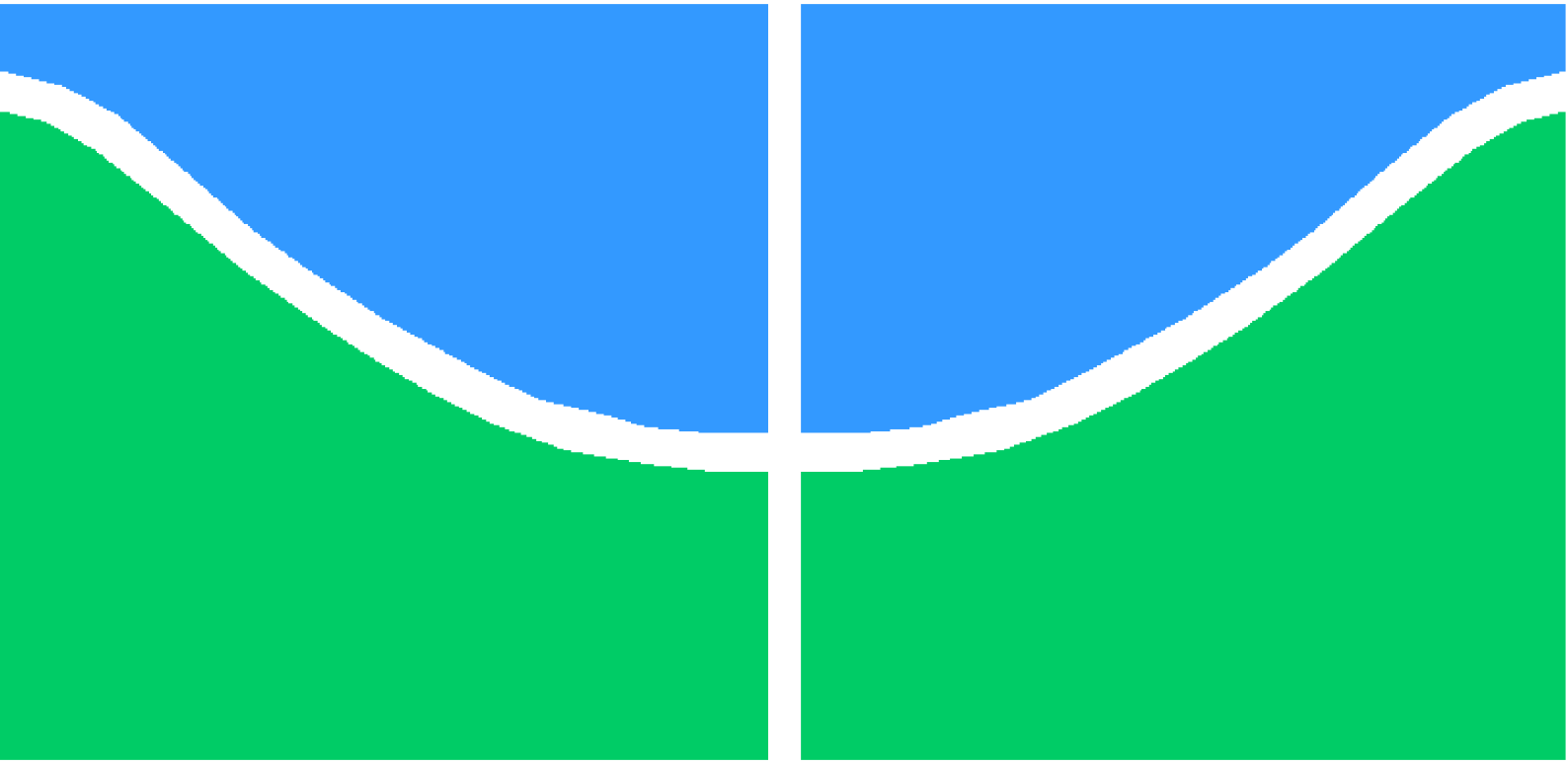

Universidade de Brasília - UnB

Faculdade UnB Gama - FGA

Software Engineering

Framework for Evaluating Educational Games: Motivational and Learning Aspects

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Monografia submetida ao curso de graduação em (Software Engineering) da Universidade de Brasília, como requisito parcial para obtenção do Título de Bacharel em (Software Engineering).

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Bruna Nayara Moreira Lima

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To children,
professional learners

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Thank you!

"When experience is intrinsically rewarding, life is justified in the present, instead of being held hostage to a hypothetical future gain"

"Quando a experiência é intrinsecamente gratificante a vida se justifica no presente, em vez de ser refém de um ganho futuro hipotético."

(Mihaly Csikszentmihalyi)

Resumo

Inovações tecnológicas permitem o uso de diferentes abordagens para o ensino e o aprendizado. A utilização de jogos de educativos tem crescido (KAPP, 2012). A possibilidade de contribuir com a educação através da aplicação de jogos educacionais inspira a execução deste projeto. Tendo isso em vista, o objetivo deste trabalho é desenvolver um framework para avaliação de jogos educacionais. A análise considera aspectos motivacionais e de aprendizado. Para prover ambos aspectos foram utilizados os conceitos de *gamification*, segundo (DETERDING et al., 2011), e a taxonomia de avaliação de currículos de Bloom (BLOOM, 1956). A construção de modelos baseados nessas características permite o desenvolvimento do sistema de avaliação. Esses modelos são apresentados e explicados neste trabalho. São destacadas as heurísticas produzidas paraque os jogos sejam avaliados. Os modelos e a avaliação desevolvidos neste trabalho permitem que pessoas não familiarizadas com os conceitos de *gamification* e avaliação curricular de aprendizado possam avaliar jogos educativos e planejar diferentes abordagens de ensino.

Palavras-chaves: Aprendizado. Motivação. Jogos.

Abstract

Technological innovation allows different approaches for teaching and learning. The use of games for learning has grown (KAPP, 2012). The possibility of facilitating education via educational games inspires the execution of this work. Thus, the objective of this project is to develop a framework for evaluating educational games. The appraisal considers motivational and learning aspects. To support both aspects of the analysis were used concepts of gamification (DETERDING et al., 2011) and bloom's taxonomy for curriculum evaluation (BLOOM, 1956).The construction of frameworks and models allows the development of an evaluation system. These models are presented and explained in this work. Moreover, are featured the heuristics developed to be followed during the evaluation. The use of the framework and evaluation created allows people that are not familiar with gamification and learning aspects to be able to evaluate games and plan different approaches to deliver instruction.

Key-words: Learning. Motivation. Games.

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List of abbreviations and acronyms

HCGD	Human-centered game design
MMO	Massive multiplayer online
MU	Motivation unit
SN	Social network

List of symbols

Contents

1 Introduction

Technological progress has been changing teaching and learning methods and techniques (PEREIRA; SCHMITT; DIAS, 2007). These innovative changes are supported by technical and non-technical aspects. Virtual environments, games are examples of technical supporting tools for learning. Not only in-class learning, but online and distance learning, also.

According to Kapp (KAPP, 2012) teachers have been using games in classroom. However learning environments are not the only industry that innovate to promote its outcomes. Kapp points out that different techniques to improve learning, problem-solving and innovation are being used in institutions. They range from schools to governmental organizations.

Different factors motivate the execution of this project. The possibility of improving learning using supporting tools is one of them. Other causes are:

- Increase understanding related to game aspects that promote learning,
- Understand cognitive aspects of learning,
- Help people to understand how games affect might help learning.

1.1 Objectives

Hereby, are presented the objectives of this project. General objective and specific objectives are declared in this section. They were used to guide the development of the work. Choices for the project development were made considering them.

1.1.1 General Objective

The development of a system for evaluating educational games is the main goal of the project. The evaluation must consider engagement and learning aspects of games and provide respective results.

1.1.2 Specific Objectives

Specific objectives were elicited based on the main goal of this project. The specific objectives are:

- Determine a framework for evaluating motivational aspects,

- Select a framework for evaluating learning aspects,
- Construct a structure to guide the evaluation,
- Design and develop the system for evaluation.

