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Artificial Intelligence Applied in Problem-Oriented Learning for Information Retrieval in a Gamified Environment

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ABSTRACT

This study investigates the application of Artificial Intelligence (AI) in a Problem-Based Learning (PBL) environment, with emphasis on information retrieval in the field of public technology procurement, from the perspective of risk management and the use of gamified strategies. The research followed a qualitative/quantitative approach in five stages: development of a case study supported by AI; creation of an original board game to simulate real decision-making situations; identification and categorization of perceived risks; application of a structured Likert-scale questionnaire to measure perception; and critical discussion of the results. This research involved professionals directly engaged in ICT acquisition processes and demonstrated that the use of games adapted to the organizational reality (serious game) enhanced engagement, supported knowledge retention, and broadened awareness of relevant risks. Among the main findings were concerns with supplier lock-in and cost underestimation, as well as the high acceptance rate (93.8%) of the gamified experience compared to the traditional expository model. It is concluded that the integration of AI, gamification, and risk management constitutes an innovative and replicable methodology, capable of strengthening training in complex governmental environments, while fostering effective communication and more informed decision-making.

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Kuroki Junior and Gottschalg-Duque (2023) note that developing informational learning environments involves substantial challenges, which are central to both education and Information Science. In the same vein, Rolim (2022) and Pereira and Silva (2022) point out that the adoption of technologies such as Information Architecture is often hindered by the reluctance of students and teachers, who generally favor traditional teaching approaches, thereby complicating communication practices.

In complex environments, simulations and gamification supported by Artificial Intelligence (AI) are presented as alternatives for effectively using information in learning, enabling access to qualified information tailored to the user's needs (Abreu et al., 2023; Sousa et al., 2024). Studies involving big data (Hancock & Khoshgoftaar, 2020), machine learning, multimodality, and ontology (Araújo & Lima, 2023) highlight the importance of integrating these concepts with the human capacity for understanding, given the volume and variety of information sources and cognitive limitations in information storage and processing.

Evidence supporting the use of game-based therapy in the treatment of serious conditions, such as Parkinson's disease (Nogueira et al., 2020) and autism (Silva et al., 2022), illustrates how the effective use of information within games can contribute to educational development, particularly in the post-pandemic landscape (Abreu et al., 2023). Conversely, failures in collecting, organizing, modeling, using, retrieving, or discarding information can lead to significant problems, including wasted resources, financial loss, misuse of data, and reduced efficiency in educational settings. This context underscores the importance of a field dedicated to managing such processes: Information Retrieval (IR), explored here through the lens of game-based approaches, which constitutes the central focus of this study (Zhu et al., 2023).

The use of an information system that allows the achievement of concrete results requires, in addition to technical precision, the observance of ethical principles (Gerlin, 2021) and compliance with data protection regulations (Melo et al., 2023). However, the impact of IR results depends on the context of application and can be influenced by the bias and intentions of the decision-maker. The application of information without a clear objective can generate serious consequences, especially in health, where the inappropriate use of data can compromise lives. Likewise, technology acquisition decisions, when made without an adequate technical basis, can be hampered by political interests, especially in public procurement (Niebuhr et al., 2020).

The pursuit of innovative strategies that enhance user engagement across fields such as technology, education, health, and public administration is a key element of information management and Information Retrieval (IR) (Duarte et al., 2020; Gomes, 2022). Within this landscape, information architecture emerges as an important support mechanism, alongside the use of artificial intelligence to generate insights, analyze data, and identify risks, producing direct benefits across multiple sectors.

In Brazil, the public procurement market accounts for roughly 12.5% of the Gross Domestic Product (GDP), which underscores its significance as an area of study for training managers (Ribeiro, et al., 2019). This field has been recently reshaped by the new Bidding Law (Law

