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PAPER

Development of a Database of Educational Games Applicable to Production Engineering

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ABSTRACT

Discussion over the years regarding the quality of newly graduated engineers in Brazil has concluded that there are gaps between learning and market expectations. Analyzing the current scenario, the Ministry of Education (MEC) has approved new national curriculum guidelines that emphasize skills development and the adoption of active methodologies. The aim is to develop students as protagonists of their own learning. One of these methodologies is game-based learning (GBL), which utilizes games for educational purposes to integrate theory and practice. GBL simulates reality and presents concepts in a playful way, resulting in greater student engagement and interest. However, research shows that a lack of knowledge and difficulty accessing such games are barriers to implementing this methodology. Previous research has focused on the development of serious game metadata (SGM), the establishment of controlled vocabularies, and the identification of educational games targeting production engineering (PE). The authors of the present paper developed a database focused on the disciplines and content covered in production engineering courses. The paper describes the database and its aims to: (a) increase the use of games in the teaching-learning process; (b) make the process more effective; and (c) prepare better professionals.

KEYWORDS

game-based learning (GBL), educational game, database, repository, production engineering (PE)

1 INTRODUCTION

Discussions about the quality of newly graduated engineers in Brazil have concluded that while the number of job openings and available courses has increased, the quality of graduates does not match the quantitative growth [1], [2]. In this scenario, the Ministry of Education (MEC) approved a set of new national curriculum guidelines (NCGs) in 2019. These guidelines emphasize the development of skills, expanding the content domain, and prioritizing traditional education [3]. The NCGs propose a more flexible curriculum focused on practical activities developed through the use of

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active methodologies (AMs). These methodologies aim to empower students to take more responsibility for their learning, placing them at the center of their education [4].

In Brazil, in addition to institutional deficiencies, there are often shortcomings in training for first-year students. They require a course to develop the skills necessary for autonomy and commitment, which are essential for applying AMs. Higher education teachers need pedagogical training, especially in technology-related courses. Without this specific training, teachers risk becoming hostages of traditional methodologies (excessive and teacher-centered), which do not offer students opportunities for the practical application of the concepts learned in class, nor meet their contemporary demands [5], [6].

A promising methodology within this scenario is *game-based learning* (GBL), where a teacher incorporates games in the classroom to introduce, simulate, or summarize the application of concepts. In addition to instilling concepts, the methodology encourages the development of specific skills, such as decision-making, leadership, and teamwork, among others [7], [8], [9], [10]. Although GBL is an exciting methodology, studies show barriers to its implementation [9], such as the challenges associated with identifying suitable educational games. Another author has reinforced this finding through research with 114 teachers in the STEM (*science, technology, engineering, and mathematics*) fields [11], highlighting a lack of information on where to find high-quality games as one of the main difficulties of implementing GBL. Other authors argue that teachers struggle to find appropriate materials because there is a lack of catalogs that encompass a wide range of games and filtering options [12]. Most are available since the majority of those catalogs tend to focus on a specific area or are overly generic [13].

Bonetti also supports this view and adds that developing educational games is not a simple task [5]. According to the author, many teachers lack the ability or knowledge to develop appropriate games. Furthermore, while there is a wide variety of games available on the Internet, they are not organized systematically, which makes searching for games time-consuming, complex, and inefficient. In this respect, the author suggests the construction of a repository.

From these observations, the current research question is: How can the identification and selection of educational games for teaching production engineering (PE) be facilitated?

1.1 Objective

The main objective of this work was to develop a tool capable of assisting in the identification of games applicable to the teaching of PE and, thus, promoting improvements in the teaching-learning process. To achieve this goal, the following specific objectives were addressed:

a) Identify environments that promote the use of games in higher education.
b) Analyze the fields utilized by these environments to describe the games.
c) Verify and compare the main desirable requirements extracted from current locations.

1.2 Motivation

An initial survey on the use of board games in PE teaching revealed the vast potential for their adoption [14]. The authors identified that one of the main barriers

to the adoption of games in education is a lack of awareness about their existence and how to utilize them effectively. One embryonic survey identified several institutional websites that offered two or more games relevant to PE [15], [16], [17]. These results reinforced the challenge of selecting appropriate games for teaching PE, a problem that was also highlighted in the current research.

2 LITERATURE REVIEW

Production engineering, which originated in the USA between the nineteenth and twentieth centuries as a result of the advancement of industrialization, is a discipline that integrates concepts from administration, accounting, operations research, manufacturing processes, and supply chain management, among others, to achieve efficiency in processes.

In Brazil, the first PE courses appeared in 1931 (Institute of Rational Organization of Work (IDORT)) and 1959 (University of São Paulo (USP)). According to [18], there are more than 1,100 PE courses offered across the country. The importance of the PE profession for economic development justifies the expansion of the course.

The NCG [19] defines the profile and competencies expected of graduates and recommends using active methodologies to achieve them. Bonwell and Eison introduced the term "active learning" in the 1990s and defined its characteristics [20]: (a) students are more involved in processes than when they just listen; (b) the emphasis is less on the transmission of information and more on the development of students' skills; (c) students are engaged in higher-order thinking (analysis, synthesis, and validation); (d) students are engaged in the activity (reading, discussing, writing); (e) there is more significant emphasis on exploring students' attitudes and values. These same characteristics also define what are currently referred to as "active methodologies" (AMs).

Active methodologies are activities that encourage students to take action, i.e., get hands-on and reflect on their work [4], [21], [22]. There are several active methodologies, such as project-based learning, problem-based learning, gamification, and game-based learning (GBL). GBL was chosen as the focus of this study because it is still an emerging subject that meets current educational demands, as it utilizes games for educational purposes. According to the literature, supplementing traditional classes (*lectures*) with GBL leads to improved learning outcomes and increased student engagement [23], [24], [25]. In addition, GBL is an excellent method to help students overcome resistance to tackling complex topics [26].

Although GBL is considered an emerging methodology, the use of games to teach specific content in the classroom is not new [27]. A game is an activity with a goal, rules, a feedback system, and voluntary participation [28]. A game's attributes include presenting clear and specific tasks, promoting deep immersion within a context, providing immediate feedback, and establishing a high degree of autonomy [29]. Educational scholars emphasize the significance of games as essential tools for enhancing cognitive skills, particularly in kindergarten and elementary school. Games actively stimulate students to be creative while also helping them acquire self-confidence and concentration [30], [31].