1.2 Project organization

This project is organized in chapters. Literature review is presented in chapter 2. Chapter 3 describes the development goals for this project. Software engineering and project management is portrayed in chapter 4. Final considerations and conclusions are declared in chapter 5.

2 Literature review

Concepts and works related to this project are presented in this chapter. Some of them were used as groundwork for the development of this project. The comprehension of both of them is necessary to support decisions throughout the execution of this project.

This chapter is organized in sections. Section 2.1 presents definition of gamification that is used in this project. Gamification frameworks were elicited and are presented in section 2.2. A taxonomy for educational objectives is presented in 2.3.

2.1 Gamification

Gamification is trending concept (YOHANNIS; PRABOWO; WAWORUNTU, 2014). Search records on Google search engine (GOOGLE, 2016) also confirms interest growth towards the term gamification, as shown in figure 1. It shows the volume of searches in a period of time ranging from February 2004 to May 2016. Even though the use of this term has increased, it is a greatly contested term. Having a definition for the concept is task that has been put some effort into. Studies conducted by (YOHANNIS; PRABOWO; WAWORUNTU, 2014), (DETERDING et al., 2011), and (HUOTARI; HAMARI, 2012), for example, intend to find a definition for *Gamification*.

A lexical approach was used by (YOHANNIS; PRABOWO; WAWORUNTU, 2014) to define gamification. It is defined as a process that is applied to an object and makes it different from previous condition. In this case, it changes the experience related to the subject matter. It is suggested that gamification is the process that integrates game elements into *gameless* objects in order to incorporate *gameful* characteristics.

Another definition for gamification is: "*a process of enhancing a service with affor-*

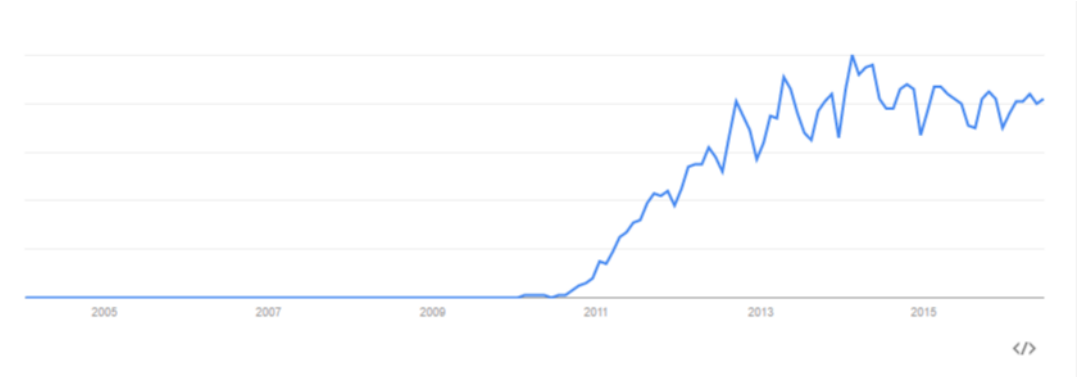

Figure 1 – Google trends for gamification (Fonte: (GOOGLE, 2016))

dances for gameful experiences in order to support user's overall value creation" (HUOTARI; HAMARI, 2012). This definition reiterates that the goal of gamification is "the experiences that it attempt to give rise to" rather than the use of game elements into non-game contexts. Previous definitions, such as (DETERDING et al., 2011), rely on the use of game elements. There are not, however, a defined group of elements strict to games.

Gamification enhances user engagement, as suggested by (HAMARI; KOIVISTO; SARSA, 2014). It influences people behavior during the accomplishment of a task (COSTA, 2015). One of the main objectives of gamification is to work with this characteristic to impact problem-solving (COSTA, 2015). According to (ZICHERMANN; CUNNINGHAM, 2011), game mechanisms affect people motivation. Furthermore, this effect might influence decision-making process and activities results.

The concept of gamification that guides this project development was chosen based on the review hereby presented. For the context of this work, gamification *is a process that enhances user engagement by integrating game elements into a product or service* .

2.2 Gamification frameworks

Based on the definition for gamification, a review of gamification frameworks was conducted. The results of this study are presented in this section. Bartle's model for gamification is presented in 2.2.1. A model proposed by Amy Jo Kim (KIM, 2012) is presented in 2.2.2. The framework for gamification Octalysis is introduced in 2.2.3.

2.2.1 Bartle's Model

Bartle (BARTLE, 1996) claims that different people play games for different reasons. Moreover, it is said that they might have different player personalities. And that they are more likely to play a game that have characteristics that are related to their player personality. These aspects are concerned with motivation. According to (BARTLE, 1996), games can be programmed or configured to increase or decrease player's motivation, which depends on the player's personality. Four player profiles were identified based on motivational aspects of games. The profiles and their engagement presented are:

- **Killers:** are engaged by ranking and competition. They like to impose themselves to others and believe winning is related to defeat opponents;
- **Achievers:** like to gather points and collect badges. The main goal for this type of player is rising levels;
- **Explorers:** for these players, curiosity is the main incentive. They progressively adventure themselves in the unknown. Experience is very important to them;

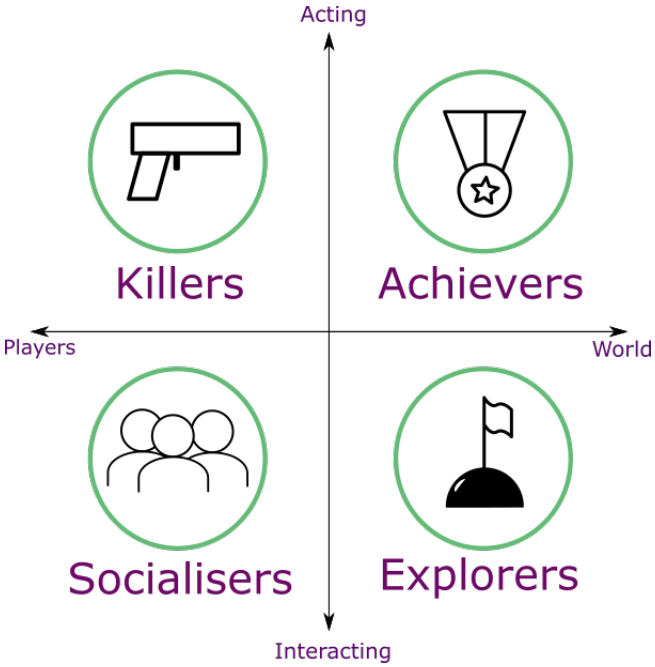

Figure 2 – Bartle's Model

- **Socialisers:** are interested in people. A game represents common interests among them. It is not, however, their main goal. Which is player interaction.

Figure 2 represents the model proposed by Bartle (BARTLE, 1996). It shows all of the four profiles previously described. They are divided in four quadrants. Y-axis represents actions related to the profiles. Actions go from interact to act. Meanwhile, X-axis represents the object to be interacted or acted upon: players or game world. Killers are players that act upon other player. Achievers act upon the world. Socialisers interact with other players. And explorers interact with the world. Even though they are separated and organized this way, that does not mean they only act or interact in this way. It represents the core motivation of each player profile.

This model for categorizing motivation, however, is not ideal for this project. The profiles elicited do not fit for all types of games. They are possible to be used balance multiplayer games. But this model does not contemplates other types of games - puzzle, strategy, and simulations, for example.