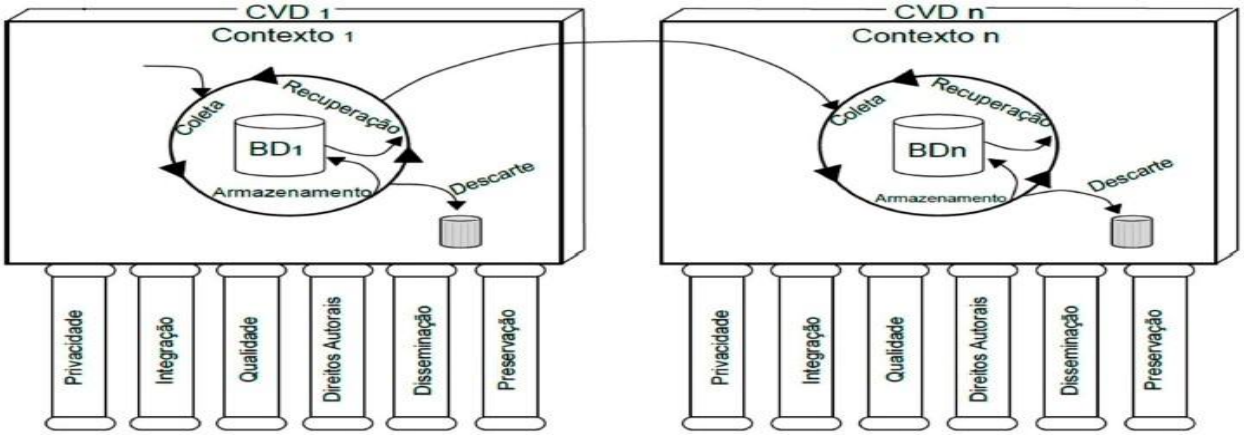
14.133/21) (Brazil, 2021), creating opportunities to design educational solutions grounded in information architecture, gamification, and risk management frameworks.

This specific knowledge track can be explored to enhance learning through playful and personalized methods, which maximize students' individual resources and consider their unique ways of learning (Sales, 2024). By associating a multimodal experience with a well-structured game interface, it is possible to avoid problems of misinformation or misinterpretation caused by biases or inadequate presentation of information (Silva-Pires et al., 2020).

Thus, information management, especially with regard to collection, plays an essential role in the provision of public services. In the context of government procurement, which involves interconnected sectors, there is room for the practical use of specific regulations applied to the information life cycle (Lima Júnior, 2022). Figure 1 illustrates these phases, highlighting how each step contributes to the practical application of information management, particularly in the development of AI case studies.

Figure 1

Phases of the Information Life Cycle [21]



Source: Sant'Ana (2016), p. 116-142.

The goal is to increase engagement and knowledge retention on complex topics, promoting a more effective user experience. This research adopts a gamified and risk-oriented approach (Heckert & Netto, 2017), considering process design from the perspective of information science (Aganette, 2020).

Theoretical Framework

Information retrieval in information science

Manning (2009) describes information retrieval as the process of identifying unstructured material within large data collections that satisfies a particular information need. Within this framework, the notion of informational sustainability has gained prominence as a new paradigm in information science, as argued by Geraldo et al. (2022).

Professionals working in information retrieval aim to design systems that are increasingly precise and efficient, tailored to user demands, particularly through the incorporation of artificial intelligence, which already plays a significant role in information science (Lelis et al., 2021; Paletta, 2024).

Efforts to enhance these systems involve developing robust search algorithms, creating ontologies and taxonomies to structure data, and employing personalized techniques to improve retrieval performance.The idea of information retrieval originated in the 1940s, during the "information explosion", characterized by the rapid increase of data. Bush (1945), in his article, "*As We May Think"*, introduced the concept of the memex machine, designed to store and access information quickly. He anticipated a future in which access to knowledge would be facilitated by electronic devices, a prediction that was realized in the *World Wide Web* (WWW) and hypertextuality. Since then, digitization and the advancement of storage technologies have driven the exponential growth of information.

According to Borko (1968), information science allows the study of the behavior and flow of information, as well as the processing necessary for its efficient retrieval. The delimitation of the forms of organization and retrieval is fundamental, especially with regard to the identification of the user's needs and the educational context (Orlandi et al., 2019).

The development of multimodal approaches, such as games, can represent an innovative alternative for information retrieval. This research explores this question to verify the effectiveness of playful methods in learning.

Information science, although complex, should be understood as a science that supports other disciplines, as argued by Buckland and Zapata (2018). As Saracevic (1991) observes, "the application of information technology in the solution of informational problems will move forward with or without information science", reinforcing the importance of a structure that supports this practice.