Although much of the initial research focused on childhood and elementary school, there is now research on using games in higher education. Some authors have reported on the experiences of game creation by higher education students [32], while others have listed games produced and used by universities for teaching PE [33]. The use of games for pedagogical purposes in higher education has grown and covers

various areas, including health [34], [35], [36], resource management [37], [38], and learning new languages [39], [40]. A common term used to represent games for pedagogical purposes is "serious game," which provides stimulation for situations and can be replaced by terms such as "educational games" [41].

As defined, educational games need to focus on teaching a specific subject, expanding concepts, or enhancing the skills and attitudes that players/students seek and acquire during the game [42], [43]. By using games as strategies to facilitate student learning, teachers are also provided with a more transparent evaluation process. The playful nature of games prevents learners from feeling apprehensive and allows the content to be studied with greater tranquility [44]. The authors also present the idea that games offer various benefits: physical (motor development), intellectual (memory, concentration, abstraction, and reasoning), social (assimilation of rules and cooperation in a group), and didactic (related to various learning theories).

On the other hand, some research highlights the barriers to implementing educational games. Related to technical, financial, or educational challenges, such studies have identified the following challenges: (a) difficulties in ensuring the construction of knowledge through the use of a particular game; (b) distractions and a lack of student focus when playing games; (c) lack of alignment with the curriculum; (d) need for equipment and training; (e) time constraints within the classroom; (f) lack of teacher skills in developing or managing games; and (g) challenges in identifying educational games [9], [11], [45].

In agreement, one author reports that the challenges associated with creating and implementing games are demanding and expensive for teachers, leading them to prefer using already available games [5]. The same author states that there is no appropriate environment from which games for educational purposes can be selected, as they are scattered on the Internet in a non-centralized manner, lacking systematic and uniform representation of their relevant information. This means that searching for games is time-consuming, complicated, and inefficient. Other authors argue that while there are catalogs of educational games available, they often require customization to meet teachers' specific requirements. Some catalogs are overly broad, making it challenging to locate relevant resources [13]. Researchers also report that catalogs on game developers' and distributors' websites must adhere to metadata standards. This often leads to games being inaccurately described, causing confusion in terms of their classification and search [46].

Given these challenges, it is essential that games are seen as learning objects (LOs), resources that can be cataloged and made available as such. This would enable teachers to identify them more easily when seeking to complement and diversify their classes. The *learning objects metadata workgroup* defines learning objects as "any entity, digital or non-digital, that can be used, reused, or referenced during technology-supported learning" [47]. A learning object is any reusable digital resource that supports teaching [48], such as images, videos, software, and animations [49]. Based on these definitions, reusable educational games can also be understood as LOs, as they serve educational purposes.

In order to retrieve and reuse LOs, they need to be stored and indexed with well-defined metadata. Metadata is the information used to structure and categorize LOs [50]. Learning objects can be found in various locations, including websites, portals, libraries, and repositories. Identifying these locations is not easy and has become a crucial aspect of the present research work. This has led to the development of a database that is now accessible virtually, following the steps described below.

Several metadata standards have been developed and applied worldwide, including the LOM *(learning object metadata)*. The LOM was developed by the IEEE

in 2002, with its most recent update in 2020. This standard offers nine categories by which learning resources may be classified [47]. These categories comprise 45 master fields, some of which are subdivided, totaling 68 fields. Another organization focused on advancing standards is the *Dublin Core™ Metadata Initiative* (*DCMI*), which developed Dublin Core (DC), a streamlined metadata standard widely used by the repositories of the top Brazilian universities. The DC is composed of 15 elements [51].

The multi-methodological study conducted by the authors of this work led to the creation of *serious game metadata* (*SGM*), a metadata standard comprising 16 fields: (1) Title, (2) Language, (3) Description, (4) Keywords, (5) Date, (6) Authorship, (7) Format, (8) URL, (9) Platform, (10) Type, (11) Target Audience, (12) Minimum Age, (13) Cost, (14) License, (15) Discipline, and (16) Competencies and Skills [52], [53], [54].

3 METHODOLOGICAL PROCEDURES

This study is characterized as applied research. It utilizes both qualitative and quantitative approaches with the aim of prescribing solutions. The objectives are achieved through the collection of data from bibliographic and documentary research.

It is pragmatic research, which involves using knowledge to inform action, incorporating normative and synthetic thinking. The goal is to streamline the process of identifying and selecting games.

The research proposal involves developing and providing access to a database by identifying locations and extracting information related to educational games applicable to higher education, with a focus on PE courses.

To achieve this goal, the authors conducted a search in the *Scopus* and *Web of Science* databases using the search terms (*repository* OR *portal* OR *metadata*) and *game* in the titles of the papers. The terms were not applied to the abstracts or keywords of papers to narrow down the search scope. Initial tests applying the search terms to these elements yielded approximately 1,200 documents in *Scopus*, with no relevant materials found within the first 100 items analyzed. Searches delimited by title returned 50 and 37 documents from the *Scopus* and *Web of Science* databases, respectively, totaling 87. The authors then used the following steps to evaluate the extracted articles:

1. Identification and exclusion of duplicate items in and between databases
2. Reading the title and excluding items that do not adhere to the scope of the research
3. Reading the abstract and excluding items that do not adhere to the scope of the research
4. Access and reading of the material in full, excluding non-adherent items

In the first stage, the authors identified and removed 31 duplicate items. Out of the remaining 56 items, 23 were discarded after title reading because they did not focus on identifying, detailing, or developing metadata, portals, or repositories for educational games. Subsequently, the authors read the abstracts of the remaining 33 items and discarded 19 publications. After thoroughly reading the remaining publications, the researchers discarded five more, leaving nine studies that align with the scope of the present work (approximately 10% of the original total). Subsequently, a complementary search was conducted in Portuguese on Google Scholar, using the terms (portal OR *repositório*) AND *jogo* AND (*educacional* OR *educativo*) to broaden

the results with a specific focus on the Brazilian context. This search returned more than 65,000 links, sorted according to Google's standard for relevance. The first 50 materials from the search were analyzed. Seven materials relevant to the present research were identified and included with the previously identified database material, bringing the total to 16 publications.

