The Power of the Game as a Mediator Tool Paradigm of Object Oriented Teaching-Learning Process

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Abstract— **with the diffusion of new technology and the impact they caused, it became necessary to understand and use them in searching for ways to help both students and teachers in the teaching and learning processes. In this context, this research presents a development model that aims to assist teachers and developers in the elaboration of educational games. This model is named Model Gaia Abstraction Game, which employs cooperative gaming techniques and the theory of meaningful learning in order to support game development. As a case study, the model was used in the development of Gaia Abstraction Game OO, which aims to assist the teaching and learning process of the Object-Oriented paradigm – one of the most complex concepts in current computing theory. Since this paradigm works mostly with objects abstraction and classification, the concept is not always clear for the students, even though it is core for the initial subjects in computing courses. This study is grounded on researches of authors who approach the importance of games as facilitators in the learning process. The major contributions provided by this study are: stress that the game can help arouse students' interest; make the classes dynamic and appealing; help students learn in a playful and pleasurable way; facilitate the mediation of knowledge; and create a mutual cooperation environment among students, promoting their full development through motivation.**

Keywords—Games; Cooperative Games; Computer Games; Object Orientation; Meaningful Learning.

I. Introduction

One of the main challenges faced by adults, youngsters, and children is having an effective learning. Teachers are in charge of providing students with a critical sense, that is, making these individuals capable of reflective thinking. This is the age of fast-paced transformation, especially in relation to science and technology – it is hard to picture current teaching and learning without technological resources. The traditional education model may no longer be enough to fulfill students' desires. Amorim et. al. [1] states that when students passively watch classes they cannot make connections with reality, because the content often does not make sense at all for them.

Another aspect to consider is that the emergence of applications and social media has been hampering teachers' performance, since competing with such devices is not an easy task. Draw students' attention in lab classes has becoming increasingly difficult. These devices offer students a wide array of fun and entertainment options, including the games [16].

In light of this situation, researchers and teachers realized that games could be used as allies – instead of enemies – in the teaching-learning process. Studies presented throughout this paper point out games can promote the development of the abstraction ability. Games encourage learning – that is, connecting knowledge and skills – ultimately leading individuals to satisfy their needs and desires.

This study presents the development of *Gaia Abstraction Game OO*, which aims to assist the teaching and learning processes of the Object-Oriented paradigm. Since the paradigm relies mostly on abstraction, the concept is not always clear for students, even though it is core for courses such as Software Modeling, Database Design, and all the Programming courses.

The game lies within the meaningful learning context: previously learned concepts are reinforced in order to be restructured – in a consistent and broader way, which makes the learning process more open to new concepts. Previous concepts are practiced throughout the game, providing players with opportunities to achieve knowledge consolidation in every step. According to Ausubel [4], meaningful learning occurs when new information is acquired through a deliberate effort of the student in connecting this new information with relevant preexisting concepts or propositions in their cognitive structure.

II. LITERATURE REVIEW

A. *Meaninful Learning with Technology*

With the emergence of new technology and the increasing diffusion of social media, the traditional education model seems no longer enough to motivate students to understand new concepts. There is an urge to create, build, and transform the teaching-learning process [14].

According to Santos [19], the learning model to fit our current needs can no longer be the traditional model – the one by which students are given ready-to-use information and are merely requested to repeat them.

As stated by Piaget [18], knowledge is always constructed through adaptation and through the challenges the individuals undergo. In order to engage students in the deepest level of meaningful learning, they must learn to perform the analogical reasoning (structurally comparing ideas), the causal reasoning (predictions, inference, and implications), construction of the conceptual model, the argumentation (rhetoric and dialectics), and the metacognitive reasoning [11].

In light of the aforementioned context, this study is grounded on the theoretical-methodological paradigm presented by Ausubel [4]. According to the author, the promotion of meaningful learning is based on a dynamic model, in which the student is taken into account with all their mental interconnections and knowledge. As means to facilitate the learning process and make it more dynamic and appealing for the students, this study uses the research conducted by Howland, Jonassen, & Marra [10] on the power of technology as facilitating means of the meaningful learning. According to the authors, technology is useful in promoting the meaningful learning because it can facilitate the thinking process. Also, technology is used to convey information and explore knowledge, allowing individuals to compare perspectives, beliefs, and points of view.

In Ausubel's meaningful learning approach, the base information stored in the cognitive structure is named anchoring-idea or subsumption. Subsumptions are specific structures that allow information to integrate within the human mind – which, in turn, is highly organized and possesses the conceptual hierarchy to store the student's previous experiences. Thus, new information can interact, promoting the transformation of previous knowledge in new.