Capurro (2003) addresses the evolution of epistemology towards a "digital ontology", in which human knowledge shares space with artificial cognitive processes. This context makes the use of AI relevant to expand the frontiers of information science.

Problem-Oriented Learning with Gamification

William Glasser's learning pyramid suggests that an individual learns, on average, 10% from reading, 20% from watching, 30% from demonstrations, 50% from group discussions, 75% from practice, and 90% from teaching (Glasser, 1969).

With this panorama, problem-based learning is an innovative possibility to boost education in Brazil, as the method uses more discussions and real student-centered practices (Hayd, 2023). The use of gamification has shown considerable potential for teaching complex subjects such as mathematics. An example of this is the development of the Math Game, a playful strategy designed to support the teaching of differential and integral calculus in engineering programs. The initiative achieved strong acceptance and contributed to improved student performance in calculus courses at the University of Brasília (Heckert & Netto, 2017).

The application of gamification to mathematics also draws attention to a longstanding issue: the notably high failure rates in Differential and Integral Calculus at the University of Brasília, a concern shared by both faculty and engineering students. As reported by Fragelli (2012) and Netto et al. (2017), failure rates typically range from 50% to 60%. This problem is connected to students' difficulties in retrieving information, whether from systems or within their own learning processes. Current instructional approaches may not be effectively supporting this information retrieval process, and Artificial Intelligence (AI) offers a possible means of reinforcement (Pinheiro & Oliveira, 2022). Several recent studies have explored the integration of these areas, investigating how gamification can be enhanced by AI and how information architecture, especially information retrieval, can optimize the experience in educational environments (Souza, 2024).

Soares Netto and Lima (2020) conducted studies on legislation in Information and Communication Technology (ICT) acquisitions. Also noteworthy is the work of Mello et al. (2001), which points out the following reasons as limiting education in the classroom: the belief of students and teachers that failure and failure are normal; the scarcity of previous knowledge that should have been acquired by students in previous levels of education; the lack of interest and motivation on the part of students; the lack of good teacher training; the large number of new concepts brought by the discipline; and the scarcity of alternative teaching methodologies to engage and inspire students.

In view of this situation, it is necessary to reflect on the difficulties observed in various disciplines, redirecting the work to offer greater support to students. It is essential to investigate how information retrieval, enabled by information architecture and AI, can help solve these problems, using gamification to enhance specific learning.

A game can be an important tool in information retrieval, using information architecture models to improve the user learning experience (Agner, 2023). The study by Gottschalg-Duque (2005) emphasizes the importance of specific tools for information retrieval, such as SiRILiCO (Information Retrieval System based on Theories of Computational Linguistics and Ontology), which was used in a pilot experiment to validate the hypothesis of developing a retrieval system based on computational linguistics and ontologies.

According to McGonigal (2012), in today's society, computer and video games are satisfying genuine human needs that the real world has failed to meet. They offer rewards that reality cannot provide, teaching, inspiring, and engaging in ways that society cannot achieve. They are bringing us together in ways that society is not (McGonigal, 2012, p. 3).

The dynamics of the gamified system offer tools that guarantee feedback to users, such as: points for performance, rankings for comparison and visualization of progress, challenges and missions that guide activities, medals as a visual representation of achievements, integration that evaluates development and engagement, engagement loops that maintain motivating emotions, customization that adapts items to the user's taste, reinforcement and feedback that inform locations and results, rules that define the dynamics of the game, and narrative that guides and informs users (Zichermann & Cunningham, 2011).

This game science, which draws on information science, has emerged as one of the most interesting and rapidly developing areas of computer science. With its ability to simulate human cognitive abilities, AI has the potential to significantly transform diverse industries.

AI, Ethics and its Application in Current Teaching, with Learning Theory from the Perspective of Risk Management

AI has become an influential tool in education, introducing innovative approaches to enhance the teaching–learning process. Since Turing's (1950) seminal question about whether machines could think, AI has advanced remarkably, marked by milestones such as the chess victory over Kasparov and the emergence of sophisticated systems like ChatGPT. These developments simulate human dialogue and offer learning support, contributing to a significant shift in educational paradigms (Hassabis, 2017; Kalla et al., 2023).

