





# Current Risk Situation Training in Industry, and Games as a Strategy for Playful, Engaging and Motivating Training

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**Abstract** Workplace safety is a constant concern in the industry, especially in activities with a high risk of accidents, such as the operation of heavy machinery, material handling, and work with electricity. Risk situation training is a fundamental tool for accident prevention and promoting a safety culture in the workplace. However, these training practices are often seen as boring, tiresome, and ineffective, leading to low employee motivation and engagement. This article presents a survey conducted with training managers to understand training taught via traditional methods, and a rapid review performed to examine the literature on the benefits of using games with a purpose to support risk situation training and make them more playful, engaging and motivating. The survey results point out problems such as low engagement levels in training that applied traditional methods. The rapid review studies support the benefits of games with a purpose in risk situation training, where researchers indicate that strategies such as immediate feedback, participatory approaches, and scenario-based training can increase the effectiveness of risk situation training, improve employee motivation and engagement, and promote a more effective safety culture in the workplace. As a contribution, this article presents insights that can support the trainers in the adoption of learning strategies that may help to achieve training sessions more playful, engaging and motivating. In addition, this work serves to provide relevant information in the discussion on using games with a purpose for risk situation training in the industry.

**Keywords:** Risk situation training in industry, digital games, games with a purpose, survey, rapid review.

## 1 Introduction

Between 2012 and 2021, almost 23,000 people died in work accidents in Brazil. This alarming figure was released by the International Labour Organization (ILO) (ONU, 2022), warning: “when it comes to workers operating machinery and equipment, accidents can be up to 15 times more frequent”. In this same period, approximately 4 percent of the global GDP per year was spent on accidental occurrences involving human actions (ONU, 2022). When this data is applied to the Brazilian GDP of 2021 (8.7 trillion reais) (IBGE, 2022), the damage is close to 350 billion reais.

Safety is a crucial factor in mitigating accidents at work, as it directly affects the health and well-being of employees and operational continuity (Cairo Junior, 2002). In this context, training workers how to behave in risk situations, the so-called risk situation training (or safety training), can arouse interest and increase the perception of risk on the part of employees, according to Facundes et al. (2016). Risk situation training must ensure employees are prepared to deal with risky situations and maintain a strong safety culture (Lacerda and Abbad, 2003).

Usually risk situation training can be monotonous and uninteresting, making it difficult for employees to stay engaged and motivated nowadays (Brahm and Singer, 2013). According to Robbins (2005), to make a training

effective, it is necessary that (i) trainees are satisfied with this procedure, (ii) content is adequate to what the job requires, and (iii) knowledge absorbed during training can be easily transferred to the professional activity. For some time, most risk situation training has been provided using materials such as handouts and videos. Meanwhile, new technologies are emerging in this scenario, generating comparisons and showing more engaging and motivating alternatives than the traditional training methods in industry, such as digital games and playful methodologies (Lovreglio et al., 2021).

In this context, this work aims to seek information on how risk situation training is conducted in industry and identify alternative techniques to so. As such, we explore **how to make risk situation training in industry more playful, engaging and motivating**. Thus, we analyzed approaches and strategies that can be used to make training more effective to employees and increase playfulness, engagement and motivation. Kwegyir-Afful and Kantola (2020) state that games with a purpose can be an attractive and innovative alternative to make risk situation training in industry more appealing and effective. Then, this work discuss the possibility of using them instead of the traditional methods.

This study is divided into two research questions (RQ) to organize and guide the investigation:

- RQ1. How is risk situations training applied in industry?
- RQ2. How can digital games with a purpose help in risk situations training in industry?

RQ1 was answered by an exploratory study, which involved the participation of 30 professionals who deliver risk situation training in industry. RQ2 was answered by a rapid review grounded on 14 studies on the subject and with support and validation of three industrial managers. Finally, with the survey responses and the works identified in the rapid review, we discussed the main problem addressed in this work (how to make risk situation training in industry more playful, engaging and motivating?).