Howland, Jonassen, & Marra [10] claim that the use of technology can be a powerful approach to learning, but some factors must be taken into consideration: technology must not be used in the traditional style – merely as means of delivering instructions for class; technology must not be used to teach students – they learn *with* them instead; meaningful learning achieves positive results if technology engage students in knowledge construction instead of its reproduction; dialogue instead of reception; articulation instead of repetition; collaboration instead of competition. They claim technologies can support meaningful learning if students learn *with* them, and not *from* them.

B. Games

Games have been increasingly more used in classroom context. Most teachers – including teachers at the Public Center for Culture and Development (*Centro Popular de Cultura e Desenvolvimento* [CPCD], in Portuguese) [7] use game resources to make classes more pleasurable and fascinating. Furthermore, such resources have strategic role in promoting logical reasoning, leading students to learn to handle everyday conflicts.

Games can be described as rich and unique resources that grant the ability to produce or transfer knowledge, causing the individuals involved in the game interaction process to acquire knowledge and achieve intellectual and cultural growth. Games promote motivation for learning and organize knowledge and skills at the same time, leading players to fulfill their needs and desires. Thus, games can favor the teaching-learning process of students with learning difficulties. According to Netto & Santos [13], educational games are ready-to-use tools a teacher can manage in order to make classes more appealing, dynamic, and fascinating.

Including games in classroom context aims to enrich educational practices with creativity and with resources that promote knowledge acquisition by the students [2]. As stated by Souza [21], games have the power to convey information in a fun and interactive way, and are especially effective when used in playful environments linked to entertainment. Using games in classroom is an interesting strategy to promote development, not only because of the motivation a game can arouse, but also because of the entertainment it can provide [8].

Soler [20] states that there is always something new about the game, which is a fundamental characteristic to arouse interest in students. This "newness" makes games one of the most suitable means for knowledge construction. Games foster pleasurable and appealing environments, promoting the students' full development.

C. Cooperative Games

Cooperative games essentially encourage competition as much as mutual cooperation between players [15]. Cooperative games are extraordinarily effective for personal development and social interaction improvement.

By playing cooperatively, individuals can spontaneously and authentically express themselves, meaning they are important and worthy essentially for being themselves – and not because of their score in the game. Through an educational environment, cooperative games teach students that winning or losing is not relevant – more important is to make everyone work together towards a common objective.

According to Orlick [17], the main focus of cooperative games is to provide opportunities for the cooperative learning and pleasurable cooperative interaction. Such games emphasize that everyone is important, since the participants depend on each other in order to accomplish goals. Games and cooperative games are ideal to teach cooperation and collaboration skills.

Using cooperative games in classroom context creates opportunities for the students to take responsibility in knowledge construction, making them work together in order to reach goals on behalf of the group – that is, leading students to help each other, and to develop problem-solving skills.

Brotto [6] and Soler [20] define cooperative games as games in which participants play *with* each other instead of *against* each other, seeking to overcome challenges, share knowledge, take risks with little concern over failure or success, and reinforce authenticity and mutual confidence between parties.

III. Gaia Abstraction Game Applied to Teaching-Learning the Object-Oriented Paradigm

Gaia Abstraction Game Object Orientation – or simply Gaia Abstraction Game OO – is divided in eight stages, each one covering a specific topic on the Object-Oriented paradigm, namely: objects abstraction, classes specification, object definition, principles of class relationship (inheritance, composition, and aggregation), data types, data visibility, cardinality, and stereotypes.

The game includes (57) fifty-seven cards, each one representing a different class (mold). The game progresses as the players collect cards – which makes them one of the most important aspects of the game. Cards are important in stages such as: attributes and methods abstraction, and determining class relationships. The cards are illustrated, so that students can "think as children" once again. According to Guedes [9], we learn, at an early age, to have an Object-Oriented approach to thinking, by expressing knowledge through abstraction and classification. As children learn simple concepts – such as person, car, and house, for instance – they also define classes, that is, a group of objects – each one belonging to a specific group, in which objects share properties and behaviors. Fig. 1 shows the cards structure in the game.

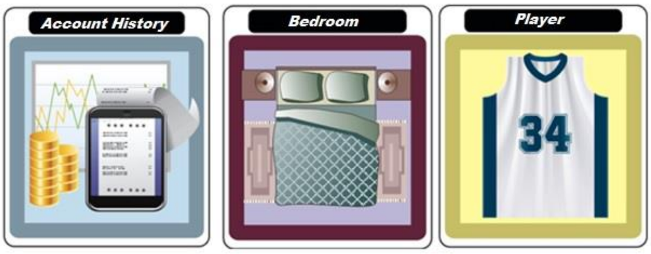

Fig. 1 – Business Cards (Bank, Hotel, and Match).