AI is understood as a branch of computer science dedicated to enabling computers to carry out tasks that humans typically perform more effectively (Ertel, 2018). Within this scope, AI plays a central role in information retrieval by enabling the indexing, structuring, and efficient recovery of large datasets (Gomes, 2022). Such systems can analyze and interpret document content, resulting in more precise and customized retrieval outcomes.

AI has also gained prominence as a pedagogical resource. Intelligent systems can adapt instructional material to meet individual learning needs, creating a personalized and interactive educational experience. AI agents function as virtual tutors, offering immediate guidance and feedback throughout the learning process, which contributes to more effective and accessible teaching practices (Chen et al., 2020; Fontoura & Villalobos, 2022).

However, the implementation of AI in teaching raises significant ethical questions. Concerns related to data leakage, discrimination, and information security risks need to be considered. The General Law for the Protection of Personal Data (LGPD) in Brazil highlights the importance of protecting user data in AI systems (Barzotto, 2022; Souza & Souza, 2024). Therefore, it is essential to address these issues responsibly and ethically, ensuring that technology is utilized to promote human well-being and societal progress (Huang et al., 2023).

Meaningful learning, as proposed by David Ausubel, emphasizes that the student needs to be in a context that considers his or her previous knowledge, known as subsumers, for learning to be effective (Ausubel, 2003). Content disconnected from the student's reality makes it difficult to use these subsumers, thereby reducing learning's interest and effectiveness (Mazzei, 2021).

In simulated educational environments, debates that address students' risks and anxieties can be critical tools in the search for innovative solutions, enabling the safe application of learning in real contexts. The creation of gamified environments to explore case studies can help mitigate risks in information technology contracting in public agencies.

Effective communication is fundamental in the educational process. The teacher must understand the implications and methods of transmitting the message, considering how the information will be interpreted by the receiver, which depends on the understanding of the sender-message-receiver trio and the dissemination vehicle (Orlandi, 2019).

Document organization, like the classification stage, facilitates the retrieval of information in any system, organizing a large number of related objects. However, it is important to recognize that the classification is biased by those who perform it, underscoring the importance of ethics in this process.

Risk management is closely related to communication, as it requires the definition of a common glossary. The ABNT NBR ISO 31000 standard, developed by the Brazilian Association of Technical Standards (ABNT, 2018) and drawing on contributions from various disciplines, countries, and professionals, highlights the importance of avoiding problems across different areas of knowledge to achieve the desired results. The complementary standard ISO 31073/2022 provides standardized terminology for the field, aiding in effective communication in risk management (Golpayegani et al., 2022).

Using information architecture, it is possible to develop educational games that help in the identification of risks and decision-making in public procurement of information technology. Soares Netto (2013) proposed a risk identification artifact to assist managers in decision-making for public ICT procurement, using a checklist based on mental models from various authors to help managers with limited risk identification experience, thereby resulting in significant savings in hiring.

Heckert and Netto (2017) proposed a board ICT bidding game to improve the learning experience of public managers on the topic of public technology procurement, based on the Brazilian Federal Government's regulations. This game could use content generated by an AI, such as OpenAI's ChatGPT, not only the authors' experience, to develop case studies tailored to classes with specific needs, as described in the methodology.

In short, the integration of artificial intelligence into current education, combined with an ethical approach based on learning theories and risk management, presents significant potential to transform education, making it more effective, personalized, and aligned with contemporary needs.

Method

Regarding the themes, it is possible to carry out applied research, from the point of view of the objectives Gil (1991), as the use of a game aims to generate knowledge for practical application aimed at solving specific education problems, on decision-making, with the support of artificial intelligence for the creation of a case study (Lunetta & Guerra, 2023).

Once the theme and the type of game (board of the designer's own design) have been defined, a case study has been created, and the game will then be applied to a group.

After that, structured interviews will be conducted with professionals who will live the experience, using a Likert scale (ranging from -3 to +3) ccording to León-Mantero et al. (2020) and Westland (2022) to identify and measure risks iarisingfrom the case study, The objective of a game can and should be, among others, to look for patterns, ideas or hypotheses that can be confirmed through the initial proposition of the proposed gamified training.