These results indicate that the research could be funded, and environments that offer information about games relevant to higher education could be identified. The authors analyzed the available filters and the information fields used to describe the games listed at each location, extracting information about the games. A compilation of this information allowed for the identification of the most significant field incidence between the environments, the analysis of the existing games, and the creation of a list of those that somewhat adhere to the PE courses. The final result was the development of a database focused on the teaching of production engineering.

4 RESULTS

Based on the publications identified in the research, the authors were able to list 34 locations (Appendix A) that provide information on games applicable to various areas of higher education. An individualized analysis of these websites was conducted to identify games relevant to the teaching of PE as well as to evaluate the functionalities presented by each in accordance with the requirements outlined by Bonetti [5].

REQ 1. Advanced search engine to search for LOs by specific attributes
REQ 2. The mechanism for managing the registration of LOs by the registered members themselves (adding, editing, and deleting games)
REQ 3. Detailed description of the games through the use of metadata, including aspects of teaching, execution, and classification of the games, among others
REQ 4. *Rating* mechanism to evaluate the quality of LOs by the registered members themselves
REQ 5. A *community of practice* (CoP) to keep the repository always up-to-date
REQ 6. Access control mechanisms for users

4.1 Catalog analyses

From the analyses, the present authors identified that:

1. In institutional repositories, there is a predominance of more straightforward searches composed of a few filters, such as Title, Author, Subject, and Date of Publication, although, in some cases, the "Type" filter is also included. Commercial websites typically offer a wider range of search fields and lists of terms, which facilitates information retrieval.
2. The locations listed exhibit different management methods. In some resources, game registration is conducted in a restricted and centralized manner (by a single individual or group) or in a shared way (with or without moderation).
3. Most of the locations studied had developed their own standards or adopted an international metadata standard to describe the games.
4. Commercial websites often enable users to rate registered games, a feature that is seldom found on informational and educational websites. This feature allows for game ranking and a more targeted selection.

5. Some sites, such as BGA, BGG, and Ludopedia, use a CoP with user registration, a game search area, and forums. In these environments, users are encouraged to register for games, rate their experiences, and participate in discussions. Game FAQs do the same and even cover the cost of registration.
6. Some websites have user registration systems for management and maintenance, along with organizers that mediate access and prevent redundancies. In some cases, access is free and does not require user registration. Some platforms also have registered users with varying levels of access.

The research by Bonetti et al. [5] resulted in implementing a robust repository in Java with a wide range of metadata. However, having discontinued the original proposal, given the difficulty in maintaining complex systems, a simpler model, JEEP (*Jogos Educacionais para Engenharia de Produção*—Educational Games for PE), was developed and tested.

4.2 Educational games for production engineering: JEEP

Based on this work, the identified games are being cataloged and made available in JEEP, a database (DB) focused on games relevant to PE. The information is updated from a registration form created using Google Drive. All those interested can access it through the link: https://bit.ly/bancodedados_jeep. Before accessing the database, users are presented with an introductory spreadsheet (see Figure 1), which provides instructions for applying filters and links using basic guidelines and a tutorial (available in PDF and video formats). By such means, users can: (1) register requests for assistance in identifying games; (2) access a tutorial for handling the database; (3) register new games; and (4) evaluate the resource.

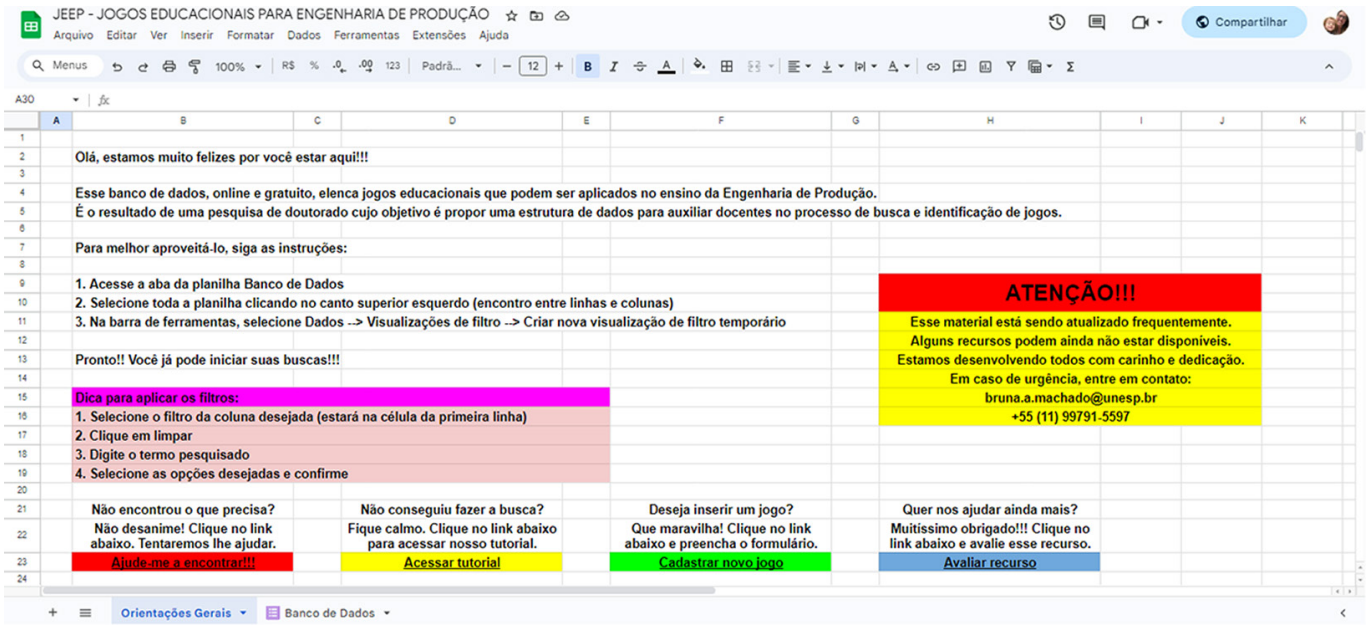
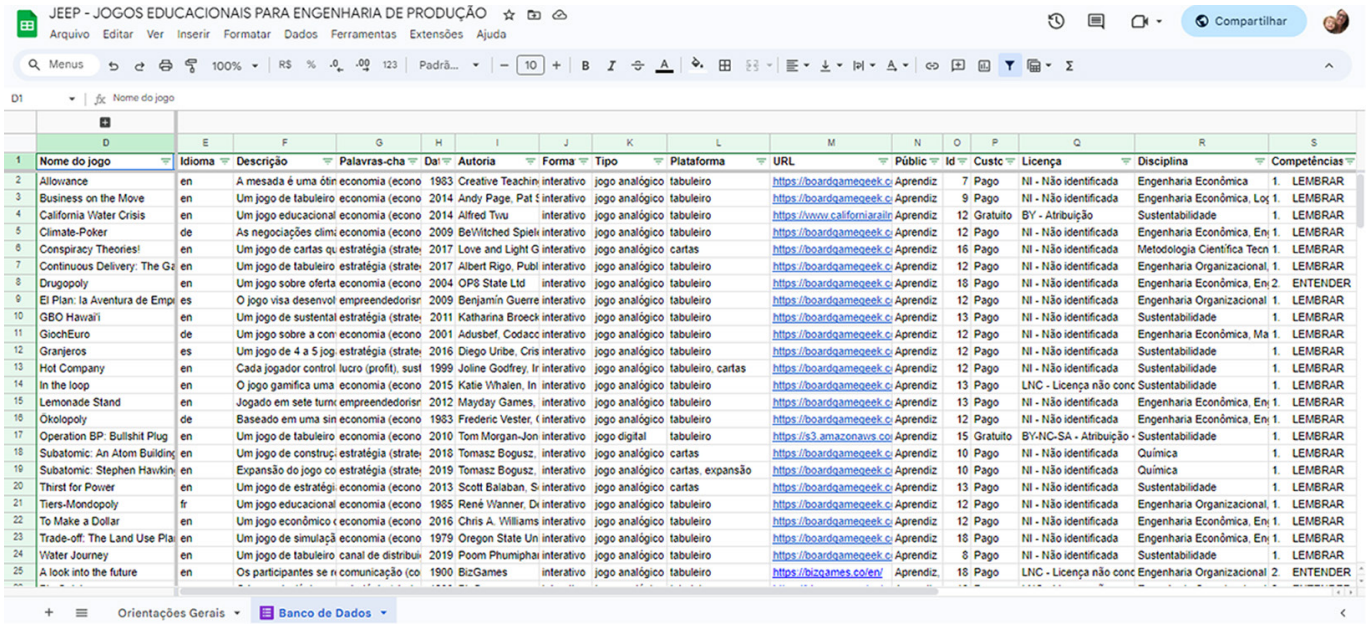