In order to understand the relationships between cards (classes), students have to determine the scenarios a card can be associated with: they must use the Business Cards, which, in turn, are divided in seven types of business. The business types represent the software requirements to be developed by the work group. Lima [12] defines requirement as a required condition or ability for a system to reach specific objectives within a project. The goal of any system – a software model or a business process – is to meet a set of requirements, that is, fulfill a group of needs through the system development. For each business, there is a brief description of the business requirements to be designed (modeled throughout the game) (Fig. 2).

Fig. 2. – Hotel Business Card.

In order to simplify the abstraction process, the game includes boards with drawings of the classes – each business in the game is related to a specific board. The boards were included to organize classes, as well as to help students visualize the relationships between them. The board interface – where several steps of the game take place – is presented in subchapter A, which describes in detail its structure and goals.

A. *Game Progression Interface*

The game progresses inside the "rooms", each one representing the visual environment of the business to be modeled during the game. As the game starts, each student receives a card, and is requested to look for the corresponding room. In this context, the student must choose one of the seven rooms (businesses to be modeled). If the student chooses a wrong option, the system displays an error message warning that the selected room does not correspond to the card. Ideally, students should read the requirements of all rooms before they choose the corresponding room (business). In order to access the requirements, students must explore the business icons – visual representations of the business. By selecting the icon, a description of the corresponding business is displayed.

Students are also encouraged to use the chat tool to request help or share information with others. At this point of the game, all the players have access to the chat, so asking for hints may be decisive in selecting the correct room – especially because if the player attempts to enter the wrong room the whole group loses points. An example of how players can benefit from the chat is that, at a first glance, some cards may fit several businesses – the card "sale" could be associated with the "drugstore", the "sale", and the "car dealership" businesses. However, after further analysis and discussion, it becomes clear this card fits just one business. Besides the drawing, cards also have different edge colors. Each set of cards (business) has a unique color: gray for the drugstore cards, light blue for the sale cards, and so on. Fig. 3 shows the interface where students select the rooms, and the chat tool with discussion topics and hints from the other players. Once students find the correct room, they can move on to the other tasks in the game.

Fig. 3. – Room Selection Interface.

It is inside the room, however, that most of the game interactions take place. In this interface, students begin to practice their knowledge about the Object-Oriented paradigm: they are requested to fill the form with the attributes (properties of the objects) and the methods (actions performed by the objects) related to their card. The game provides a list of initial predetermined attributes and methods, but only a few are correct. False options were placed in order to challenge students, since several attributes and methods are similar. The difference (and the challenge) lies on spelling – accentuation, cedilla, and letter spacing – because such marks totally escape the nomenclature patterns for attributes and methods.

In addition to working with attributes and methods, in this stage of the game students also practice the visibility concept and the data types. According to Guedes [9], visibility indicates the access level of a specific attribute or method inside the class or inside a specific group of classes. In the game, visibility types are represented by symbols to the left of attributes and methods, namely: public, protected, and private. Public visibility is represented by the (+) symbol, meaning that an attribute or method can be accessed by any object; protected visibility is expressed by (#) and states that, in addition to the objects in the parent class, access is granted to attributes and methods in child classes; lastly, private visibility is represented by (–), meaning that only objects in the parent class are able to visualize and use the attributes and methods. The visibility types described are largely used in current system modeling process. In turn, data types define the possible data values and the possible operations to be performed over data. Data types are categorized in primitive and structured. The following data types are practiced in the game: *varchar, int, date, float, double, boolean,* and *time.*

In the game, students must correctly fill the descriptions for attributes and methods. Attributes are described by: visibility, object property (special characters are forbidden), and its related data type – for instance: **(# cod: int)**, meaning the client identifying code. In turn, the methods are described by: visibility; object action; and () open and close parentheses, representing the method output – for instance: **(+ list_cli())** is the method to list all clients stored in the system database.

The game also addresses the concept of identifier attribute (a unique property of an object) – which is extremely important at this stage. An identifier attribute (ID) allows the individualization of each instance. An instantiated object connects with its identifier attribute (ID), granting exclusive access to its location. Students must choose the identifier attribute for each object from the list of predetermined attributes.

The player will be able to request another card once the attributes and methods for the current card are completely filled – students must assure there are no blank fields left. The system provides more cards according to the number of players, but each player will receive three cards maximum. Fig. 4 shows the interface used for attributes and methods abstraction. The room interface includes three question mark icons and a help icon. The question mark icons lead to a help screen on the topics: attribute, method, and identifier attribute (ID) – one icon for each topic. The help screen then displays a description of each component. As for the help icon, it briefly describes all the topics related to the Object-Oriented paradigm covered by the game. The icons were designed so that, as the game progresses, students can be independent, that is, teacher's assistance is not necessary – doubts concerning the game are all covered in the help section.