For this work, the following steps will be considered: 1) Creation of a case study (with prompt and chatgpt). 2) Application of the own design game (reading of the case studies). 3) Compilation

of the risks found. 4) Application of a Likert form to assess the risks found. 5) Results and discussions.

In the initial stage of this research (preliminary stage, or 0), a literature review was conducted, with the objective of fostering dialogue among related works and developing an essay that enables reflection, as described in topics 1 and 2.

Regarding the public, a public organization of the executive branch was selected, which had large-scale hiring (over 50 hires per year) and an annual hiring plan published in Brazil (2024b). The organization was the National Electric Energy Agency (ANEEL), which, along with three other listed organizations, provided a team of 16 professionals to carry out the work on a date agreed upon by the researcher and the institution, with profiles that work in public contracting of ICTs. The forms were applied on 05/10/2024, at 5 pm, in an institutional training context, where other questions were also asked, in addition to those within the scope of the research, which were not considered for this publication.

For stage 1, in order to validate the main points related to Public Technology Procurement in the context of Normative Instruction (IN) 94/2022 of the Digital Government Secretariat (SGD) and the Ministry of Management and Innovation (MGI), a specific case study was developed, based on this knowledge track. This study aimed to illustrate the practical situation and simulate the common challenge faced by public managers of the entity when implementing the governance guidelines for contracting.

The case could address, among others, real or simulated situations, highlighting planning issues, bidding modalities, price research, contracting of cloud services, execution or control of Information Technology (IT) acquisition processes, with an emphasis on legality, efficiency and alignment with current public policies, where AI will suggest the best, based on prompt, created by the authors specifically for this work.

The study was structured to present a problem, a set of decision options, and a critical analysis of possible solutions, thereby promoting an interactive and collaborative learning environment.

With the use of the tool (OpenAI's ChatGPT, plus version) ChatGPT (2024), in topics prioritized by AI, ChatGPT itself, after applying the following command promtp (prepared by the authors), obtained a case study, with the following prompt: "You are a specialist in Information Technology bidding, based on bidding law number 14,133/21 and IN 94 of SGD/MGI of 2022. Considering the two regulations, create one real/simulated case study of high complexity, prioritized by relevance at its base, on the theme of planning ICT hiring, that includes three voting options for the groups. Make the case study that is a recurring problem and based on risk management, which brings to light the context of the reality of the public service and in Brazil, and highlights urgent decisions to be made, under penalty of interrupting a purchase of an organization".

The statement created was as follows: Price Estimate for Contracting Cloud Computing Service. Context: A public authority plans to hire cloud computing services to host its systems and data in a secure and scalable way. During planning, the IT team faces difficulties in making a reliable price estimate due to the diversity of solutions available in the market. In addition, the

offers vary depending on the contracting model (IaaS, PaaS, SaaS) and the required service level (SLA).

Voting options:

a) Conduct price research only with local suppliers: seek quotes only from national companies that offer cloud services, in order to comply with legislation and simplify the estimation process. This approach, however, can lead to a limited and outdated estimate, as it does not consider the diversity of the global cloud market.
b) Use price bank from previous contracts: Base the estimate on previous public contracts for similar services, complemented with updated market quotations. While this option is practical, there is a risk of underestimating costs due to rapid technological evolution and variations in cloud service offerings.
c) Conduct benchmarking and market analysis: Conduct a comprehensive market analysis, including domestic and international suppliers, considering different contracting models and service levels. This approach is the most complete, but it requires time and resources to identify price patterns and customize contracting according to the specific needs of the agency.

Comment on the correct answer: Option C is the most recommended, as benchmarking and detailed market analysis allow you to obtain a more realistic price estimate in line with the requirements of the cloud computing sector. Although it requires greater effort, it minimizes the risks of inappropriate hiring and ensures compliance with the precepts of Law 14,133/21.

With the case study created and previously answered for feedback purposes, let's now move on to the stage of creating a game. The vote of the participants will be placed later.