2.2.2 Amy Jo Kim's Model

The model proposed by (KIM, 2012) was based on Bartle's model. Her model, however, does not relate motivation to player profile. The motivation is correlated to verbs, called social engagement verbs. They capture motivational patterns, not only for games, but also for social media. There are four main engagement verbs. They map to Bartle's profiles (BARTLE, 1996). However, they are not constrained for massive multiplayer

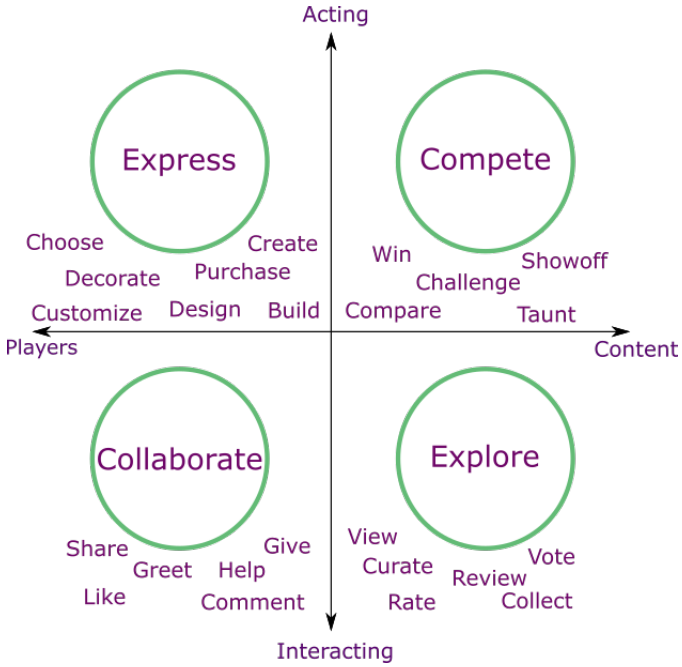

Figure 3 – Amy JO Kim's Model

online (MMO) games. They were designed to work appropriately with casual, social and serious games. The social engagement verbs are:

- **Express:** is a replacement for the killer profile. It expects to overcome challenges and be rewarded;
- **Compete:** is similar to achiever profile. It promotes competition and prize collection;
- **Explore:** is identical to explorer profile. Its motif is the discovery of new content, people, tools;
- **Collaborate:** is analogous to socialisers. Collective actions are purposeful.

Amy Jo Kim's model is represented on figure 3. Social engagement verbs are featured in the quadrants of the figure. Similarly to Bartle's model, the verbs above x-axis are related to acting. The verbs below are related to interact. Verbs on the left are affected or affect upon players. The engagement verbs on the right, however, are relate to content. Each main verb is portrayed on the respective quadrant. Along with the main engagement verbs, there are other verbs that are related to the motivation represent on the quadrant.

2.2.3 Octalysis

Octalysis is a gamification framework proposed by Yu-Kai Chou (CHOU, 2015). He says that gamification is related to motivation. Besides, games were first in mastering

motivation-focused system construction. Because of that, he mentions, the term "gamification" was conceived. This model was proposed based on studies about games. Chou (CHOU, 2015) asserts that games are fun because they affect people's units that engage in certain tasks. These units, related to specific game techniques, influence people. Some of them in a inspiring and powerful way. Others, in a manipulative and, even, obsessive way. This framework for gamification, octalysis, is composed by 8 units, called core drives. They represent different types of engagement: meaning, empowerment, social influence, unpredictability, avoidance, scarcity, ownership, and, accomplishment.

- **Meaning:** every person has a different view of life mission. This core represents motivation related to own interests about this mission.
- **Empowerment:** people involved in creative process of creation. The feeling of the capacity of creating is the engagement related to this core drive.
- **Social influence:** this unit is composed by social elements that increase people's influence. Relationships, tutoring, inspiration by other people constitute the engagement contained in this core drive.
- **Unpredictability:** the desire to discover new things and find the unknown encourages people. The unknown and the possibility to always have a new experience are the essence of this core drive.
- **Avoidance:** this core drive is based in the possibility to avoid something from happening. A person might keep playing, for example, to avoid losing all the progress until that point.
- **Scarcity:** is a core drive based on the desire of *something* that is not possible to have. This "thing" might be an object, an experience, a situation.
- **Ownership:** this encouragement is related to assets that one might have. It is related to the feeling of belonging. The creation of an avatar, for example.
- **Accomplishment:** is related to the progress of a task. Overcoming challenges that mean move on to a next challenge engages a person.

The framework model create by Chou (CHOU, 2015) is represented on figure 4. The framework is portrayed as an octagon. The sides of the polygon are correlated with one of the core drives that engage people. They were arranged in the octagon in a placement that would convey an idea of groups. The group constituted by the engagement core drives shown in the top of the polygon are called "white hat". The "black hat" is composed by the core drives placed in the bottom of the figure.

Figure 4 – Octalysis framework (Source: (CHOU, 2015))

White hat	Black hat
Accomplishment	Scarcity
Meaning	Avoidance
Empowerment	Unpredictability

Table 1 – White and Black Hat

Table 1 shows the white and black hat classification for the framework. Chou (CHOU, 2015) says that accomplishment, meaning and empowerment constitute the white hat. They are related to positive emotions. Core drives in the black hat are scarcity, avoidance, and unpredictability. These are negative emotions. However, Chou (CHOU, 2015) points out, that does not mean they are bad emotions or engagement.

Gamification experts are likely to be able to use the octalysis framework to produce good gamification products. It can be achieved by balancing motivation, the core drives and the profile of the audience for that gamification, according to Chou (CHOU, 2015). To achieve the expected result there are different ways that the gamification might be implemented. To help the execution of the gamification process, Chou (CHOU, 2015) discriminate techniques related to each type of motivation. Techniques are also shown in figure 4.

2.3 Bloom's Taxonomy

The *Bloom's Taxonomy* is a framework to classify educational objectives and curricula (KRATHWOHL, 2002). It intends to facilitate the exchange of information; and to help curriculum builders gain perspective on the educational plans (BLOOM, 1956). The

most important matters that the taxonomy helps to increase understanding are: learning, instruction, assessment and alignment (ANDERSON et al., 2001). Having a better comprehension about them, helps educators and curriculum builder answer the following questions.

- **Learning:** What is important for students to learn in this context?,
- **Instruction:** How does one plan to deliver instruction that will result in high levels of learning?
- **Assessment:** How does one select or design assessment instruments and procedures that provide accurate information about how well the audience learns?
- **Alignment:** How does one ensure that objectives, instruction and assessment are consistent with one another?

Educational goals are, usually, described in a program curriculum. When they are defined according to Bloom's taxonomy the processes of planning learning experiences and preparing evaluation methods are easier(BLOOM, 1956). These learning objective statements are subdivided in the subject – usually a noun or noun phrase – and the intended behavior – commonly represented as a verb or a verb phrase (KRATHWOHL, 2002; ANDERSON et al., 2001). The Bloom's revised taxonomy (ANDERSON et al., 2001) presents these two aspects as separated dimensions: knowledge and cognitive.

2.3.1 Knowledge Dimension

It is possible to achieve different types of knowledge using the same content. Anderson (ANDERSON et al., 2001) states that varied objectives can be focused on the same content to emphasize different types of knowledge. Knowledge, in this context, is domain specific. Construction and development of knowledge reflect the specificity in the revision of the taxonomy (ANDERSON et al., 2001). The types of knowledge are presented in the revised taxonomy as a dimension.

The knowledge dimension contains main four categories – factual, conceptual, procedural, and meta-cognitive. Factual knowledge embodies basic elements that experts use in communicating that content. These elements are believed to have some value in themselves as concrete references (ANDERSON et al., 2001). Conceptual knowledge, however, contains knowledge of categories, classification, and the relationships among them. This knowledge includes the organization and structure of the content, and how different parts are interconnected and interrelated, and how they function together (ANDERSON et al., 2001). Procedural knowledge is the knowledge of the process to accomplish a specific activity or task. This process might be skills, algorithms, techniques, or methods. Moreover,

procedural knowledge includes the criteria used to decide when to use the procedures which a person might know. The fourth category of knowledge, meta-cognitive, became a category of the taxonomy after its revision. Meta-cognitive knowledge is about awareness of a person's own knowledge and cognition, and about cognition, in general (ANDERSON et al., 2001). Meta-cognitive knowledge also includes knowledge of strategy, task, and person variables.