Fig. 1. Database starter spreadsheet

JEEP is composed of sixteen SGM elements (see Figure 2), three additional columns that indicate the origin of the information (date/time, email, and name of the person responsible for the registration), and a further three columns developed for future

functionalities and registration control (resource indication note, comments, and a link to the registration form). This additional information is only visible to administrators. JEEP allows users to filter all fields according to their needs and interests.



Nome do jogo	Idioma	Descrição	Palavras-cha	Da	Autoria	Forma	Tipo	Plataforma	URL	Públic	Id	Custc	Licença	Disciplina	Competências
Allowance	en	A mesada é uma ótin	economia (econo	1983	Creative Teachin	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	7	Pago	NI - Não identificada	Engenharia Econômica	1. LEMBRAR
Business on the Move	en	Um jogo de tabuleiro	economia (econo	2014	Andy Page, Pat S	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	9	Pago	NI - Não identificada	Engenharia Econômica, Lo	1. LEMBRAR
California Water Crisis	en	Um jogo educacional	economia (econo	2014	Alfred Twu	interativo	jogo analógico	tabuleiro	https://www.californiarailr	Aprendiz	12	Gratuito	BY - Atribuição	Sustentabilidade	1. LEMBRAR
Climate-Poker	de	As negociações clim	economia (econo	2009	BeWitched Spiele	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Econômica, En	1. LEMBRAR
Conspiracy Theories!	en	Um jogo de cartas qu	estratégia (strate	2017	Love and Light G	interativo	jogo analógico	cartas	https://boardgamegeek.c	Aprendiz	16	Pago	NI - Não identificada	Metodologia Científica Tecn	1. LEMBRAR
Continuous Delivery: The Ga	en	Um jogo de tabuleiro	estratégia (strate	2017	Albert Rigo, Publ	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Organizacional,	1. LEMBRAR
Drugopoly	en	Um jogo sobre oferta	economia (econo	2004	OP8 State Ltd	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	18	Pago	NI - Não identificada	Engenharia Econômica, En	2. ENTENDER
El Plan: la Aventura de Empr	es	O jogo visa desenvol	empreendedorisr	2009	Benjamín Guerre	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Organizacional	1. LEMBRAR
GBO Hawai'i	en	Um jogo de sustental	estratégia (strate	2011	Katharina Broeck	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	13	Pago	NI - Não identificada	Sustentabilidade	1. LEMBRAR
GiochEuro	de	Um jogo sobre a com	economia (econo	2001	Adusbef, Codacc	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Econômica, Ma	1. LEMBRAR
Granjeros	es	Um jogo de 4 a 5 jog	estratégia (strate	2016	Diego Uribe, Cris	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Sustentabilidade	1. LEMBRAR
Hot Company	en	Cada jogador control	lucro (profit), sust	1999	Joline Godfrey, Ir	interativo	jogo analógico	tabuleiro, cartas	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Sustentabilidade	1. LEMBRAR
In the loop	en	O jogo gamifica uma	economia (econo	2015	Katie Whalen, In	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	13	Pago	LNC - Licença não conc	Sustentabilidade	1. LEMBRAR
Lemonade Stand	en	Jogado em sete turn	empreendedorisr	2012	Mayday Games,	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	13	Pago	NI - Não identificada	Engenharia Econômica, En	1. LEMBRAR
Ökolopoly	de	Baseado em uma sin	economia (econo	1983	Frederic Vester, (	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Econômica, En	1. LEMBRAR
Operation BP: Bullshit Plug	en	Um jogo de tabuleiro	economia (econo	2010	Tom Morgan-Jon	interativo	jogo digital	tabuleiro	https://s3.amazonaws.co	Aprendiz	15	Gratuito	BY-NC-SA - Atribuição -	Sustentabilidade	1. LEMBRAR
Subatomic: An Atom Building	en	Um jogo de construç	estratégia (strate	2018	Tomasz Bogusz,	interativo	jogo analógico	cartas	https://boardgamegeek.c	Aprendiz	10	Pago	NI - Não identificada	Química	1. LEMBRAR
Subatomic: Stephen Hawkin	en	Expansão do jogo co	estratégia (strate	2019	Tomasz Bogusz,	interativo	jogo analógico	cartas, expansão	https://boardgamegeek.c	Aprendiz	10	Pago	NI - Não identificada	Química	1. LEMBRAR
Thirst for Power	en	Um jogo de estratégi	economia (econo	2013	Scott Balaban, Si	interativo	jogo analógico	cartas	https://boardgamegeek.c	Aprendiz	13	Pago	NI - Não identificada	Sustentabilidade	1. LEMBRAR
Tiers-Mondopoly	fr	Um jogo educacional	economia (econo	1985	René Wanner, Di	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Organizacional,	1. LEMBRAR
To Make a Dollar	en	Um jogo econômico (	economia (econo	2016	Chris A. Williams	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	12	Pago	NI - Não identificada	Engenharia Econômica, En	1. LEMBRAR
Trade-off: The Land Use Pla	en	Um jogo de simulaçã	economia (econo	1979	Oregon State Un	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	18	Pago	NI - Não identificada	Engenharia Econômica, En	1. LEMBRAR
Water Journey	en	Um jogo de tabuleiro	canal de distribui	2019	Poom Phumiphai	interativo	jogo analógico	tabuleiro	https://boardgamegeek.c	Aprendiz	8	Pago	NI - Não identificada	Sustentabilidade	1. LEMBRAR
A look into the future	en	Os participantes se r	comunicação (co	1900	BizGames	interativo	jogo analógico	tabuleiro	https://bizgames.co/en/	Aprendiz	18	Pago	LNC - Licença não conc	Engenharia Organizacional	2. ENTENDER