This work contributes to understand the dynamics of risk situation training in industry based on the perception on the evaluation of these events from the professionals who develop and conduct related activity. Other contributions refer to identifying interests of industrial and training managers regarding digital games for training in the industry, and presenting the state of the art of games with a purpose for training in risk situations in industry. We expect that the discussion can contribute to the adoption of games as a tool in risk situation training in industry, favoring engagement and motivation through playfulness in the training processes.

This article is organized as follows: Section 2 provides the backgrounds for this work. Section 3 presents the research method. Section 4 refers to the protocol and results of the survey. In Section 5, protocol and results of the rapid review are reported. Section 6 presents the discussion of results. Section 7 includes the threats to validity and limitations of this work. Finally, final remarks are presented in Section 8.

## 2 Background

### 2.1 Organizational Training for Risk Activities in Industry

Organizational training can be conceptualized as the development of professional skills and competencies, according to the requirements of the position to be occupied. The goal is to make the individual more productive and able to achieve the goals of the corporation in which he or she is inserted (Venturi et al., 2021).

According to Pinto et al. (2011), all industrial activities involve some risk. Risk activities are those carried out in environments or with equipments that subject the worker to an accident due to occupational hazards. Occupational hazards are characterized by any work situation that may harm the worker's health, from ergonomic dangers in an office to more aggressive agents in industrial areas such as heat, noise and proximity to dynamic equipment (Facchini et al., 1991).

Since the middle of the 20th century, accidents at work have come to be seen in many countries as capable of impacting the economic side of companies (Barbosa and Ramos, 2012). Therefore, organizational training focused on safety and accident prevention is essentially part of a strategy that adheres to the values of companies that have

risky activities in their production environments, keeping the staff up to date with market practices that are increasingly competitive and capable of conducting the work safely (Lacerda and Abbad, 2003).

As claimed by Burke et al. (2006), risk situation training programs based on teaching paradigms, such as lectures and awareness campaigns, may not be appropriately connected with work reality. Laberge et al. (2014) and Romero et al. (2019) reported in their findings that motivating workers in training sessions is not a simple task and that the success of a training program depends directly on the methodology and investment.

### 2.2 Kirkpatrick's Four Levels of Training Evaluation

For a training program to be effective, it must undergo evaluations to verify whether the training given had the desired effects on people and the organization (Abbad et al., 2000). In the literature, there are some models for training evaluation.

The training transfer model to the workplace, devised by Baldwin and Ford (1988), measures the application of the knowledge, skills and competencies acquired by an employee during training in his/her daily work environment. These authors proposed that successful transfer depends on factors such as the similarity between the training and the work environments, the relevance of the training to the employee's tasks and responsibilities, and the employee's willingness to apply what has been learned. On the other hand, the model proposed by Kraiger et al. (1993) suggests that training evaluation should consider three types of outcomes: cognitive signals, affective learning, and skills learning.

In the 1950s, Donald Kirkpatrick and Wendy Kirkpatrick created a learning evaluation model with their family name (Kirkpatrick and Kirkpatrick, 2016). The present work chooses to use of Kirkpatrick's model because, even after a few decades, this model remains practical, appropriate and applicable in several contexts (Alsalamah and Callinan, 2021b), with recent publications such as (Agarwal et al., 2019) and (Alsalamah and Callinan, 2021a) attesting the method as efficient and current. The Kirkpatrick model consists of four levels of evaluation: reaction, learning, behavior, and results, as shown in Figure 1 (Kirkpatrick and Kirkpatrick, 2016).

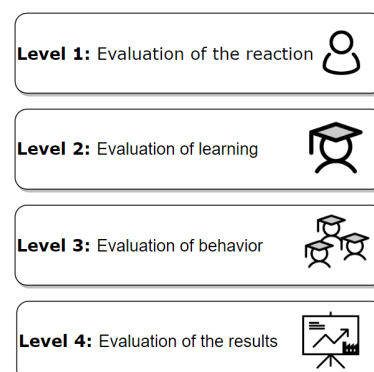


Figure 1. The Kirkpatrick model.