Types of knowledge	**Sub-types**
Factual	Terminology
	Details and Elements
Conceptual	Classifications and categories
	Principles and generalizations
	Theories and structures
Procedural	Skills and algorithms
	Techniques and methods
	Criteria for procedures
Meta-cognitive	Strategic
	Cognitive tasks
	Self-knowledge

Table 2 – Bloom's taxonomy: Types of Knowledge

Table 2 reflects the understanding of knowledge types, according to (ANDERSON et al., 2001). There are four major types of knowledge: factual, conceptual, procedural, and meta-cognitive. These types are divided in sub-types. There are 2 sub-types related to factual knowledge. They are knowledge of terminology, and knowledge of specific details and elements. Regarding conceptual knowledge, 3 sub-types are presented. Knowledge of classifications and categories; knowledge of principles and generalizations; and knowledge of theories, models, and structures. Procedural knowledge presents 3 sub-types: knowledge of subject-specific skills and algorithms; knowledge of subject-specific techniques and method; and knowledge of criteria for determining when to use suitable procedures. The last major type, meta-cognitive, is constituted by 3 sub-types of knowledge. Strategic knowledge, knowledge about cognitive tasks, and self-knowledge.

2.3.2 Congnitive Dimension

"Two of the most important educational goals are to promote retention and to promote transfer of knowledge" (ANDERSON et al., 2001). Retaining knowledge is the ability to remember a given material in the future. Transferring knowledge is the capability of using what was learned to solve new problems, and answer questions. The cognitive processes discriminated in the revised taxonomy (ANDERSON et al., 2001) range from the ability to retain to the ability to transfer knowledge.

The cognitive dimension contains six categories – remember, understand, apply, analyze, evaluate, and create (ANDERSON et al., 2001). The cognitive processes related to remember expect that the learner will be able to retrieve relevant information from long-term memory. There are two subtypes in *remember* – retrieve and identify. They mean recall and locate knowledge in presented material, respectively. The next category, *understand*, promotes the ability to construct meaning from instructional messages. These messages might be via oral, written, and graphic forms. The sub-types are interpret, exemplify, classify, summarize, infer, compare and explain. Moreover, understand implies that the learner is able to build connections between the incoming knowledge and the prior knowledge (ANDERSON et al., 2001). Moving forward in the cognitive processes, there is the *apply* category. Apply means that known procedures will be executed to perform exercises or solve problems. There are two situations: when the task is familiar and when it is not. When the task is familiar, it is generally known the procedural knowledge to be used. Then the task is executed – execute is a sub-type of apply. When the task is not familiar, then the knowledge to be used to perform the action must be determined. And this requires some degree of understanding of the problem and of the solution. This second situation is the second subcategory of apply – implement (ANDERSON et al., 2001).

The process of analyzing involves breaking the content into its constituent elements and determining how they relate to one another and to the overall structure. This process includes differentiate – distinguish relevant from irrelevant parts of material; organize – determine how elements function together; and attribute – determine intention of a material. The process of evaluating is defined as making judgments based on criteria and standards. Is is pointed out, however, that not all judgments are evaluative (ANDERSON et al., 2001). The use of criteria and standards is what differentiates evaluative judgments from other judgments. Checking and critiquing are the sub-types of *evaluate*. The last category, create, involves the ability to putting elements together to produce coherent structure. The process of creating involves making a new product by reorganizing known elements or concepts into a different structure or pattern (ANDERSON et al., 2001).

2.3.3 Learning Objectives

The intended learning outcome of an educational program, workshop, or module is called learning objective (ANDERSON et al., 2001). Learning objective statements are, usually found, in educational programs curricula. Educational games, however, usually do not have a curriculum. Even though expected learning outcomes might be clear for game makers. When they are not explicitly stated in a curriculum, they might be implied in the instructional activities, or in the assessment(ANDERSON et al., 2001). Activities and assessment help clarify, however it is important that learning outcomes are clearly

understood and stated.

To categorize the learning objectives in the taxonomy table, the verb phrase must be examined in relation to the cognitive processes and the noun phrase to the types of knowledge. To have a better clue where each of them belong, it is advised to rely on the sub-types(ANDERSON et al., 2001). This analysis allows a person to answer the learning question.

2.3.4 Instructional Activities

The instructional activities, help learners to achieve the learning objectives. They describe tasks and actions to be done. Unlike the learning objectives, that are placed in one cell, they, might be placed in multiple cells, even if they are related to one objective. Further, it is possible not to have the instructional activities in the same cell as its objectives. This happens because the verbs of the objective can be decomposed in different activities that facilitate their application. Consequently, they might assist learners to develop more than one kind of knowledge and cognitive processes (ANDERSON et al., 2001).

3 Development

The main goal of this project, as presented in 1.1, is the design and development of an automated system for evaluating educational games. The evaluation methodology was developed based upon two main concepts. They are: the revision of Bloom's taxonomy (ANDERSON et al., 2001) and human-centered game design framework based on Octalysis (CHOU, 2015). Bloom's taxonomy is used to evaluate the alignment of learning goals in the game. Motivational aspects are the characteristics appraised under the Octalysis framework. The evaluation must be conducted by a person familiar with the game. From the evaluator perspective, the system extract important information and present the outcoming results. The resulting evaluation helps the appraiser to get a better understanding about learning and motivational aspects within the game. The awareness of these peculiarities of the game are indicators that might guide people on choosing games for education, depending on specific purposes.

The proposed evaluation software is intended to be part of an integral system. It consists of a social network. Where, the evaluation is one of the main features. This social network aims to integrate functionality that appeal to educational games audience. It is intended to: display games and promote discussion about them, evaluate games, and facilitate knowledge distribution among the community. Besides, it is supposed to consolidate these objectives with the conveniences associated to social network features.

This section presents the goals of this project and the development of them. It also explains aspects that helped designing the solution. The main proposal is explained in 3.1. The evaluation methodology, and the system developed in this work, are presented on the section 3.2. Establishing structures and heuristics were necessary to implement the evaluation methodology. The frameworks are: human centered-game design and bloom's taxonomy. They are presented, in sections 3.3 and 3.4, respectively.

3.1 Introduction

This projects contemplates an evaluation software for educational games. The evaluation results are intended to fulfill some dicontinuities that might exist in the context of educational games. Some of them are: dispersed knowledge about the matter, the need to ensure games are aligned to learning expectations, difficulty of finding educational games, the necessity to display games to their audience, the lack of places to gather the community, To be able to ensure alinment between curriculum and the learning objectives of a game, educators need to analyze the game. This analysis may emphasize different aspects, depending on the intentions. In that respect, it is designed and developed an