Fig. 4 – Interface for attributes and methods selection.

Once all players finish selecting attributes and methods for their cards, they are granted access to the board screen. Several concepts of the Object-Oriented paradigm – such as class relationships, cardinality, and stereotypes – are practiced in this interface. As mentioned in the beginning of this subchapter, each room is connected to a specific board, and each card fits an ideal position. This placement method was designed to avoid classes overlapping – which would cause bad visualization. In order to organize classes, students must communicate, since each player will be handling only their own cards – and not their peers'.

Relationships are a major topic in the game, since they guide the choice of cardinality and stereotypes. The following relationships are available in the game: binary, inheritance, aggregation, and composition. Binary relationships happen between objects from two different classes. In inheritance, a class or object inherits from (is based on) another, which can be a superclass (also called parent class, base class), or a subclass (child class, heir class). Broadly speaking, child classes inherit properties and actions, that is, attributes and methods from parent classes. Aggregation, in turn, implies the object information (the whole) will be complemented with information from one or more objects of another class (the part). Finally, composition is a variation of the aggregation relationship, characterized by a stronger link between whole and part components, in which component parts associate with a single whole. In this case, removing the *whole* (parent class) will cause the *parts* (child classes) to be removed, too.

At this point of the game, students are completely independent to try different relationships, regardless of the player the class belongs to. Any player can perform the action once they feel confident, since the game is cooperative – winning or losing is a group status. Prior to completing this task, students are expected to have discussed as a group in order to reach a common decision on the relationships. Fig. 5 presents the board composition in the game. Some classes are represented with a ticker outline stroke, meaning the player can only interact with a specific set of cards.

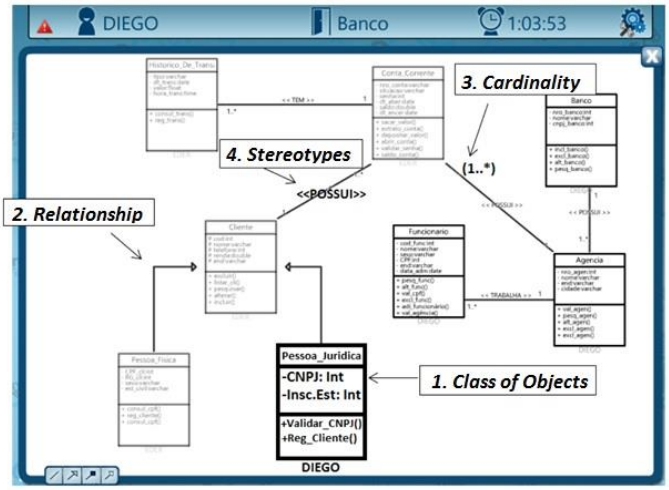

Fig. 5 – Bank Business Board; all Relationships, Cardinalities, and Stereotypes completed.

Once the relationship stage is completed, students progress to the final portion of the game – cardinality and stereotype selection. Cardinality – also called multiplicity – aims to determine the minimum and maximum number of objects involved in the association. That is, cardinality helps determining the relationship, because it defines the number of occurrences within a relationship. This example appears in Fig. 6: a BANK has "1...*" (one or more) BRANCHES, but a BRANCH is part of only one BANK "1…1*" (one or one). The first digit indicates the minimum cardinality, and the second indicates the maximum cardinality. In Gaia Abstraction Game OO, cardinality follows the same nomenclature patterns of most modeling UML and DER tools, which are predefined: ((1...1), (1...*), (0…*), and ((0…1)). It is the players' responsibility to use it correctly, according to the relationship selected by them.

Along with the cardinality specification, the student must also determine the relationship stereotype, since stereotypes grant associations a certain degree of extensibility – in addition to providing the identification of such associations (relationships). Similarly to the cardinality, stereotypes follow the UML nomenclature patterns, and are graphically represented by <<>> (two "less than" and two "greater than" symbols), that must be typed on top of the relationship field. In this version of the game, stereotypes intend to promote the understanding on the relationships between classes (cards). For instance, Bank (class) <<has-a>> (relationship) Branch (class). Fig. 6 demonstrates the interface screen for the selection of relationships (associations), stereotype, and cardinality. In order to access this screen, the student must double click the relationship field, which will lead to the interface screen called Association Property. At this point, should the student have doubts on the type of relationship, it is possible to change the status instead of deleting the relationship – they must simply click on the association box and change the type (Fig. 6).