Fig. 2. JEEP database

5 DISCUSSION

The layout of the information is plausible. All the information fields are accessible on a single screen, including the URL that directs the user to the game itself or to a supplementary information page. In this proposal, the database contains results from a game registration form. This allows every user to access the link provided in the initial spreadsheet and automatically register a game listed. Administrators can delete and edit the data, although these edits are only validated by database analyses if they are derived from the initial form. Although external users are not able to make edits, they can suggest changes by using direct comments in the data area field. Users who have registered an item can keep the link provided in the email to make changes to the record. Every change is recorded in the database as a comment and remains accessible to administrators and users until it is reviewed.

The tool does not have a key field (identifier), which means that duplication of content is a possible drawback. However, these duplicates can be easily identified and deleted by administrators.

Currently, the database does not include a scoring feature. However, at the moment a game is registered, there is a question about the user's intention to recommend it. The authors have assigned scores to some of the extracted and analyzed games, including those from Ludopedia and BGG [55], [56]. This field, however, is only visible to administrators. For the definition of scores calculated by averages, there is a need for data interaction with other forms, a functionality that still needs to be taught and developed. As an additional educational objective, the authors aim to create an evaluation tool akin to the one devised by El Borji and Khaldi [57], which assesses the quality of a game based on pedagogical, technical, and gameplay perspectives. This tool will require a well-established CoP, one that is very familiar with

the games registered in the database. To widely disseminate the database and define a potential CoP, the initial proposal is that the professors who participated in the research by Machado [52], [53], [54] should share their experiences and needs, register games, and contact the administration. Survey participants were the first to have access to the resource, evaluate it, and actively participate in its regular updates.

Although research shows that access control is necessary to allow users to register, edit, sell their games, participate in forums, and access games, among other activities, the authors view the DB format as a weakness because it does not offer detailed levels of access or user interaction. The authors consider this to be an interesting future development, allowing for an analysis of the usability of the proposed resource and the development of new tools and functionalities. It is possible to restrict access to the proposed DB, requiring interested parties to request permission from administrators. However, such an action runs counter to the objectives of expanding access to information, as this practice could hinder the registration of individuals who prefer not to be identified or disclose personal information. Therefore, the database necessitates the registration of the names and email addresses of individuals who contribute new game information. In any case, the administration provides a direct communication channel that allows users to inquire about the database and submit suggestions.

The evaluation process of the proposed tool is crucial for verifying its effectiveness. Thus, an evaluation based on the one proposed by Bonetti [5] has been made accessible. This tool presents standardized methods for analyzing the usefulness of the DB and utilizes strategies to prevent inattentive or random form filling by respondents. However, there are still a significant number of respondents evaluating the tool. Until this moment, two professors have contacted the authors, requesting permission to share the material with their colleagues. One professor has already contacted the authors, thanking them for the material and suggesting a live stream. This channel could be the beginning of a community of practice.

6 CONCLUSION

The main objective of this research was to develop a DB tool capable of assisting in the identification of games suitable for teaching PE, aiming to enhance the teaching-learning process. To this end, the authors pursued the following specific objectives:

a) **Identifying environments that promote the use of games in higher education.** The authors identified 34 environments but found that none of them offer a wide range of games focused on the PE course.
b) **Analyzing the fields used in these environments to describe the games.** Through analyses of fields and filters, the authors devised data extraction plans and created the JEEP. These analyses also facilitated the development of a metadata standard and adjustments to the data vocabulary.
c) **Verifying and comparing the main desirable requirements from the existing locations allowed deeper analyses of improvement possibilities for the DB.** Based on the results obtained so far, the authors have concluded that prioritizing the development of a more robust tool (based on design and programming) is not necessary at this time. The current focus needs to be on strengthening a community of practice to expand the project and further develop new functionalities.

Even so, the authors are eager to establish a more robust repository or transfer the acquired data to an educational institution repository that preferably utilizes the

DSpace platform. This would ensure interoperability among various Brazilian and international repositories. This is a subject for future research.

JEEP allows anyone with its link to: (a) access information about games relevant to PE; (b) register new games; and (c) raise questions and provide suggestions. Currently, the biggest challenge for researchers is manually registering the games using the form. This step is necessary to compile and present the information automatically through graphics. The same is true for edition validation, which is affected solely by editing the original registration form.

Regarding the research performance, it is essential to mention that (a) the manual search for games is exhaustive and presents a smaller number of results than searches in spaces focused on games as a whole; (b) automated searches allow a greater variety of games but do not imply better quality elements; and (c) the existing institutional repositories could be better used if they were readjusted, mainly by inserting the "type" field in the searches.