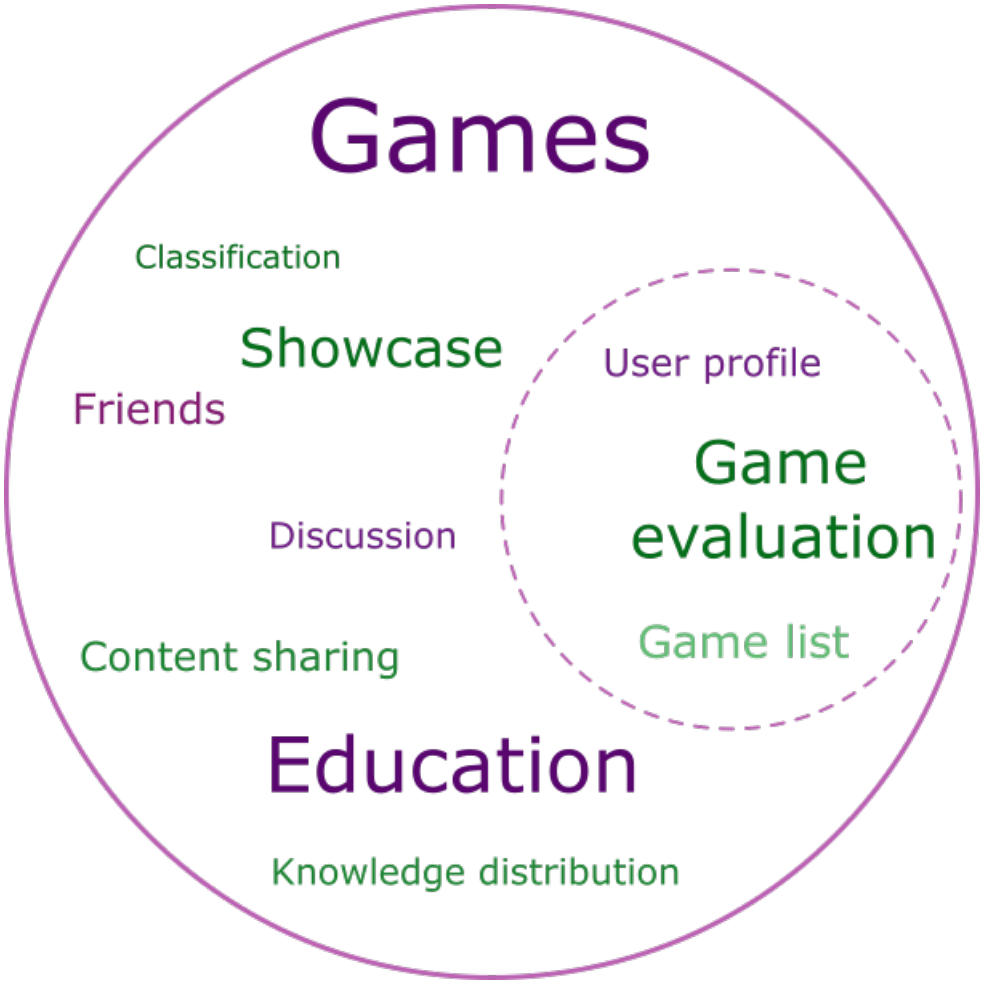

Figure 5 – Social Network Proposal

evaluation system that aims to resolve this. Motivational aspects and pedagogical matters are given priority in the creation process.

This project considers two main aspects of educational games: motivational and pedagogical. And develops a system for evaluating them. Regarding the motivational aspect, the groundwork comes from a framework for human-centered game design, developed by Chou (CHOU, 2015). However, this previous feature does not comprehend the necessary pedagogical characteristic incorporated in this kind of games. Thus it is indispensable to make a curriculum analysis of these aspects based upon Bloom's taxonomy and its cognitive dimension (ANDERSON et al., 2001). They were adapted to fulfill the needs of this project. It intends to help the community by diminishing the time demanded to study and understand these properties.

Thus, this aims to connect and cooperate with an specific community: educational games supporters. Including: game makers, educators, and parents, and any person interested in games and education. The subject of this work is the planning and making of the evaluation system. Each of them is presented on the following section 3.2.

Figure 5 shows the aspects of the system presented before. It shows features that will be designed and implemented in this work, as well as projections for future work. The features presented in the big circle are features presented for future work of a social network, for example. Among them, there are features, as previously stated, that developed in this project. They are exhibited inside the dotted circle: user profile, evaluation system, and games list. User profiles are registered in the web site. The game list is a representation of the games that were filed by the users. This list displays information of the respective games. The educational games analyzer (EGA) analyzes the game information the user provided and produces the results for each game. The results for each evaluation are used to produce the results for the game. It is presented as information of the game.

3.2 Automated evaluation

In this project, EGA was developed to evaluate particular aspects of educational games.The attributes considered for the outcomes are related to the cognitive dimension of Bloom's taxonomy(ANDERSON et al., 2001) and the gamification framework Octalysis (CHOU, 2015). The extraction of these information is based upon the models constructed and presented in sections 3.4.1 and 3.3.1. To produce the intended outcome, the evaluation system must be given information about the game. This must be done by an user that has played the game. The data given to EGA are used as input for the evaluation heuristic presented on 3.3 and 3.4.

To be able to design the system, it was necessary to dissect the expected result into concepts that constitute it. They are Bloom's taxonomy and Octalysis framework. To be able to implement a system that can conclude such factors, some work had to be done. These concepts were studied and used in a way that brings only valuable information for the evaluation process. This information must be understood by the system. It should be arranged in a way that can be inserted into it. The material regarding those topics must be broken down to their constituent elements, discerning relevant information. Allowing the construction of a structure that can be programmed into the evaluation. The process of shaping them are presented in 3.3.1 and 3.4.

Each of these framework structures was analyzed separately. Hence, ensuring that they present best possible evaluation results for the specific context. The evaluation process are presented as heuristics. The resulting heuristic is presented in 3.3.2.

3.2.1 Evaluation Framework

The input for this evaluation framework is an educational game. The system needs to identify some elements, of the game. To do that, the system presents the appraiser some options. The answers regarding them, are used to extract the needed information. Then,

EGA performs the necessary processing over the information to provide the resulting evaluation. The expected output for the evaluation is a report regarding learning and motivation aspects of the game.

Figure 6 represents the overall concept for the system. A person who intends to evaluate the game will interact with it, providing sufficient material. The system will process the evaluation. From the provided data will be extracted the results for the evaluation. Then, the results will be presented to the user.

Figure 6 – Evaluation Flow

To be feasible to provide the user with good results, the framework must think over some entity. The entities are organized as structures that facilitate processing the evaluation. They are explained in section 3.3.1 and section 3.4.1. They present the structures for the human-centered game design and the Bloom's taxonomy frameworks. The thinking process is explained in 3.3.2.

3.3 Human-Centered Game Design

The evaluation contemplates characteristics regarding human-centered game design framework. Which deliberates about motivational aspects. Evaluating games under these considerations, requires comprehension about the topic. Having it as an automated system requires patterns that can be implemented. The operations performed by the system implemented need to be concise. The main characteristics of the design framework must be preserved. However, any aspects that are not elementary for the results, are taken off the application.

The human-centered game design framework used as groundwork to this perspective of the evaluation were analyzed. Important information were discriminated from elements that were not needed for the aspects intended to be evaluated. They and their relationship were modeled in a way that could be used for the evaluation. However, there was a concern to assure they were still consistent to the framework.

3.3.1 Structure

It is presented hereby the structure for the human-centered game design framework that will be used in the game evaluation process. This architectural organization of the topic was constructed and presented by (MOREIRA; BELA; FREITAS, 2016). Chou's (CHOU, 2015) framework - Octalysis, and Fredericks (FREDERICKS; BLUMENFELD; PARIS, 2004) work were used as groundwork for this construction.

Chou's (CHOU, 2015) framework presents characteristics that motivate people. They are separated in, what he calls, core drives. Moreover, they present techniques that can be implemented in games. These elements and their relationships were mapped. Besides that, the motivational attributes raised by other works - (FREDERICKS; BLUMENFELD; PARIS, 2004) - were used in the construction.

The construction was based in modeling the overall structure and relations existent. To design it, it was necessary to breakdown concepts and identify elements. These elements were used as base for the framework. Their relations were mapped and organized to compose the structure. The details of the construction of the framework is in ANEXODOARTIGO. These elements are motivation units. A unit is represented on figure 7. A motivation unit is constituted by its definition, motivation techniques, and attributes. Attributes are related to every unit, varying the involvement with each of them. Techniques, however, might belong to more than one unit, these are called implicit relations among units.

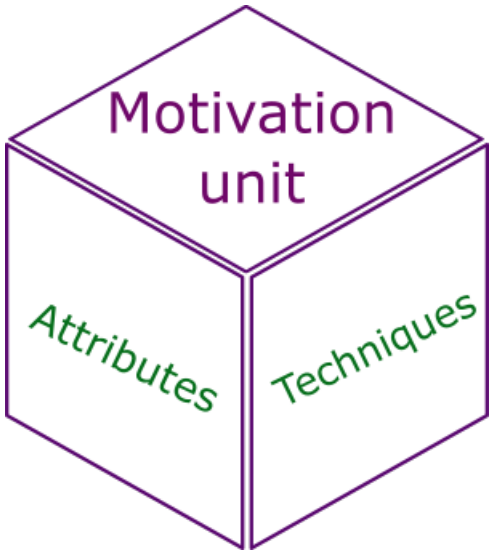

Figure 7 – Motivation unit

The resulting structure is presented on figure 8. There are eight cubes in the image. Each of them represent an unit of basic motivation. In the upper polygon, their names are written: meaning, empowerment, social influence, unpredictability, avoidance, scarcity, ownership, and, accomplishment. All of them are related to techniques and attributes. In