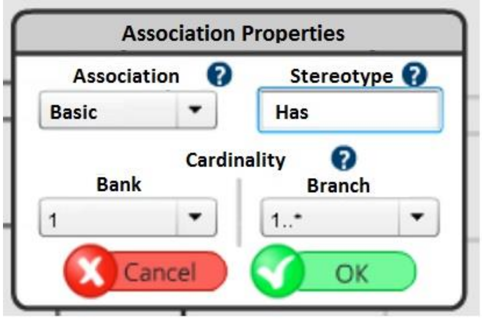

Fig. 6 – Association Property Interface.

Once all cards were received – related to the business the group is modeling – and all the required tasks are completed, the game is finished. Students must click on the "finish" button in their own workspace. By doing that, a message is displayed on the screen: "waiting", since the other players, too, must complete their tasks in order to end the session.

After completing all tasks, the group score is displayed to all the players, including the score per stage and the final score. In the game, the score is not individual, but indicates the group performance instead. This was designed to promote cooperation within the group, preventing players to becoming individualistic. Also, this avoids arguments between players. The development of Gaia Abstraction Game OO is guided by the approach of important authors on cooperative games, such as Orlick [38], Brotto [6], and Soler [20]. The main goal is to provide opportunities to promote cooperative learning and pleasurable cooperative interaction, where students play *together* instead of *against each other*. It aims to overcome challenges and share knowledge, since the players depend on each other to reach goals.

B. Chat Tool

When playing cooperatively, communication and interaction between participants is essential. To be considered cooperative, a computer game must provide an environment in which participants work independently and can be arranged in groups to reach a common goal. In order to promote cooperation, some aspects are necessary, such as: multiplayer support, and communication between participants. According to Arriada [3], communication is key to engage a cooperative team.

Gaia Abstraction Game OO resorts on a chat tool to promote communication. The chat tool is provided through a computer network where messages are exchanged in real time, that is, all players receive the messages synchronously.

The chat tool is an important component within the game setup, as several situations throughout the game require communication between players to perform tasks. Gaia Abstraction Game OO includes two chat modalities: first, the general chat room – where all players can interact – is used in the beginning of the game to help students find their room. Once students are inside their rooms, they start using the room-specific chat – the second modality – where the players in each work group interact in order to reach a common objective: completing all tasks in the shortest possible time, with the highest possible score. Examples of the general chat and the room-specific chat in use are available in Fig. 7. While having the conversation, students are expected to realize the importance of the tool in helping them find their room and abstract the attributes and methods correctly.

Fig. 7 – Chat Room Interface with Conversation Examples.

IV. Case Study

Prior to testing the game in classroom context, professors and students were consulted – in informal discussions – to start mapping the level of knowledge students had on the Object-Oriented paradigm. It also proved students have difficulty understanding the concept. One of the major difficulties reported by students was transforming real-world objects in computing objects. Since the subject is highly conceptual, classes are often exhausting. Among the difficulties reported by professors is motivation. Professors strive to make classes more interactive and appealing – especially because the subject is considered as one of the most complex and difficult to understand in computing courses.

After the informal discussion with professors and students, the effectiveness of the game in teaching-learning the Object-Oriented paradigm was verified and validated. The game was tested with two distinct groups of players: students and professors.

A. Group of Students

The game evaluation – performed in software modeling classes – had two phases: first, Object-Oriented concepts were explained, emphasizing the class structure (abstraction, objects, classes, attributes, relationships, etc.); the second phase covered the explanation on the game structure and goals.

The game was tested with around 150 (one hundred fifty) students, aged 15 to 19, in four classes from the Computing for Internet technical course. Assessment occurred in two situations: first, the game was tested in each class, meaning only students belonging to that class formed the groups. Second, groups of students were formed regardless of their class, with a maximum of 35 (thirty-five) students (maximum number of participants the game was designed for). Assessment objectives included the level of cooperation and integration the game promoted between students. The same professor taught three out of four classes, whilst the fourth class had a different lecturer, meaning that different approaches could have been used in teaching the subject, causing students to have different levels of understanding on the paradigm.

Following that, a quantitative questionnaire was used to measure whether the game helped the teaching-learning process of the Object-Oriented paradigm. As they finished the game, students were handed the questionnaire – which included 15 questions on the assistance provided by Gaia Abstraction Game OO concerning their learning process.

B. Group of Professors

The game was tested with 10 (ten) professors of computing courses, who teach – or had taught – classes on the paradigm. Similarly to the assessment with the students, the assessment with professors happened in two phases: in the first, concepts on the Object-Oriented approach were briefly explained, emphasizing the topics covered by the game, so that professors could evaluate and validate its effectiveness; the second phase covered the explanation on the game structure and goals.

In order to measure the assistance provided by the game in the teaching-learning process, professors were handed a questionnaire including 5 (five) questions. The answers had a grading scale from 1 to 5, described as follows: 1 "failing"; 2 "poor"; 3 "fair"; 4 "relevant"; and 5 "very relevant".