The evaluation of the reaction measures participants' reactions to the training program. The measurement can be done through satisfaction surveys, seeking to evaluate the responses concerning the content and format of the training. Evaluation of learning (the second level of Kirkpatrick's model) analyzes how much participants learned during training based on tests, evaluations or other activities that can measure the knowledge acquired (Kirkpatrick and Kirkpatrick, 2016). The third level evaluates whether the behavior of employees (evaluation of behavior) who underwent training has changed in any way as a collective and medium-term evaluation stage. This level can be measured through field observation of the employee's behavior in the work environment and by evaluating performance indicators. The fourth level (evaluation of the results) analyzes the impact of training on organizational outcomes, such as increased productivity, cost reduction or reduction in the number of accidents, among others. Organizational results can be measured through data analysis, performance indicators or quantification of events such as accidents and incidents (Kirkpatrick and Kirkpatrick, 2016).

### 2.3 Digital Games as Information Systems Applied to Training

Information systems (IS) and organizations are linked in such a way that both influence each other. This influence occurs in several fields, such as structure, managerial decisions, and culture (Laudon and Laudon, 2004). Digital games can be seen as IS as they incorporate features and elements such as data input, player commands, processing of these inputs, output, and feedback. Digital games can present processes, collect and handle information, resulting in player decision-making (Xexéo et al., 2021).

Digital games, as IS, can propagate helpful information, transmit knowledge effectively, and allow the measurement of a trainee's performance (Chittaro and Ranon, 2009). As such, digital games can contribute to organizational health, allowing workers to improve the execution of business processes and may even contribute with their visions and improvements (Ferreira and de Classe, 2022).

In this context, the application of games for organizational training is perceived as a practical proposal for knowledge retention and engagement of people, presenting better results than traditional training (lectures or videos etc.). Therefore, this strategy becomes a powerful and innovative tool to act in changing the safety culture in an organization (Lovreglio et al., 2021).

### 2.4 Related Work

Gao et al. (2019) conducted a systematic review in which 49 scientific studies were analyzed the effectiveness of computational approaches (such as digital games) in risk situation training. As a result, the researchers show that the validity of traditional methods is well-founded, and more studies are needed to support digital games even if there are indications that such technology (and other computational means) can provide better results. However, this study did

not involve professionals who experience the problems investigated in the present work in practice.

Peiró et al. (2020) present a systematic review on risk situation training in the construction sector, focusing on workers with low professional and academic qualifications. The authors analyzed 18 studies on the topic and points out the challenges of implementing and evaluating risk situation training. For the analysis of the risk situation training found in the selected studies, the authors used Kirkpatrick's 4-level model for training evaluation, stating that this method is widely used in assessing risk situation training. The review detailed risk situation training and revealed the low number of studies on this subject (only 18 met the inclusion and exclusion criteria over 20 years). Despite profiling risk situation training in a specific industry sector, the authors did not rely on the expertise of trainers and managers who design and deliver risk situation training to validate their findings.

Concerning the games with a purpose for education in the industry, Almeida and Simoes (2019) pointed to the role of these games in industry 4.0 as tools for educating people about industrial subjects. As the main challenges, the authors highlighted the difficulties of simplifying the real world in these games. Other authors, such as Checa and Bustillo (2020), Mystakidis et al. (2021) and Tanaka et al. (2023), focused their research on investigating games that use simulations-based virtual reality and how it can improve risk situation training.

Although the works of Gao et al. (2019) and Peiró et al. (2020) address the effectiveness of training in the industry, they differ from the present work, which investigates the subject based on a mixed methodological approach to address both academia and industry perspectives. In other words, while those related works focus on systematic reviews, which involve the analysis of a large number of existing studies to identify patterns and trends, the present work comprises a survey to capture the perceptions of trainers about training they provide in industry, and a rapid review to identify the industry's interests in alternative training methods and present a state of the art directed to what is being developed in practice.

Even Almeida and Simoes (2019) addresses games to education in the industry, the authors did not focus on the context of risk situation training, which is the purpose of our paper. Also, Checa and Bustillo (2020), Mystakidis et al. (2021) and Tanaka et al. (2023) pointed to virtual reality as a possible path to follow for these games. However, we identified virtual reality as a viable approach to creating games for risk situation training, but it is not unique.

## 3 Research Method

To guide this research, four steps were defined: an informal literature review, an opinion survey with training managers, a rapid review of the literature with the support of training managers, and the synthesis of information discussing the results of the survey and rapid review. A summary of the steps can be seen in Figure 2.