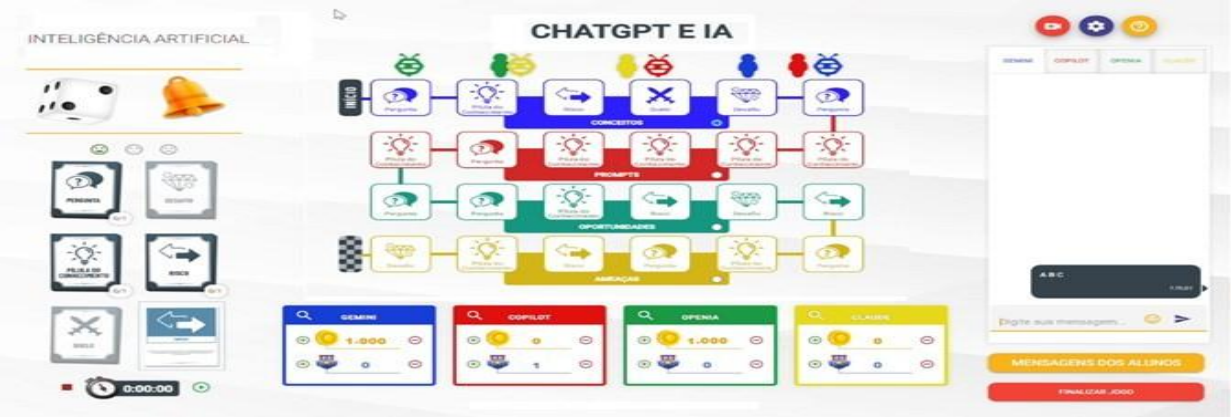
In stage 2, the creation of the game was made, which is a design approach of the authors, with the case study, whose intention is to show that each phase has a risk that needs to be addressed, from internal context, external context, solution risks, process and (specific) projects, according to Netto (2013), which thus generated a risk matrix for the case study, called Risk Management Map, of the Brazilian ICT procurement process Brazil (2024a).

Creating games from a risk management perspective offers a detailed analysis of the challenges and impacts during development. This strategic approach aims to ensure decisions that mitigate risk, resulting in safer, higher-quality games.

By applying this methodology, students can anticipate problems, implement preventive measures, and make the process more efficient, ensuring legal compliance. Risk management also helps to identify opportunities for innovation, resulting in remarkable in-game experiences. As such, it is essential for successful game creation. In Figure 2, it is possible to verify the proposal of the board for the simulation of the case study.

Figure 2

Game Design: Cloud Case Study



ANEEL

This gamified proposal, which could or could not have the use of an AI to create case studies, which is a tool to be used by the teacher, serves as a great model of multimodal communication between participants, fostering doubts, debates and an exchange of information superior to a conventional classroom, once an experience with personalized case studies is created, based on the difficulties of the class.

With the parameters of the game content defined, it was necessary to apply a form to collect the perception of the interviewees in relation to the level of risk perception, on the theme of the game, before the dynamics. After data collection, we move on to the next topic.

In step 3, after reading the case study on the theme of the game, created by ChatGPT's AI, and each respondent's response, it was observed that 50% of respondents got the case study right, and 50% got it wrong. After the debate among all with the help of the facilitator (researchers), 100% of the interviewees converged to the same opinion, showing that the debate, after the mistake of some, can be a success factor after the application of the case study.

Thus, the interview form was then delivered to all participants, in order to obtain a comparison between the learning already known by the students (passive - listening to the teacher teach) and active learning (allowing honest error - debate between who got it right and wrong), about which risks the participant perceived after debating the case study. The following questions were asked:

1) List the three main risks you perceived, and create a probability x impact matrix for each risk, using a Likert scale from -3 to +3, with +3 as the maximum.

2) What grade (from 0 to 10) would you give your experience with the game, compared to a traditional class?

The methodology followed a risk identification process based on a sample of 16 participants, in which each individual highlighted 3 risks and evaluated them using a Likert scale from -3 to +3. After the classification of the data, the probability x impact matrix of the case study, demonstrated in Figure 3, indicated and prioritized that the risk of "non-compliance with safety requirements" was perceived with a high severity (average impact +2.9) and a relevant probability (average +1.8), while the risk of "underestimation of costs" presented a lower

probability (+1.4) and significant impact (+2.5). The highlight (highest risk) was "lock-in", which had a probability of 2.6 and an impact of 2.8.