C. Results

An initial analysis of the data collected from the questionnaires handed to students and professors reports Gaia Abstraction Game OO can significantly and positively assist the understanding of Object-Oriented concepts. Most respondents reported the game had a positive impact on practice.

This initial evaluation involved students from a technical course who have had previous experience with the Object-Oriented paradigm in order to measure the improvement promoted by the game.

When asked about the level of improvement the game could promote to the teaching-learning process of the Object-Oriented paradigm, students reports were: 47% (out of 150 participants) reported the game promoted a successful improvement, 51% reported it promoted an average improvement, and 2% did not respond (Fig. 8).

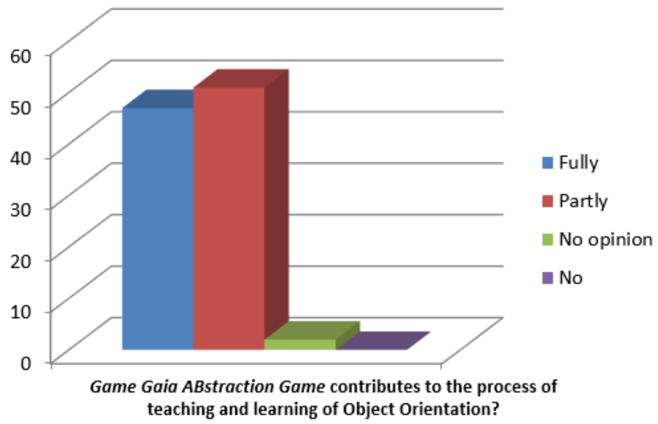

Fig. 8 – Improvement promoted by Gaia Abstraction Game OO in the teaching-learning process of the Object-Oriented paradigm.

From the sample of students who reported the game promoted an average improvement in the teaching-learning process, 8% reported it improved between 10 to 30%, 48% reported it improved between 40 to 60%, and 44% reported it improved between 70 to 90%, as shown in Fig. 9.

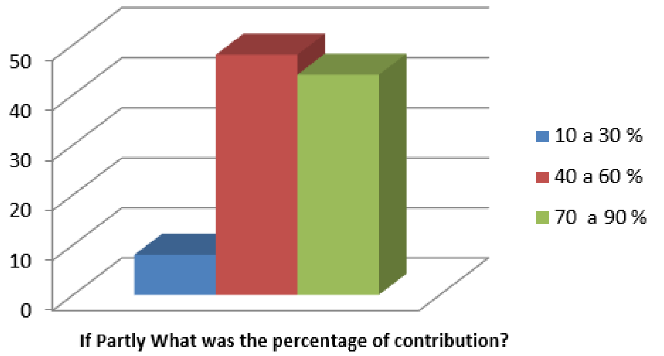

Fig. 9 - Percentage of improvement promoted by the game among respondents who reported aa average level of improvement.

When asked to what extent Gaia Abstraction Game OO improved the understanding of core concepts, such as abstraction, objects, classes, and relationships, most students reported the improvement promoted to learning was successful or average (Fig. 10).

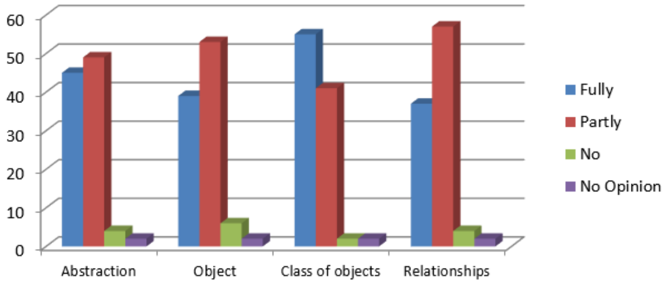

Figura 10 - Percentage of improvement the game promoted for core concepts: abstraction, objects, classes, and relationships.

When asked whether Gaia Abstraction Game OO promoted cooperation between participants and work groups, 91% responded positively, whilst 9% said the game did not provide a cooperation environment between participants (Fig. 11).

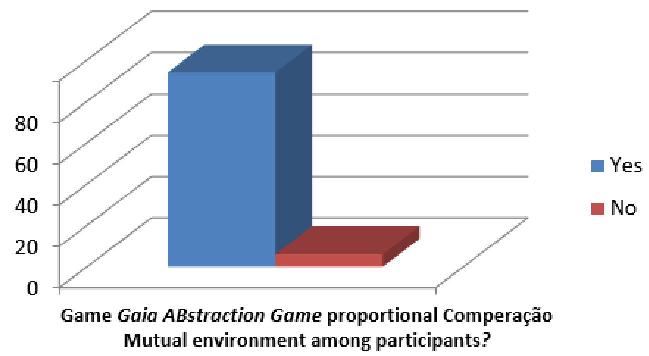

Fig. 11 - Percentage of students who reported Gaia Abstraction Game OO promoted cooperation between participants.