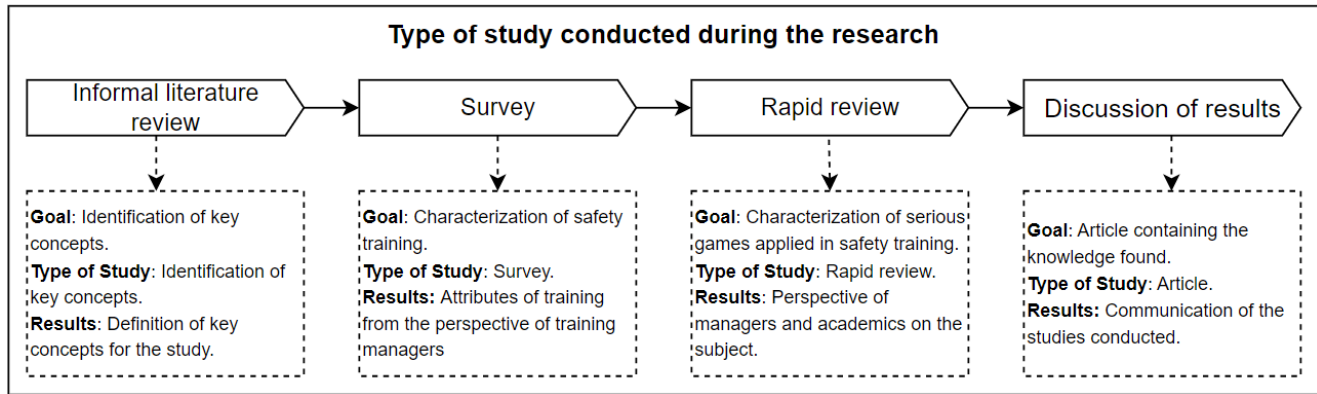


Figure 2. Research method overview.

The definition of the number and content of the stages was inspired by the work of Dias-Neto et al. (2010). In the **informal literature review**, i.e., literature review without explicit or systematic criteria for the search and critical analysis (Cooper, 1998), the researchers could identify in scientific studies the main concepts and characteristics of training for risk situations in the industry via Google Scholar, which is a search tool that indexes scientific and academic articles. As a result, it was possible to observe that risk situation training is an essential element for mitigating accidents in industry (Lacerda and Abbad, 2003). However, there is interest in tools that can increase playfulness, engagement and motivation (Li et al., 2017). The review also retrieved studies that mentioned the importance of training evaluation and models used for this purpose (Alsalamah and Callinan, 2021b; Agarwal et al., 2019), from which Kirkpatrick's model was identified for further exploration and understanding of its levels.

To investigate options for improving training, it is necessary to know the deficiencies reported by those who manage and provide this training. To do so, a **survey** (Section 4) was conducted, which included responses from 30 training managers for risk situations aimed to look into their perceptions about training sections.

With the answers and deficiencies reported by training managers, this work proposes the use of digital games as an alternative to making training more playful, engaging and motivating. As such, investigating the literature to know how these games are used in industrial training is necessary. Thus, a **rapid review** (Section 5) was conducted. According to Cartaxo et al. (2018), it combines academic practice with the knowledge of professionals who experience a target problem in their daily lives.

Finally, in the **discussion of results** step, the studies are organized and communicated to the research and practice communities. This step comprises the discussion of the survey and rapid review findings, as well as the important relationship found between the results of both studies (i.e., what was observed in the literature and the practical perceptions of the participants). At this stage, limitations and possible threats to the validity of the studies are also raised.

## 4 Risk Situation Training in Industry

A survey offers the possibility of gathering information by questioning a group of people, within a specific domain, in a systematic way, enabling the direct knowledge of relevant information by the respondents, quickly and at low cost (Kitchenham et al., 2015; Creswell and Creswell, 2017). In this work, the survey sought a better understanding of risk situations training applied in industry from the point of view of training managers.

The work of Pfleeger and Kitchenham (2001) inspired the steps that guided the survey: **planning** (i.e., goal setting, research planning, and questionnaire preparation and validation); **execution** (i.e., participant selection and questionnaire distribution); and **results** (i.e., data analysis and construction of the report of the found knowledge).