The authors hope that, based on this research, new databases will be made available in different areas of knowledge. This will: (a) increase the use of games in the teaching-learning process; (b) make the process more effective; and (c) prepare better professionals with greater vision, capable of leveraging new solutions and promoting more significant educational development.

The authors conclude that the limitations of JEEP are acceptable for an initial model. This is because creating a similar database does not require knowledge about programming, hosting, and integrating databases, and it also allows for a smaller investment of financial resources.

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8 REFERENCES

[1] L. M. Lins, M. S. Salerno, B. C. Araújo, L. A. V. Gomes, P. A. M. M. Nascimento, and D. Toledo, "Escassez de engenheiros no Brasil? Uma proposta de sistematização do debate," *Novos Estud. – CEBRAP*, no. 98, pp. 43–67, 2014. https://doi.org/10.1590/S0101-33002014000100004

[2] M. J. Tozzi and A. R. Tozzi, "Escassez de engenheiros no Brasil: Mito ou realidade," in *Proceedings of the XXXIX Congresso Brasileiro de Educação em Engenharia COBENGE*, Blumenau, SC: COBENGE, 2011.

[3] M. Despeisse, "Games and simulations in industrial engineering education: A review of the cognitive and affective learning outcomes," in *2018 Winter Simulation Conference (WSC)*, Gothenburg, Sweden: IEEE, 2018, pp. 4046–4057. https://doi.org/10.1109/WSC.2018.8632285

[4] A. C. Lázaro, M. A. V. Sato, and T. C. R. Tezani, "Metodologias ativas no ensino superior: O papel do docente no ensino presencial," *CIET:EnPED*, 2018.

[5] T. M. Bonetti, "Proposta de um modelo de repositório colaborativo para compartilhar informações de jogos para o ensino de computação," Dissertação (Ciências da Computação), Pós Graduação em Ciências da Computação da Universidade Federal de Santa Catarina, Florianópolis, 2014.

[6] M. Valentová and P. Brečka, "Assessment of digital games in technology education," *Int. J. Eng. Pedagogy*, vol. 13, no. 2, pp. 36–63, 2023. https://doi.org/10.3991/ijep.v13i2.35971

[7] E. Pesare, T. Roselli, N. Corriero, and V. Rossano, "Game-based learning and gamification to promote engagement and motivation in medical learning contexts," *Smart Learn. Environ.*, vol. 3, no. 1, p. 5, 2016. https://doi.org/10.1186/s40561-016-0028-0

[8] N. C. Rice, A. Guru, C. N. Keeler, D. R. Keshwani, and J. Keshwani, "Comparison of game-based learning and traditional lecture approaches to improve student engagement and knowledge transfer in STEM education," in *ASEE Annu. Conf. Expo. Conf. Proc.*, 2018, vol. 2018.

[9] E. Tsekleves, J. Cosmas, and A. Aggoun, "Benefits, barriers and guideline recommendations for the implementation of serious games in education for stakeholders and policymakers," *Br. J. Educ. Technol.*, vol. 47, no. 1, pp. 164–183, 2016. https://doi.org/10.1111/bjet.12223

[10] C. V. de Carvalho, M. P. Lopes, and A. G. Ramos, "Lean games approaches – Simulation games and digital serious games," *Int. J. Adv. Corp. Learn.*, vol. 7, no. 1, p. 11, 2014. https://doi.org/10.3991/ijac.v7i1.3433

[11] D. Tuparova, V. Veleva, and G. Tuparov, "About some barriers in usage of educational computer games by teachers in STEM," in *Proceedings of the International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, IEEE, 2019, pp. 727–730. https://doi.org/10.23919/MIPRO.2019.8756999

[12] M. W. Morie, I. Marfisi-Schottman, and B. T. Goore, "Information extraction model to improve learning game metadata indexing," *ISI Int. J. Inf. Syst. Eng.*, vol. 25, no. 1, pp. 11–19, 2020. https://doi.org/10.18280/isi.250102

[13] M. W. Morie, I. Marfisi-Schottman, and B. T. Goore, "LGMD: Optimal lightweight metadata model for indexing learning games," in *International Conference on Smart Applications and Data Analysis*, Marrakesh, Morocco: Springer International Publishing, 2020, pp. 3–16. https://doi.org/10.1007/978-3-030-45183-7_1

[14] B. A. Machado, F. B. D. Souza, J. D. S. Rodrigues, and M. R. R. Georges, "Jogos de Tabuleiro e suas Contribuições para o Desenvolvimento das Competências do Engenheiro de Produção," in *Encontro Nacional de Engenharia de Produção*, Foz do Iguaçu, Paraná, Brasil: ABEPRO, 2020. https://doi.org/10.14488/ENEGEP2020_TN_STO_351_1808_41112

[15] FORAC, "Educational games," FORAC – Forest to customer. [Online]. Available: https://www.forac.ulaval.ca/en/knowledge-transfer/educational-games/. [Accessed: Jul. 17, 2023].

[16] MIT, "Teaching Resources Library. MIT Management Sloan School." [Online]. Available: https://mitsloan.mit.edu/teaching-resources-library/management-simulations. [Accessed: Jul. 18, 2023].

[17] SUTD, "ESD games," *Engineering Systems and Design (ESD)*. [Online]. Available: https://esd.sutd.edu.sg/about/esd-games/. [Accessed: Jul. 17, 2023].

[18] MEC, "E-mec," 2021. [Online]. Available: https://emec.mec.gov.br/. [Accessed: Apr. 03, 2021].

[19] MEC, *Diretrizes Curriculares Nacionais*, 2019. [Online]. Available: https://normativasconselhos.mec.gov.br/normativa/view/CNE_RES_CNECESN22019.pdf. [Accessed: May 21, 2020].

[20] C. C. Bonwell and J. A. Eison, *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports*, (1st ed.). Washington: Jossey-Bass, 1991.

[21] L. C. B. da Silva, A. C. Loureiro, F. M. Magoni, and V. M. B. Gonçalves, "Active methodologies and digital technologies in learning: A systematic literature review," in *2022 17th Iberian Conference on Information Systems and Technologies (CISTI)*, 2022, pp. 1–5. https://doi.org/10.23919/CISTI54924.2022.9820582

[22] J. Morán, "Mudando a educação com metodologias ativas," *Coleç. Mídias Contemp. Convergências Midiáticas Educ. E Cid. Aproximações Jovens*, vol. 2, no. 1, pp. 15–33, 2015.