Professors' opinions on the effectiveness of Gaia Abstraction Game OO reported a positive feedback: 90% of the topics were given marks 4 or 5, proving the game relevance in teaching learning the Object-Oriented paradigm. Table 1 summarizes the grades given.

TABLE I – PROFESSORS' FEEDBACK

Questions versus Professors	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Mean
In your opinion, does Gaia Abstraction Game cover a wide array of concepts related to the Object-Oriented paradigm?	5	5	5	5	5	5	5	4	5	5	**4,9**
In your opinion, did Gaia Abstraction Game successfully assist the teaching process of this paradigm?	4	4	5	5	5	5	4	3	5	5	**4,5**
In your opinion, can Gaia Abstraction Game be considered a facilitating tool in the teaching-learning process?	5	5	5	5	5	5	5	5	5	5	**5**
In your opinion, does Gaia Abstraction Game provide students with a cooperation environment?	4	4	5	5	5	5	5	3	5	4	**4,5**
In your opinion, did the game help the teaching-learning process of the Object-Oriented paradigm become more interesting, appealing, dynamic, and playful?	5	5	5	5	5	5	5	4	5	5	**4,9**

a. Created by the authors

V. CONCLUSION

A major difficulty in computing courses – especially in conceptual courses, such as Software Modeling, Analysis Theory, and Database Project – is to increase students' motivation. Since the beginning of the course, students are often used to working and learning through repetition and memorization, as opposed to abstracting acquired knowledge in problem-solving techniques.

Using Gaia Abstraction Game as a mediating methodology in teaching those courses is an attempt to motivate students and stress the importance of the subject.

Thus, this study presented related games used in different education fields; stressed the importance of cooperative games in meaningful learning; and, lastly, described the game development – including real-life scenarios where Object-Oriented concepts are largely employed. Students, then, are able to practice such concepts in modeling businesses in the game. By playing the game, students are taught to prepare a class diagram step by step, as well as to apply Object-Oriented concepts in building a system.

Since the Object-Oriented paradigm is majorly abstract, playing the game may help students become more confortable and motivated so that learning can be easy and effective – that is, students understand the concepts and are able to employ them in real-life situations. This conclusion is drawn from a case study: the game was tested in courses where the Object-Oriented paradigm is taught. The results also show that using games promote knowledge construction and improve students' confidence – in this context, lecture classes become low priority in the teaching process. Students and professors can benefit from using Gaia Abstraction Game OO in several ways, such as:

- More dynamic, appealing, and motivating classes;
- Promotion of a cooperation environment between students, since the game is played in groups rather than individually;

- Learning in a playful and pleasurable environment;
- Students who are more familiar with the paradigm can help others while playing the game;
- Students can relate theoretical and abstract concepts to real-life situations they are familiar with.

The feedback received from students and professors through the questionnaires suggests significant improvement in learning the Object-Oriented paradigm, which leads to believe that Gaia Abstraction Game OO may be a powerful tool in the teaching-learning process. The need for further investigation – testing with more students, and with different levels of knowledge – is undeniable. However, initial evaluations indicate the game has a positive impact on learning.

Future work includes designing a function to either implement the classes modeled during the game in executable code in programming courses, or integrate several courses with the modeled objects. Also, the game interface needs improvement, as well as the chat tool – which could be more interactive – integrating sound and video features – so that information sharing between students can be more dynamic.

The concepts and components described in this study can also be merged into a development model for educational games. In fact, the approach is currently being used in the development of games for Mathematics, entrepreneurship, and English classes.

REFERENCES

[1] AMORIM, MYRNA CECÍLIA MARTINS DOS SANTOS; OLIVEIRA, ELOIZA SILVA GOMES; SANTOS, JOEL ANDRÉ FERREIRA; QUADROS, JOÃO ROBERTO DE TOLEDO. Aprendizagem e Jogos: diálogo com alunos do ensino médio-técnico. 2016 Educação & Realidade, Porto Alegre, v. 41, n. 1, p. 91-115, Mai. 2016.

[2] ANDRADE, MARIEL; ALMEIDA, EWERTON; SILVA, CHERLIA; MELO, MARIA THAMIRES; OLIVEIRA THIAGO; FALÇÃO FRANCIELLY AND ARAUJO ALBERTO. Colentando: Desenvolvimento de um Jogo para o Ensino-Aprendizagem no Campo da Educação Ambiental. 2012. In: XI SBGames 2012 SBC – Proceedings of SBGames (XI SBGames), Brasília.