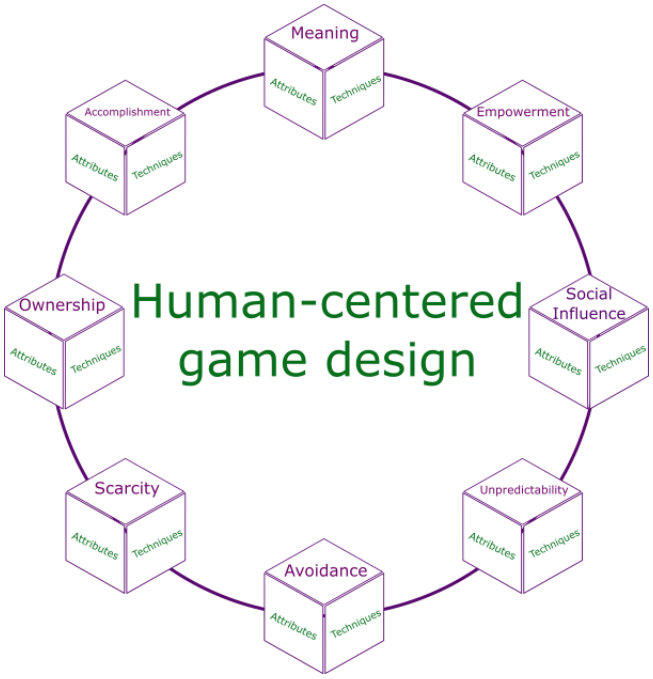

Figure 8 – Human-centered game design framework

the figure, they are not discriminated, being illustrated by “techniques” and “attributes”. The units of motivation are placed in the image in positions that might represent different types of motivation. For instance, the part of the top are the motivation regarding positive emotions. Contrariwise, the ones positioned on the bottom, are related to negative emotions. They do not, however, represent bad motivation.

3.3.2 Evaluation heuristic

This subsection presents the heuristic designed to evaluate educational games according to the human-centered game design perspective. The heuristic was designed to fulfill the needs presented previously. It formalizes the steps that an specialist would follow to do it manually. Having a formal heuristic for this evaluation process allows implementing an automated solution, facilitating and demanding less time. Moreover, people that do not have expertise about the topic, would have the possibility to evaluate games.

Even though it is considered as an unique evaluation, it was separated in different sections. These sections represent types of evaluation. They are referred as simple, complete, and profound. They are components of the evaluation that will be implemented. The whole evaluation processes depends nos only on the human-centered game design framework. Thus, hcgd and the other processes were integrated later on the design and development of this work.

Figure 9 shows the whole evaluation processi, also presented in (MOREIRA; BELA; FREITAS, 2016). It specifies all the different types of evaluation. Besides, it

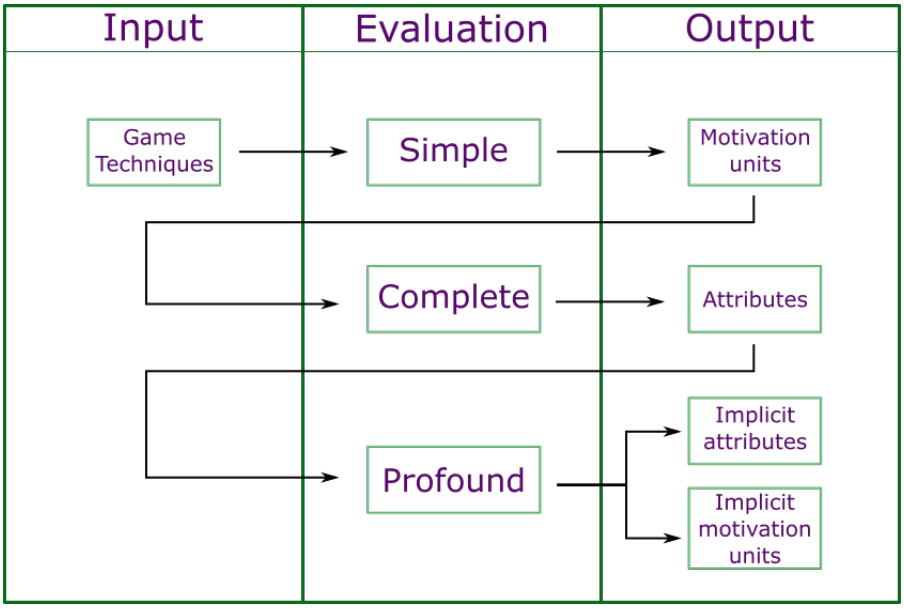

Figure 9 – Types of human-centered game design evaluation

presents the input and output of each of them. An evaluation is considered input for the next evaluation. This does not happen, however, if it is the last type, profound. These evaluation types compose an unique evaluation, proposed here. However, each of them can be considered as an evaluation individually containing relevant results, depending on the purpose of the person evaluating the game. They are briefly presented in this paragraph, and in more details in the following paragraphs. The first type of evaluation, simple, take as input, the game to be evaluated. It is given to the system by the appraiser – who needs to have an understanding of the game, even if just by playing it. The artifacts produced during the simple evaluation are used by the next. Complete evaluation, then, produces its outcomes and, if the evaluation proceeds to the profound evaluation, gives it to the next steps. The results of the last type of evaluation are presented to the user.

Simple evaluation uses information from the game to identify human-centered game design aspects. The core drives that are affected by the game are identified in this stage of the evaluation. To do so, the data taken from the game are inspected to diagnose important content that is relevant to the identification process. The structure of this framework that defines and explains what is relevant in this step was presented in section 3.3.1. Motivation units listed as main result may be sufficient to the expectations. If so, it is given as result. If not, the evaluation continues to the next evaluation steps. The next evaluation moment, complete evaluation, follows through the process from where the previous one stopped. Partial and final products from previous evaluation are necessary to continue the process. The techniques and the core drives mapped for the game are used to look for the relationship within the game. Therefore, the attributes can be inferred. They are submitted to the user as result if the complete evaluation is satisfactory. Otherwise,

the evaluation goes on and the profound evaluation is required. The profound evaluation, similar to the complete evaluation, needs the partial and final products of the previous evaluation. This happens, because all the evaluation types combined compound an unique evaluation. From what is done so far, implicit relations and characteristics are found. To do so, it is required the analysis of the relations deeper than its first level. After algorithmically processed this is possible. The result for the last evaluation stage is done here. All the results are compiled together to show a complete result evaluation.

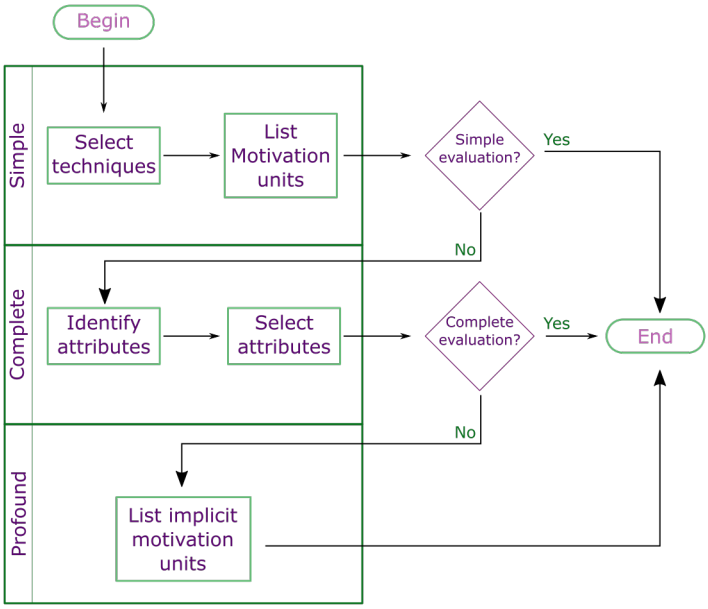

Figure 10 – Human-centered game design evaluation heuristic

Figure 10 represents tasks in the evaluation process. Horizontal lanes represent the evaluations previously shown on figure 9. Lanes are labeled on the left edge, they are, from top to bottom, simple, complete and profound, respectively. First lane shows tasks for the simple evaluation: select techniques, and list motivation units (MU). If only simple evaluation is required, the flow ends. Otherwise, complete evaluation begins. It is shown in the second lane. There are two correspondent tasks for this evaluation. They are represented on the rectangles in the second lane - identify attributes, and select attributes. The evaluation comes to an end, if the evaluation complete is sufficient. If not, it continues to the next steps. The lane on the bottom represents the last evaluation type: profound. There is one task related to this type: list implicit motivation units.