[23] R. F. Herrera, M. A. Sanz, L. Montalbán-Domingo, T. García-Segura, and E. Pellicer, "Impact of game-based learning on understanding lean construction principles," *Sustainability*, vol. 11, no. 19, p. 5294, 2019. https://doi.org/10.3390/su11195294

[24] Pratiwi and L. S. Istiyowati, "Simulation and games based learning model for learning math in higher education," *Univers. J. Educ. Res.*, vol. 8, no. 9A, pp. 16–20, 2020. https://doi.org/10.13189/ujer.2020.082003

[25] M. Wang and X. Zheng, "Using game-based learning to support learning science: A study with middle school students," *Asia-Pac. Educ. Res.*, vol. 30, no. 2, pp. 167–176, 2021. https://doi.org/10.1007/s40299-020-00523-z

[26] G. L. Sales, J. L. L. Cunha, A. J. Gonçalves, J. B. da Silva, and R. L. dos Santos, "Gamificação e Ensinagem Híbrida na Sala de Aula de Física: Metodologias Ativas Aplicadas aos Espaços de Aprendizagem e na Prática Docente," *Conex. – Ciênc. E Tecnol.*, vol. 11, no. 2, 2017. https://doi.org/10.21439/conexoes.v11i2.1181

[27] J. M. Hill, C. K. Ray, J. R. Blair, and C. A. Carver Jr, "Puzzles and games: Addressing different learning styles in teaching operating systems concepts," in *Proceedings of the SIGCSE Technical Symposium on Computer Science Education*, 2003, pp. 182–186. https://doi.org/10.1145/792548.611964

[28] J. McGonigal, *Reality is Broken: Why Games Make Us Better and How They Can Change the World.* New York, NY: The Penguin Press, 2011.

[29] S. Bahadoorsingh, R. Dyer, and C. Sharma, "Integrating serious games into the engineering curriculum-a game-based learning approach to power systems analysis," *Int. J. Comput. Vis. Robot.*, vol. 6, no. 3, pp. 276–289, 2016. https://doi.org/10.1504/IJCVR.2016.077372

[30] J. Piaget, *Development and Learning*. Porto Alegre: UFRGS/FACED/DEBAS, 1995.

[31] L. S. Vygotsky, *The Social Formation of the Mind: The Development of Higher Psychological Processes* (3rd ed.). São Paulo: Martins Fontes, 1989.

[32] Y. Real and J. Hurtado, "Collaborative creation between students and teachers for the development of an evaluation gameboard in class," in *Proceedings of the HEAD'19. 5th International Conference on Higher Education Advances*, Editorial Universitat Politècnica de València, 2019, pp. 1365–1373. https://doi.org/10.4995/HEAD19.2019.9499

[33] M. A. L. Ruiz and G. E. O. Giacaglia, "Uma análise dos jogos de tabuleiro no ensino da Engenharia de Produção – CICTED," in *Proceedings of the Congresso Internacional de Ciência, Tecnologia e Desenvolvimento*, Taubaté, 2017.

[34] A. Alloni *et al.*, "Computer-based cognitive rehabilitation: The CoRe system," *Disabil. Rehabil.*, vol. 39, no. 4, pp. 407–417, 2017. https://doi.org/10.3109/09638288.2015.1096969

[35] J. M. Clochesy, M. Buchner, R. L. Hickman Jr, M. D. Pinto, and K. Znamenak, "Creating a serious game for health," *J. Health Hum. Serv. Adm.*, vol. 38, no. 2, pp. 162–173, 2015.

[36] M. R. G. M. Pires, D. Guilhem, and L. B. D. Göttems, "Jogo (IN)DICA-SUS: Estratégia lúdica na aprendizagem sobre o Sistema Único de Saude," *Texto Contexto – Enferm.*, vol. 22, pp. 379–388, 2013. https://doi.org/10.1590/S0104-07072013000200014

[37] F. Bellotti *et al.*, "Serious games and the development of an entrepreneurial mindset in higher education engineering students," *Entertain. Comput.*, vol. 5, no. 4, pp. 357–366, 2014. https://doi.org/10.1016/j.entcom.2014.07.003

[38] B. Y. Othman, S. Abdelali, B. Amine, E. Aachak, E. O. Fatiha, and B. Mohamed, "Classification, evaluation and assessment of serious games in business field," *J. Theor. Appl. Inf. Technol.*, vol. 91, no. 1, 2016.

[39] Mohd. E. Eltahir, N. R. Alsalhi, S. Al-Qatawneh, H. A. AlQudah, and M. Jaradat, "The impact of game-based learning (GBL) on students' motivation, engagement and academic performance on an Arabic language grammar course in higher education," *Educ. Inf. Technol.*, vol. 26, no. 3, pp. 3251–3278, 2021. https://doi.org/10.1007/s10639-020-10396-w

[40] A. A. Syahidi, A. A. Supianto, and H. Tolle, "Design and implementation of Bekantan Educational Game (BEG) as a Banjar language learning media," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 3, pp. 108–124, 2019. https://doi.org/10.3991/ijim.v13i03.9257

[41] G. Bascoul, J. Schmitt, D. Rasolofoarison, L. Chamberlain, and N. Lee, "Using an experiential business game to stimulate sustainable thinking in marketing education – Ganaël Bascoul, Julien Schmitt, Dina Rasolofoarison, Laura Chamberlain, Nick Lee, 2013," *Journal of Marketing Education*, vol. 35, no. 2, pp. 168–180, 2013. https://doi.org/10.1177/0273475313491497

[42] J. V. Dempsey, B. A. Lucassen, L. L. Haynes, and M. S. Casey, "Instructional applications of computer games," presented at the Annual Meeting of the American Educational Research Association, New York City: ERIC, 1996.

[43] Rismayani, A. Paliling, A. Nurhidayani, and M. Pineng, "Fundamental design of flood management educational games using virtual reality technology," *Int. J. Online Biomed. Eng.*, vol. 18, no. 3, pp. 19–32, 2022. https://doi.org/10.3991/ijoe.v18i03.27787

[44] L. da L. Giaretta, L. Alves, T. Petry, and M. S. Silveira, "Camaleão: Ferramenta de apoio a confecção de jogos educativos computadorizados," in *Proceedings of the Congreso Iberoamericano de Informática Educativa, Brasilia. Anais do Congreso Iberoamericano de Informática Educativa*, 1998.