Figure 3

Probability x Impact Matrix of the Case Study

Risco	Probabilidade (Média)	Impacto (Média)
Falta de conformidade	+1.8	+2.9
Subestimação dos custos	+1.4	+2.5
Dependência de fornecedor (lock-in)	+2.6	+2.8

The Likert scale is presented as essential in the cataloguing of qualitative data, according to Likert (1932), especially when we talk about risks that are qualitative and subjective to the judgment of each interviewee.

The questionnaire was composed of: 1) explanatory text: presented the objective of the research and the guidelines; 2) consent form: the participant indicated that he understood the objectives and conditions of carrying out the research, as well as the acceptance to participate; 3) identification of the participant's profile: allowed understand the profile, maintaining anonymity; 4) 2 questions from the Likert questionnaire, to identify risks in the case study in question and compare the game with traditional methodology.

The Google Forms tool was made available for response through a QR code that directed to the form, which was answered immediately after the case study debate, allowing a comparison between the classic mode of learning and a game.

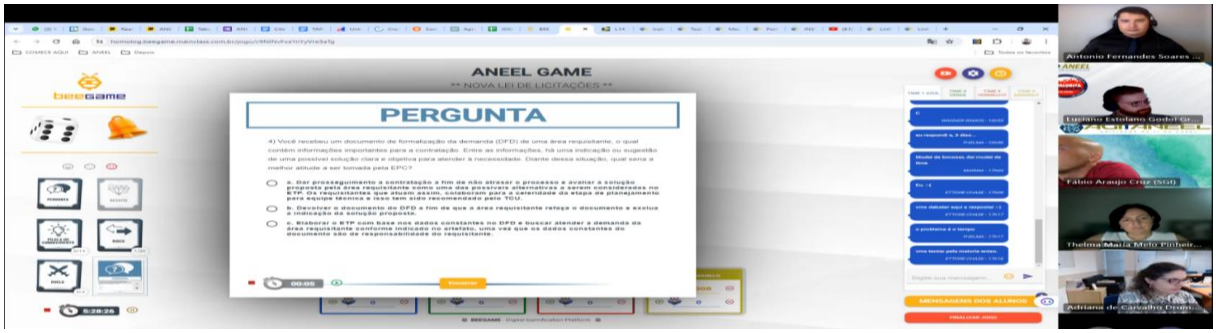
For question 2, regarding the experience with the game, the score of the participants was 93.8%, indicating that the experience with the game and case study is more effective, as shown in Figure 4. Figure 5 shows the moment of application of the case study with the ANEEL class.

Figure 4

Game with Case Study x Traditional Classroom

Figure 5

Application of the Case Study at ANEEL



Next, stage 3 will be discussed, with the results and discussions obtained from this work.

Results And Discussion

The findings obtained with the group of 16 ICT procurement professionals reveal several relevant patterns about how learning occurs when games and case studies are used as instructional strategies. The high acceptance rate of 93.8% demonstrates not only a favorable perception of the gamified method but also suggests that participants recognized added value compared with traditional expository instruction. This positive reaction is coherent with Glasser's learning pyramid and with Hayd's (2023) arguments about PBL, which emphasize that active participation tends to foster deeper cognitive engagement than passive listening.

Beyond acceptance, the participants' initial difficulty in responding to the case study is equally revealing. The fact that exactly half of the group selected the incorrect option indicates that, prior to debate, the comprehension of the problem was fragmented. This aligns with the literature on information retrieval failures (Fragelli, 2012; Pinheiro & Oliveira, 2022), which points out that students often struggle not because they lack access to information, but because they lack the ability to interpret, evaluate, and retrieve it effectively. The subsequent discussion, which led all participants to converge on the same correct answer, illustrates how collaborative reasoning, supported by the structured scenario, can compensate for individual cognitive gaps. This dynamic demonstrates, in practice, Ausubel's (2003) theory of meaningful learning, in which new knowledge is anchored through interaction with prior experiences and peer exchanges.

One of the most significant findings was the identification of "lock-in" as the most prominent perceived risk. The emphasis on vendor dependence is not accidental; it likely reflects accumulated institutional experiences in ICT procurement, where technical asymmetries between suppliers and public managers may restrict decision-making autonomy. The prominence of this concern reinforces the argument made by Soares Netto (2013) and later by Heckert and Netto (2017), who highlight that poorly structured procurement processes can lead to contractual rigidity and long-term financial or strategic constraints. The game, by simulating this risk in a controlled environment, allowed participants to externalize latent concerns that traditional lectures might not elicit.