### 4.1 Planning

The survey aimed to answer the research question RQ1 (**How is risk situations training applied in industry?**). To help answer this question, we formulated sub-questions based on Kirkpatrick's training evaluation method, with a sub-question defined for each model level:

- (SR1) **Reaction evaluation:** How do the trainees respond to the training?
- (SR2) **Learning evaluation:** Do the trainees absorb and apply the knowledge presented in training?
- (SR3) **Behavior evaluation:** Does the training trigger the desired behavioral changes?
- (SR4) **Results evaluation:** How are the training results verified by the interested company or institution?

The questionnaire used in the survey was divided into three parts. The first one contains a brief explanation of the research purpose and a free and informed consent form (Bispo Jr et al., 2021). The second one aims to identify the participants' profile with questions about age, gender, education, place of birth, profession, and region where he/she works. The third one presents the questions that help capture the perception of the participants regarding the training, where questions were elaborated to support the answers to the research sub-questions. The questions in the third part can be seen in Table 1, with closed questions

**SRQ6** (i.e., the participant can choose among the options “lecture”, “slides”, “videos”, “practical training” and “handouts”, being able to select one or more items simultaneously) and the others being discursive.

**Table 1.** Questionnaire’s questions about training sessions.

Kirkpatrick level	Code	Question
Training situation	SRQ1	For which risk situations do you train the team?
	SRQ2	What is the level of satisfaction observed in the participants (trainee) BEFORE the training session?
Reaction	SRQ3	What is the level of interest and engagement of the participants DURING the training session?
	SRQ4	What is the level of satisfaction observed in the participants AFTER the training session?
	SRQ5	What reactions would you like participants to have after the training?
Learning	SRQ6	What is the methodology used in the training you give?
	SRQ7	How do you assess whether the participants absorbed the knowledge satisfactorily?
	SRQ8	What do you do if some participant in training does not absorb the knowledge satisfactorily?
Behavior	SRQ9	Is it possible to observe the intended behavior changes after training?
Results	SRQ10	What are the business indicators impacted by the training you provide?
	SRQ11	How are the indicators in the previous question disclosed in the company where you work?
General opinion	SRQ12	Free opinion

To validate the questionnaire, a pilot was conducted, which involved two training managers in industry (both technical professionals in occupational safety). This pilot aimed to add reliability to the questionnaire by meeting essential quality requirements, such as the objectivity of the questions, the scope of the proposed topics and the appropriate questions arrangement (Manzato and Santos, 2012). In the pilot, the participants informed that the questionnaire should have the order of its questions and some terms changed to meet the logical sequence and make questions more precise and objective for the respondents.

### 4.2 Execution

After executing the pilot and implementing the suggested adjustments into the questionnaire, the survey was sent out to training managers of a large company in the energy sector through an online electronic form, using a messaging application used corporately by this company, where the respondents received it individually. Participants were asked to forward the form to more colleagues with the desired profile for the research. The form was made available on January 4th, 2023, and remained accessible until the 23rd of the same month.

This research delivered each participant the informed consent form (ICF), clarifying that we would not collect any sensitive data which came to identify them. Participation was voluntary, and the participant could give up at any time. Also, we explained in ICF that we would treat data not to allow participant identification. We manage all data following the Brazilian data protection law.

### 4.3 Results

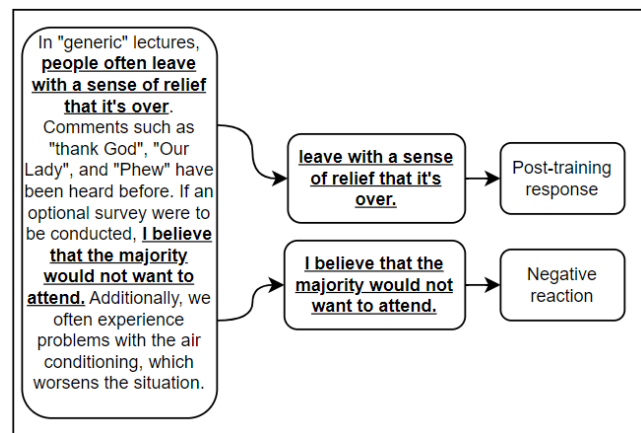
A quantitative analysis was applied on the data collected<sup>1</sup> from the demographic questions to explore the participants’ profiles and to summarize and describe the information

<sup>1</sup>Survey data: <https://doi.org/10.5281/zenodo.7902811>

obtained. The study used descriptive statistics techniques, such as graphs and tables.

