in the content presented. In addition to these criteria, also was used the gamification when the progress bar for the user to know in real time on your navigation and on its degree of interaction and apprehension of the content in the virtual environment was planned. For people with special needs can enable the accessibility mode that allows continuous audio description of all content presented to blind people, as well as expansion of characters or images to people with low vision. For blind people, it is possible to print the exercises in Braille and embossed figures and illustrations. Still, with a focus on meeting also subjects with hearing impairment, all presented content is explained in detail on the screen to facilitate learning.

The collaborative approach to development of GLO allowed respectively development: Requirements, Conceptual Design (Concept Map and Storyboard) and Digital Modeling.

It was found that the accessibility and gamification must be project prerogatives that must be established when the genesis of the project and not later, when implemented,

only aiming at their adaptation to these contexts. The developed GLO is concerned from accessibility criteria to allow teaching and instructional content can reach a greater number of subjects with and without hearing or impaired vision (blind and people with residual vision - low vision).

Thus, it is important to understand that in the absence of a single definition, theories of learning objects can be seen as complementary, and develop LOs is an important step to understanding these objects as well as for the promotion of education.

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