As a first step of the evaluation, the techniques existent in the game are selected. By analyzing them and the structured mapped, shown in figure 7, affected motivation units are listed. If simple evaluation is sufficient, results are presented. Results are composed by the core drives and a brief explanation of each of them. Otherwise, The evaluation process continues. The next stage, aims to identify the attributes related to the game under evaluation. Several attributes may be affected by the game. Along these lines, the

attributes are raked and selected regarding their relevance within the context. Complete evaluation is treated as done. As results of these type of evaluation are presented the MUs, previously identified, and the attributes that are more likely to be influenced by the game. As the evaluation process advances, there is the profound evaluation. In the section of the evaluation process, the implicit relationships among core drives, techniques and attributes on the structure are analyzed. They allow the evaluation to discover core drives that have an indirect effect.

The evaluation starts by retrieving information about the game. The techniques existent in the game must be discovered. They are inferred from answers to the questions on the system. These questions collect material that can be compared to the characteristics of each technique mapped on the structure of the framework. The resulting techniques are used as input to the following steps of the evaluation. They are important to identify the core drives. After selecting the techniques, the core drives are identified from the data present in the mapped structure. The structure relates different aspects of the framework. Techniques and core drives are related to each other. Because of this, it is possible to find the core drives. One technique might be related to more than one core drive, so they might bring out more core drives than techniques, even though, they are more likely to have more techniques than core drives. Regarding the simple evaluation, the results may be presented. They are composed by the core drives and a brief explanation of each of them.

Likewise the simple evaluation previously described, there is the complete evaluation. The set of techniques and core drives in the prior evaluation section is used in this stage of the evaluation. The complete evaluation uses it to identify attributes influenced by the interaction with the game. All techniques are related to all the attributes, varying the level of alignment between them. Attributes are inspected and their influence reflects the participation of the techniques in the game. The value of each attribute in the game are calculated based on the relation of each attribute with the techniques.

Profound evaluation, on the other hand, searches for implicit relations among these elements. Core drives and attributes are not related directly. The techniques intermediate their relation. These implicit connections allows the last steps of the evaluation to bring result that would be unclear without the modeled structure. By analyzing the attributes resulting from previous steps, implicitly impacted core drives can be extracted. And are used to indicate the motivation in the game.

3.3.3 Methodology in action?

(MOREIRA; BELA; FREITAS, 2016) uses the, hereby presented, framework and heuristics of evaluation in the game Advisor to the King (AttK), designed by (BRITT et al., 2009). AttK is a game designed to teach argumentative skills to the target audience.

It was influeced by an intelligent tutoring system. Thus, it attempts to "teach the same types of knowledge as the tutoring systems did" (BRITT et al., 2009). AttK introduces a ludic fantasy to the learner, here as a player. (GEE, 2005) and (CLARK; MAYER, 2011) principles of educational game design were used to improve the game (BRITT et al., 2009).

The evaluation of AttK was conduted to both evaluate the game and test the proposed methodology. However, at the time the research was conducted, the methodoly was not automatic. It had to be done manually, according to the framework structure and following the steps of the evaluation, shown in 3.3.1 and 3.3.2. This study validates the use of the methodology.

(MOREIRA; BELA; FREITAS, 2016) articulate the benefits of the use of this methodoly and its contibution to the suggested context and audience. It is also declared that good results are achieved by using aligned games and gamification in classroom. Based on these result, the framework and methodoly were implemented.

3.4 Cognitive Learning

The evaluation system considers different aspects of a game. One of them is related to the Bloom's taxonomy cognitive processes (ANDERSON et al., 2001). The implementation of a system that is able to infer important aspects related to the Bloom's taxonomy, required the overall structure of the taxonomy to be breakdown and rearranged.

This was done to a certain extent that permits it to be understood by computer. Besides that, it needs to contain relevant information that allows the evaluation to be consistent with the expectations. This section describes what must be done to permit this kind of evaluation to be performed by computers interacting with a person.

Bloom's taxonomy is intended mostly for teachers, and curriculum experts (BLOOM, 1956). Also, it is mainly intended for making sure the objectives, activities and assessment are aligned. That means it is used to improve existent curriculum and facilitate the making of new curriculum. Because of that, it is, more often than not, a knowledge that concerns this audience. Thus, it is not common for other people to be proficient in the subject matter. Bloom's taxonomy is designed and structured to ease curriculum builder and educators to increase their understanding of curriculum content, intended learning, activities and assessment. Evaluating a curriculum may be a complicated task if the learning objectives are not clear stated, or are ambiguous, even though it is expected to be written and explicit (ANDERSON et al., 2001).

Written objectives are explicit and, even so, are likely to confound curriculum analysts. Evaluating learning objectives that are not clearly stated, might cause more

confusion. This is one of the reasons that evaluating games is more time consuming than evaluating curriculum, still for curriculum experts. To be able to do so, it is necessary that the person is familiar not only with the taxonomy, but the game as well. Specially because games objectives are not so clear to the audience of the game. Besides, the main purpose of evaluating educational games is different from curriculum evaluation. The evaluation of games has the purpose of classifying games regarding some aspect. It means that even curriculum experts will take some time to bring their knowledge from curriculum building to games evaluation.

This solution aims to help people that want to use educational games. Their choices can be based on aspects that are aligned to what they have previously planned to learn or teach. They will be able to choose consciously the ones that have the same objectives as they have when preparing classes, for example.

The implemention of EGA required deep understanding of the subject matter. In this context, Bloom's taxonomy. As previously presented on section (BLOOM, 1956), it was revised by (ANDERSON et al., 2001). The revision features two dimensions: cognitive processes and knowledge. The amended structure of the taxonomy is the groundwork for this project.It supports one of the main characteristics that is intended to be evaluated: cognitive process. This dimension promotes comprehension of cognitive processes for retention and transfer of knowledge.

Knowledge dimension is considered important to increase the curriculum alignment understanding. However, it will not be used on the evaluation system design. It was determined not to include knowledge dimension, because the main purpose of the evaluation system, so far, is to relate motivational and pedagogical aspects. Cognitive dimension accomplishes this objective satisfactorily. Evaluating this aspects required an structure that are understandable by algorithms. To achieve this, it was imperative to understand the taxonomy framework and be able to discriminate relevant information from irrelevant.

3.4.1 Learning structure

The construction of the framework structure that the evaluation was based upon, is presented in this subsection. The conception depends on the perception and understanding of the overall structure. In this context, only the cognitive domain. The processes existent in this domain are presented on figure 11. The figure demonstrates them in the same arrangement as it is presented on the revised taxonomy. Where the complexity grows as they go up in the figure. They are: remember, understand, apply, analyze, evaluate, and create, respectively.

Constructing the structure used as framework for the evaluation system required

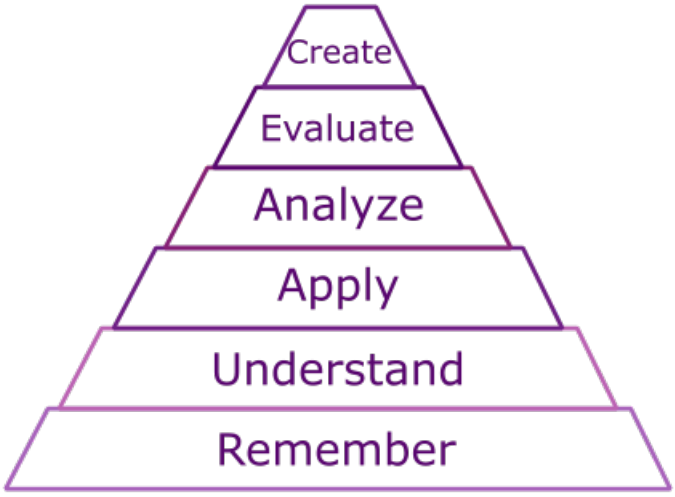

Figure 11 – Cognitive processes

actions. Each of them will be studied separately. This investigation allowed the understanding of basic elements that compose each process. These components and their relationship will be analyzed to find correspondences among them all. They are the a fundamental part to selecting significant parts.