To analyze the answers obtained in the questions shown in Table 1, the grounded theory presented by Strauss and Corbin (1990) were adapted to the qualitative analysis techniques applied in this work. Then the qualitative analysis were organized into two steps: i) open coding: where data is segregated and categorized; and ii) axial coding: where the relations among the categories defined in the previous step are identified. As this study deals with a small group of training managers compared to the possible sample universe across the industry, selective coding, as proposed by Strauss and Corbin (1990), is not applicable since this coding is used to identify broad and theoretical patterns in data that may represent a significant part of the population to be observed. So, only open and axial codings were used in the qualitative analysis.

As exemplified in Figure 3, open coding was performed while reading the responses, where the researchers examined the data and identified concepts, ideas and themes that emerged from them. Open coding is an iterative process, meaning you must revisit the data several times to determine all relevant pictures. The open coding technique was guided by the questions presented in Table 1, in which two researchers conducted the coding and validated each other’s work to increase consistency and reliability of the analysis.



**Figure 3.** Coding example.

With the aid of the *Atlas.ti* software, the researchers organized the concepts identified in the open coding into broader categories and explored the relations among them to create a conceptual model that can help explain how the codes identified are related to each other, thus fulfilling the second step of qualitative data analysis (axial coding). The codes were grouped into four categories, referring to Kirkpatrick’s four levels of training evaluation.

#### 4.3.1 Participants’ Profile

From 30 participants, 47% aged between 45 and 54 (14 participants), 43% are between 35 and 44 years old (13 participants), 7% aged over 54 years old (2 participants), and 3% (1 participant) is between 25 and 34 years old (Figure 4). The gender question had answers only between

the options “Male” and “Female”, in which 93% of respondents chose Male (28 participants) and 7% Female (2 participants).

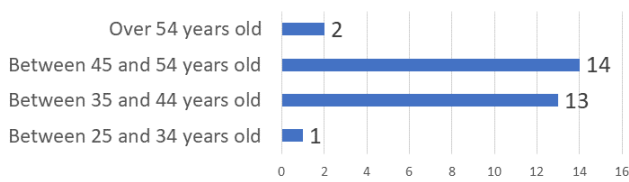


Figure 4. Participants’ age.

Regarding the participants’ education level, 30% reported having completed higher education, and the same number of those completed high school (9 participants each). Those who said incomplete higher education were 17% of the participants (5 participants), and 23% (7 participants) reported having some level of specialization, as presented in Table 2.

Table 2. Participants’ education level.

Educational level	Amount
High school	9
Incomplete graduate	5
Complete graduate	9
Specialization or MBA	7

The professional activities focused on occupational safety technicians (77% - 23 participants). Some participants who provided risk situation training are nurse, reserve military, environment technician, electronics technician, maintenance supervisor, maintenance coordinator and platform manager, each of them representing 3% of the participants (i.e., 1 participant in each profession).

### 4.3.2 Level 1 - Reaction Evaluation

First, we sought to find out for which types of risks the training given by the participants were observed (SRQ1). From the respondents, 50% (15 participants) reported that they provide training aimed at **firefighting**, 47% (14 participants) for **work at height**, and 40% (12 participants) were involved in theoretical and practical training for **work in confined spaces**. Topics such as **use of personal protective equipment (PPE)**, **first aid**, **hearing protection**, and **respiratory protection** were also mentioned.

After that, to verify the trainers’ perspective regarding **SR1 (Reaction evaluation - “How do the trainees respond to the training?”)** of the training they provide, the sub-questions SRQ2, SRQ3, SRQ4 and SRQ5 were investigated.