[45] W. Watson, S. Yang, and D. Ruggiero, "Games in schools: Teachers' perceptions of barriers to game-based learning," *J. Interact. Learn. Res.*, vol. 27, no. 2, pp. 153–170, 2016.

[46] J. H. Lee, J. T. Tennis, R. I. Clarke, and M. Carpenter, "Developing a video game metadata schema for the seattle interactive media museum," *Int. J. Digit. Libr.*, vol. 13, pp. 105–117, 2013. https://doi.org/10.1007/s00799-013-0103-x

[47] IEEE, "IEEE Learning Object Metadata (LOM)," *Standards*, 2020. [Online]. Available: https://standards.ieee.org/standard/1484_12_1-2020.html. [Accessed: Aug. 20, 2021].

[48] D. Wiley, "Learning objects need instructional design theory," in *The ASTD e-Learning Handbook*, 2002, pp. 115–126.

[49] J. C. Braga, S. Dotta, E. Pimentel, and B. Stransky, "Desafios para o Desenvolvimento de Objetos de Aprendizagem Reutilizáveis e de Qualidade," in *Workshop de Desafios da Computação Aplicada à Educação*, Curitiba, Paraná, Brasil: UFPR, 2012, pp. 90–99.

[50] L. M. R. Tarouco, M. C. J. M. Fabre, and F. R. Tamusiunas, "Reusability of educational objects," *New Technol. Educ.*, no. 1, pp. 1–11, 2003.

[51] DCMI, *Dublin Core Metadata Element Set, Version 1.1: Reference Description*. 2012. [Online]. Available: https://www.dublincore.org/specifications/dublin-core/dces/. [Accessed: Sep. 01, 2023].

[52] B. A. Machado, F. B. D. Souza, and J. D. S. Rodrigues, "Definição de Metadados para Jogos Educacionais a partir de uma Revisão Sistemática," in *Encontro Nacional de Engenharia de Produção*, Fortaleza, Ceará, Brasil: ABEPRO, 2023. https://doi.org/10.14488/ENEGEP2023_TN_ST_408_2011_45734

[53] B. A. Machado, F. B. D. Souza, and J. D. S. Rodrigues, "Definição de Metadados para Jogos Educacionais a partir do Learning Object Metadata (LOM) na perspectiva de docentes em Engenharia de Produção," in *Encontro Nacional de Engenharia de Produção*, Fortaleza, Ceará, Brasil: ABEPRO, 2023. https://doi.org/10.14488/ENEGEP2023_TN_ST_408_2011_45737

[54] B. A. Machado, F. B. D. Souza, and J. D. S. Rodrigues, "Definição de Metadados para Jogos Educacionais a partir do Dublin Core (DC) na perspectiva de docentes em Engenharia de Produção," in *Encontro Nacional de Engenharia de Produção*, Fortaleza, Ceará, Brasil: ABEPRO, 2023. https://doi.org/10.14488/ENEGEP2023_TN_ST_408_2011_45773

[55] B. A. Machado, F. B. D. Souza, G. L. Garcia, and J. P. Papa, "Trezentos e oito jogos educacionais para o ensino da Engenharia de Produção," in *Simpósio de Engenharia de Produção*, Bauru, São Paulo, Brasil: SIMPEP, 2023.

[56] B. A. Machado, F. B. D. Souza, and G. L. Garcia, "Dois mil e dois Jogos Educacionais para o Ensino da Engenharia de Produção," in *Encontro Nacional de Engenharia de Produção*, Foz do Iguaçu, Paraná, Brasil: ABEPRO, 2022.

[57] Y. El Borji and M. Khaldi, "Comparative study to develop a tool for the quality assessment of serious games intended to be used in education," *Int. J. Emerg. Technol. Learn.*, vol. 9, no. 9, p. 50, 2014. https://doi.org/10.3991/ijet.v9i9.4150

9 APPENDIX

9.1 Appendix A – List of identified catalogs

No.	Name	Link
1	APPS UNIVESP - REA	https://apps.univesp.br/repositorio/catalogo/
2	BIZGAME	https://bizgames.co/en/
3	Board Game Arena (BGA)	https://pt.boardgamearena.com/
4	BoardGameGeek (BGG)	https://boardgamegeek.com/
5	CESTA	http://cesta2.cinted.ufrgs.br/xmlui/
6	ESD Games (SUTD)	https://esd.sutd.edu.sg/about/esd-games/
7	FORAC	https://www.forac.ulaval.ca/
8	Gamefaqs	https://gamefaqs.gamespot.com/
9	How to Smile	http://howtosmile.org/
10	IEEE Try Engineering	https://tryengineering.org/students/games/
11	Itch.io	https://itch.io/
12	La référence Serious Game	https://www.serious-game.fr/
13	Lean Simulations	https://www.leansimulations.org/
14	Livre Saber (LiSa)	http://livresaber.sead.ufscar.br:8080/jspui/
15	Ludopedia	https://www.ludopedia.com.br/
16	MERLOT	https://merlot.org/merlot/
17	MIT Sloan School of Management	https://mitsloan.mit.edu/
18	MobyGames: Game Browser	https://www.mobygames.com/browse/games
19	OASIS	https://oasis.geneseo.edu/
20	OER Commons	https://www.oercommons.org/
21	Open Learn	https://www.open.edu/openlearn/
22	Open Rehab Initiative (ORI)	https://openrehab.org/
23	PHET Interactive Simulations	https://phet.colorado.edu/
24	ProActive	http://www.ub.edu/euelearning/
25	PROCOMUN	https://procomun.intef.es/
26	Serious Game Classification	http://serious.gameclassification.com/
27	Serious Game Information Center	https://seriousgames-portal.org/
28	Short Sims	https://www.shortsims.com/house
29	Tabletopia	https://tabletopia.com/games
30	The Interactive Fiction Database	https://ifdb.org/
31	The Serious Games Typology Project	https://typology.seriousgames.online/
32	WISC-Online Arcade	https://www.wisc-online.com/Arcade
33	WorldCat.org	https://www.worldcat.org/pt
34	Zillions of games	https://www.zillions-of-games.com/

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