The multimodal nature of the game also appeared to play a central role in supporting communication and comprehension. By blending narrative, rules, visual cues, debate, and guided facilitation, the game functioned as an applied information architecture model, enabling participants to navigate the "knowledge path" more intuitively. This is consistent with Agner (2023) and Kuroki Junior and Gottschalg-Duque (2023), who argue that multimodal interfaces enhance learning by organizing information in ways that mirror users' mental models. In this study, the multimodality helped clarify abstract regulatory concepts and made risk identification more tangible.

The results also highlight an important distinction between group and individual learning. While individual analysis led to divergent responses, collective debate corrected misunderstandings, strengthened argumentation, and enhanced information retrieval through observation, justification, and trial-and-error. This supports Glasser's premise that group discussion promotes higher retention and aligns with McGonigal's claims about games fulfilling cognitive and social needs unmet by traditional formats. The finding suggests that collaborative gamification could reduce the "learning gaps" often found in individualized instruction.

An additional hypothesis arising from these observations is the potential to design differentiated learning tracks tailored to students from public institutions who frequently enter the workforce with limited training in risk management and ICT governance. By exposing these learners to simulated procurement scenarios, the game could help them develop more mature risk perception, thereby improving their decision-making capacity. This could ultimately translate into more responsible use of public resources, a central goal in contemporary government management.

When compared to the traditional classroom setting, the participants perceived a clear gain in their learning regarding the identification and interpretation of risks in ICT procurement. This perception is coherent with research on active methodologies and problem-based learning. However, this conclusion must be interpreted with caution, given the modest sample size (n = 16) and the fact that all participants belonged to a single federal agency with specific procurement routines. These characteristics represent natural limitations of the study, and future research should expand the sample across multiple governmental bodies and include longitudinal measurements to verify whether the observed effects persist over time.

From a practical standpoint, the findings strongly indicate that games designed from a risk-management perspective can serve as effective training tools for public managers. The structure allows learners to rehearse complex decisions without real-world consequences and to internalize regulatory principles through guided reflection. Educational institutions and professional schools of government may benefit from integrating similar methods into their curricula, particularly in areas that combine legal requirements, technical complexity, and high stakes, such as cloud computing procurement, cybersecurity, and implementation of AI-based systems.

In summary, the study not only validates the pedagogical potential of gamification but also demonstrates that its value comes from more than entertainment: its structured, multimodal, and interactive nature enhances information retrieval, reduces ambiguity, strengthens communication, and provides a safer space for cognitive experimentation. These results reinforce the relevance of

advanced learning strategies in a field where errors can have concrete operational, financial, and political consequences.

Conclusion

The application of games adapted to public agencies can increase risk perception and learning on defined tracks, improving decision-making in specific legislation and internal communication. This perception varies between organizations, but the recurrent use of the game can improve knowledge of the topic, depending on the context and information needs.

Each organ has its particularities, and the use of multimodality with a game serves to present a vision that can guide research groups, without intending to be a definitive compendium.

The challenge lies in the organization of information and a *User-Experience UX* to facilitate the understanding and retrieval of information from various sources, adapting layout, with external resources and hyperlinks that promote richer communication.

This transforms the intuitive search for risks into a formal mapping of activities, centralizing information that helps in their identification. The use of artificial intelligence, both for simulations and for learning, enables continuous revision and is recommended, given that analytical capacity varies among individuals.

The proposal focuses on ICT hiring, but future research should also include topics such as entrepreneurship, LGPD, Innovation Law (Complementary Law 182), and the practical use of ChatGPT in content generation, which will impact the production of information in academia. The work raises questions about information retrieval and the effectiveness of a game in improving organizational decision-making, encouraging future investigations that expand testing, given its complexity.

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Author Contributions

Antonio Fernandes Soares Netto: Supervision (Lead), Conceptualization (Lead), Writing – Original Draft (Lead), Methodology (Lead), Writing – Review & Editing (Lead).

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Generative AI Use Disclosure Statement

No generative AI tools were used in the writing or analysis of this manuscript.

Data Availability Statement

Data will be available on request from the authors.

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