3.4.2 Cognitive processes study

Anderson et al revision of Bloom's taxonomy (ANDERSON et al., 2001) presents six major cognitive processes. They are explained and defined accordingly. Besides, they have sub-categories - where each of them are explained too - which are related to assessment. The assessment tasks related to each of them are an important factor for the alignment question - one of the main purposes of the taxonomy. Moreover, there are instructional activities, that are not noted out.

Figure [REFBLOOMFIGURE] is a visual representation of the processes and subprocesses structure of the taxonomy. Each process is composed by some subprocesses. They are considered higher cognitive processes as they are higher in the figure. For example, "Create" is the highest cognitive process. And "Remember" is the lowest. Every subprocess is associated with a set of assessment. They are listed in table [INSERT ASSESSMENT TABLE]. Each assessment is related to at least one subprocess. These relations were used by the system to present consistent results. They are shown in table [INSERT TABLE].

4 Proposal development

This chapter presents processes and methods used in the development of this work. The methodology choice was based on different aspects. It is supported by the compatibility of the problem this work intends to solve, and the proposed solution. Besides, it was based upon the needs identified. They might be, but are not restricted to, time, flexibility, and visibility of the work.

4.1 Software Engineering

Software engineering is a discipline concerned with aspects regarding software production (SOMMERVILLE et al., 2011). Ranging from development processes, to tools, methods, and theories. Moreover, it involves time and financial constraints.

Sommerville et al(2011), present different approaches to manage software development. They are introduced as plan-driven and agile approaches. Plan-driven approaches software development is planned in advance. Differently, agile approaches follow the agile manifesto values (BECK et al., 2001). They are planned during the development, and embrace changes.

Agile project management frameworks and practices were adapted to be used in this project. The following sections present them. Furthermore, adjustments made to them to fulfill this context are also presented in the next sections.

4.2 Project Management

This section presents project management aspects regarding this work. Agile management frameworks were used to guide and supervise the development of this work. They are described in section 4.2.1. Schedule and respective tasks are presented on section 4.2.2.

4.2.1 Scrum and Kanban

Scrum is a framework to manage product development. It enforces iterative, incremental approach to problem-solving (SCHWABER; SUTHERLAND, 2014). With regards to the flexibility, scrum is appropriate for the context of this work. Iterations, called sprints, allocate a pre-defined period of time (citebib:mundra2013scrum). Thus, they are planned accordingly. The amount of work intended to be performed in a sprint must be reasonable to a sprint time-box. Because it is an incremental framework, sprints are expected to comprehend the development of valuable products. Furthermore, it suggests

roles, events, artifacts and rules. Each one of these elements have a specific purpose within the framework. However, they are not mandatory. Maintaining its adaptability nature.

Scrum aims for achieving transparency for stakeholders, permitting inspection, and facilitating adaptation. They are considered pillars of the scrum framework. These pillars were designed to address problems that might affect the development. They are presented in the next paragraphs.

Transparency: requires that observers share the same understanding of what is being seen. And outcomes must be always visible. Ensuring that what not only the understanding is the same, but the content also is the same.

Inspection: suggests that scrum artifacts are audited, as often as needed. It must be observed, however, that the frequency of inspection do not unbalance the work to be done. Performing inspections intends to detect variances that might hamper the progress of the development.

Adaptation: deviations might be found during inspection routines. If they are out of acceptable limits, the process or development must be adjusted. Modifications should be made as soon as possible. Minimizing risks and impacts that are likely to be caused by the deviations.

In the context of this project, some scrum practices were selected to be performed. They were chosen based on the advantages they would bring to the development. Practices that would not aggregate as much values as it would overcome the effort put into its performance, were eliminated of the scrum adaptation made for this work. The practices, artifacts, and events gleaned were:

- Product backlog,
- Sprint,
- Sprint backlog,
- Sprint planning,
- Sprint review.

Artifacts incorporated are product backlog and sprint backlog. Scrum events adapted to the context are planning, and review meetings. The product considered is the proposed social network. Product backlog elicited consist of a list of features and work to be done for the social network. They were presented in section **??**. Respecting the extent of time determined for the development of this work, they were assorted. A product backlog is considered to never be complete, once they might incorporate new functions, requirements and enhancements. A set of the product backlog selected to be developed during a sprint

is considered: sprint backlog. In this context, sprints are projected to last a week. Sprint planning and review are meetings. They were adapted to be an unique meeting. During meetings, project progress is discussed. As well as next steps.

Besides, scrum also allows employment of other processes and techniques to the framework. To improve the visibility of the work, the Kanban method is used in this project. It facilitates the visualization of the workflow, and the limits for the work in progress (IKONEN et al., 2011). Kanban boards do not have rules to regulate their usage. There are, however, practices that aim to guide their implementation. For instance, the board usually represents stages that tasks flow as their implementation progress. Because of this, tasks are preferably represented in easily moved material - physical, as sticky notes, or digital, as in specific software products. Hence, the overall situation of the project is illustrated on the board. It promotes increase of motivation and control over activites (IKONEN et al., 2011). The Kanban board, in this work, was executed physically. There are four columns: product backlog, tasks to be done, tasks in progress, and finished tasks. Sticky notes were used to represent tasks.

4.2.2 Schedule

The project is subdivided in two releases. The first part of the project was developed during the first semester of 2016, referred as *release 1*. The second release is expected to happen during the second semester of the same year. This section presents the schedule for the first release, tasks executed, and respective outcomes.

The execution schedule for release 1 is presented on table 3. It presents performed tasks. They are separated into three groups: general, motivation, and learning. The are related to the months when they were executed. Tasks grouped as motivation are related to motivational aspects that support the proposed evaluation. Meanwhile, tasks allocated as learning are correlated to the cognitive processes associated with learning, that guide the evaluation. Other tasks are categorized as general.

The tasks planned and executed in release 1 are presented in tables 3 and 4. Table 3 portrays tasks and when they were executed. Table 4, however, relates tasks and their respective descriptions, and outcomes.

	Tasks	March	April	May	June
General	Review literature	X	X		
	Define proposal	X	X		
	Refine proposal			X	X
	Report project			X	X
Motivation	Review frameworks	X			
	Select framework	X			
	Extract elements		X		
	Map relations		X		
	Develop heuristic			X	X
Learning	Review frameworks	X			
	Select framework	X			
	Study framework		X	X	

Table 3 – Release 1 schedule overview

	Task	Description	Outcome
General	Review literature	Review works related to this project	Study
	Define proposal	Define intended results and activities to accomplish them	Draft proposal
	Refine proposal	Refine proposal according to execution constraints	Final proposal
	Report project	Write document to report findings and goals	Document
Motivation	Review frameworks Select frameworks	Study existing frameworks Select frameworks that provide foundation to achieve the goals	Study Octalysis and others
	Exctract elements	Identify elements of the frameworks that will compose solution	List of elements
	Map relations	Map relations of elements to create model for the solution	Model for relations
	Develop heuristic	Formalize evaluation process based on model	Process definition
Learning	Review framework	Study frameworks that evaluate learning objectives	Study
	Select framework	Select appropriate taxonomy	Bloom's Taxonomy
	Extract elements	Identify and extract relevant elements	List of elements

Table 4 – Tasks and outcomes for release 1

5 Conclusion

5.1 Final Considerations

Finding a proper game that is suitable for a specific learning goals is not an easy task. There are characteristics that might affect learning. They must be analyzed to ensure a game is appropriate for the situation. Evaluating these aspects require comprehension regarding concepts that involve them. The development of a software that support by assessing this characteristics would facilitate their evaluation. Moreover, digital evaluations allows the creation of an repository for educational games and their respective evaluations. It is possible to add other features that will increase communication and promote discussion about them.

Research for the concepts that are observed for the expected evaluation was conducted. The results provided enough background for modeling structures that are suitable for this project goals. Thus, the development of the system will be continued.

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