[3] ARRIADA, MÔNICA, RAMOS, EDLA. Uma Taxionomia para as Formas de Organização das Atividades Cooperativas de Aprendizagem. 2000 In: XX WEI 2000 SBC - Congresso da Sociedade Brasileira de Computação (XX WEI), Curitiba.

[4] AUSUBEL, DAVID ET AL. Psicologia Educacional. Interamericano. 1980.

[5] BARBOSA, PRISCILLA ALVES, MURAROLLI, PRISCILA LIGABÓ. Jogos e Novas Tecnologias na Educação". Revista Perspectivas em Ciência Tecnológicas, 2013 http://www.fatece.edu.br/revista/perspectivas/volume2/pdf/Priscila%20Alves%20Barbosa%20e%20Priscila%20Ligab%C3%B3%20Murarolli.pdf. Jan 2014.

[6] BROTTO, FÁBIO OTUZI: Jogos Cooperativos. O Jogo e o Esporte como um Exercício de Convivência. Santos, SP, Projeto Cooperação. 2001.

[7] CENTRO POPULAR DE CULTRURA E DESENVOLVIMENTO. Quando Sinto que já sei. 2014. Available at https://www.youtube.com/watch?v=HX6P6P3x1Qg. Access in Dez 2015.

[8] ESPINOSA, RUTE S. C; GÓMEZ, JOSÉ L. E. Aprendizagem Baseada em Jogos Digitais Entrevista com Professores que utilizam jogos digitais em suas práticas educativas. 2013 In: XI SBGames 2013 SBC – Proceedings of SBGames (XI SBGames), São Paulo, SP. ISBN: 2179-2259.

[9] GUEDES, GILLEANES T. A. UML 2: Uma Abordagem Prática, São Paulo, Novatec, 2009.

[10] HOWLAND, JANE. L; JONASSEN, DAVID. H; MARRA, ROSE. M. Meaningful Learning with Technology, 4th Edition. 2011 Available at: https://www.pearsonhighered.com/assets/hip/us/hip_us_pearsonhighered/samplechapter/0132565587.pdf, access in Feb 2016.

[11] JONASSEN, DAVID. H. Learning to Solve problems: A handbook for designing problem-solving learning environments. New York: Routledge. 2011.

[12] LIMA, ADILSON DA SILVA. UML 2.3: Do Requisito à Solução, São Paulo, Érica. 2011.

[13] NETTO, D. P. S., SANTOS, M. W. A. AlfaGame: Um Jogo para Auxílio no processo de Alfabetização. 2012, In: 23º Simpósio Brasileiro de Informática na Educação (SBIE 2012), Rio de Janeiro, RJ. ISBN 2316-6533.

[14] OLIVEIRA, EDER DIEGO; BARROS, RODOLFO MIRANDA DE. ABstração Game um Jogo para Facilitar o Processo de Ensino e Aprendizagem da Orientação a Objetos, 2013 In: XXXIII Congresso da Sociedade Brasileira da Computação 2013, Maceió. XXI Workshop Sobre Educação em Computação, 2013. p. 395-400.

[15] OLIVEIRA, EDER DIEGO; BARROS, RODOLFO MIRANDA DE. Gaia ABstração Game: Proposta de um Jogo para Mediar o Processo de Ensino-Aprendizagem do Paradigma da Orientação a Objetos 2013, In: XVII Simpósio Brasileiro de Games e Entretenimento Digital 2013, São Paulo. v.1.p. 533-540.

[16] OLIVEIRA, EDER DIEGO; BARROS, RODOLFO MIRANDA DE. Gaia ABstração Game: Um Jogo para Ensinar o Paradigma da Orientação a Objetos 2015, In: XVII Simpósio Internacional de Informática Educacional 2015, Setúbal. Portugal.

[17] ORLICK, TERRY. Vencendo a Competição: Como Usar a Cooperação 1989. São Paulo, SP. Circulo Livro.

[18] PIAGET, JEAN. Biologia e conhecimento. Petrópolis: Vozes, 2003.

[19] SANTOS, JÚLIO CÉSAR FURTADO DOS. O Desafio de Promover a aprendizagem Significativa. 2012 Available at: http://cenfophistoria.files.wordpress.com/2012/02/textodesafio.pdf. Access in 15 April, 2013.

[20] SOLER, REINALDO. Jogos Cooperativos, Rio de Janeiro, 3ª edição, Sprint. 2006.

[21] SOUZA, ALESSANDRA AD KAFURE IVETTE. O Fator Emocional no Desenvolvimento do Jogo 2012. In: XI SBGames 2012 SBC – Proceedings of SBGames (XI SBGames), Brasília.