Sub-Questions SRQ2, SRQ3 and SRQ4 were focused on how to know, from the perspective of training managers, what is the level of expectation (satisfaction) of the trainees before, during and after receiving the training (i.e., the level of pleasure when they arrive to be trained, during the training session and after the event is over). It is also questioned what level of satisfaction the managers expected at the end of the training they provide (SRQ5).

As seen in Figure 5, the expectation **before training** is low, as it is directly linked to the adverse reaction of trainees. The red dotted lines link the codes directly to the category in question. A solid black line connects codes that are related to each other. Two codes assigned to the responses given by participants in the qualitative analysis are linked to this low expectation, translated by the “negative reaction” code: excessive use of lectures and repetitive content. The answers<sup>2</sup> to say that all participants’ answers were in Portuguese, and the transcriptions presented in the article are translations into the English. to the questionnaire show the context of this low expectation:

*“Some of them on their faces already show disinterest because they think the content is repetitive.”*  
[Participant 5]

*“Brief presentation without the use of media.”*  
[Participant 8]

In this regard, attention is drawn to the report made by participant P3, in which he/she says that **“more elaborate training, using media resources, increases interest”**. This indicates the possibility of a connection between the level of expectation and satisfaction with which an individual addresses a training session with the type of method or media used.

Reports of positive reactions from trainees when arriving at the training sessions were identified in the speech analyses, but also mentioned the lack of interest and involvement of other participants. It can indicate that these positive aspects may be a minority among the observed cases, as in the case of the comment:

*“I can notice two groups: the resistant/unmotivated and the motivated trainees.”*  
[Participant 17]

When participants respond about the level of satisfaction and engagement **during the training sessions**, positive and negative comments also emerged. The negative comments point to the **low interest** in some people and behaviors such as low level of interaction and lack of attention to the content taught. This can be seen in the excerpts:

*“Little interest and engagement.”*  
[Participant 22]

*“Most go in mute and go out silent. Many even nap due to the time of the lectures.”*  
[Participant 28]

*“Not very motivated to participate. We have to try to rescue this interest somehow.”*  
[Participant 8]

The positive reports by the respondents, identified in the qualitative analysis, go through indications of engaged trainees and short answers such as **“very good”**. However, the comment made by participant P25 stands out - he/she made the connection between engagement in training with risk situations and the occurrence of practical activities:

<sup>2</sup>It is important

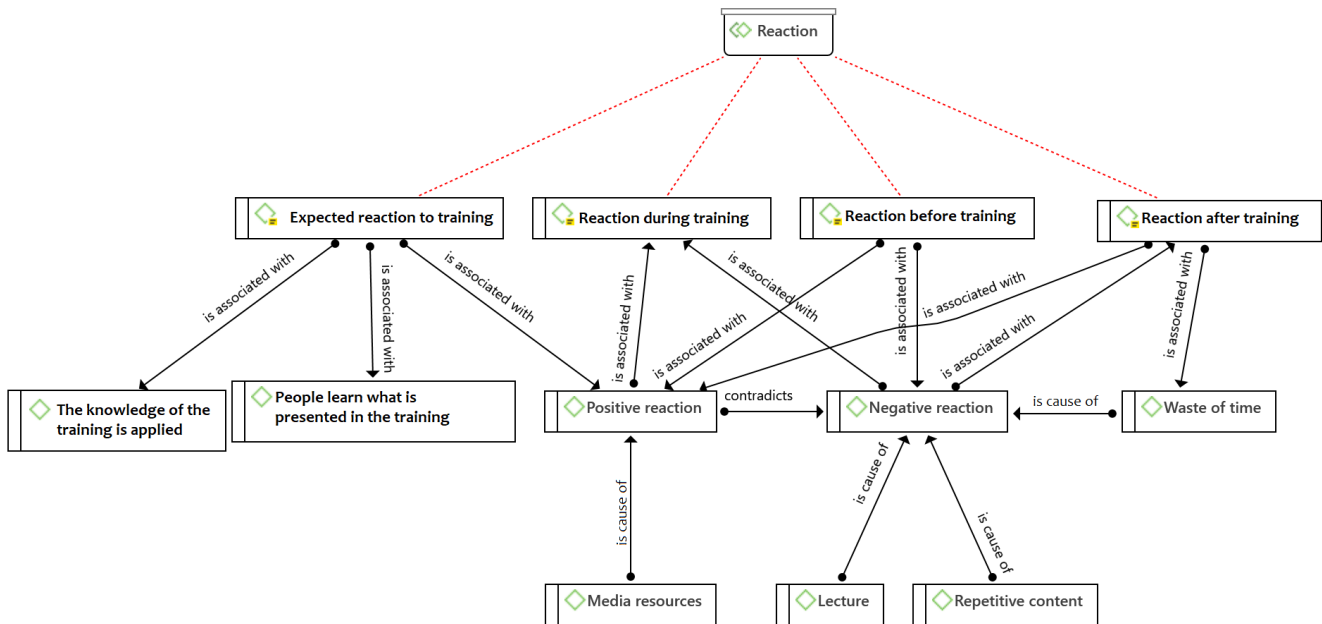


Figure 5. Codes and relations associated to the reaction level.

*“In general, face-to-face training with practical approaches has a greater engagement of participants.”*  
[Participant 25]

*“Positive reactions as all training aims to protect human life.”*  
[Participant 20]

When questioned about the level of satisfaction after the training, the participants report that the trainees leave the training sessions with a good level of satisfaction, but with reservations. There are also reports that trainees consider the training session a waste of time:

Additionally, the participants demonstrated a desire for training methods or methodologies different from what they used (such as lectures, videos, slides etc.). Such interest was observed, which was called by one of the participants “restructuring”:

*“Some are even motivated by the acquired knowledge, but most see it as an obligation to fulfill prerequisites to work or continue working.”*  
[Participant 30]

*“[...] to adapt the transmission methodology so that the listener can absorb the knowledge satisfactorily.”*  
[Participant 1]

*“There are few who show enthusiasm. Most of them demonstrate that there was a waste of time.”*  
[Participant 7]

**SR1 - How do the trainees respond to the training?**  
There are indications that people who receive risk situation training do so out of obligation, without interest or motivation. According to managers, low engagement may be linked to repetitive and passive training.

Finally, the participants answered what level of satisfaction they would like to see in their trainees when they leave the training (SRQ5). The answers converged and point out that managers want their trainees to use the knowledge acquired in training. In addition, it demonstrates that they learned what was taught and applied it in practical work activities. However, these comments are made as if this were a goal far from being achieved. To illustrate such a conclusion:

*“I would like them to have at least the interest in solving their doubts, but the feeling they pass is that they are immersed in a profound disinterest in learning.”*  
[Participant 5]

*“It would be interesting if the participants replicated the knowledge.”*  
[Participant 13]

### 4.3.3 Level 2 - Learning Evaluation

Regarding SR2 (Learning Evaluation - “Do the trainees absorb and apply the knowledge presented in training?”), the questionnaire items SRQ6, SRQ7 and SRQ8 were answered by the participants. The goal is to inform which training method has been used in the sessions they conduct, how the managers assess whether the trainees have absorbed the knowledge satisfactorily and what is done if any training participant demonstrates that he/she did not understand all the content.

As illustrated in Figure 6, referring to the answers to SRQ6, most participants in this study (87%) reported that they provide training in the form of **lectures** (26 participants), 83% related that they use **slides** (25), 73% use **videos** during training (22) and 17% use written material such as **handouts** (5) as a way of transmitting the

information. Participants who said they applied some **practical training** were 63% (19 participants), and 10% (3) said they used another way to apply training, such as daily dialogues with the respective teams. The participants were allowed to choose multiple answers.

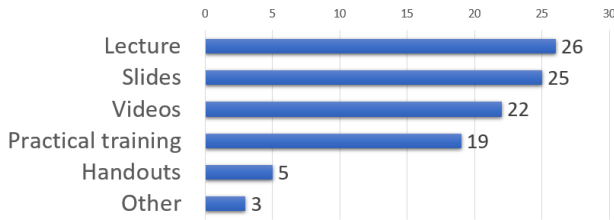


Figure 6. Most used training methods.

Based on the answers to questions SRQ7 and SRQ8, the diagram shown in Figure 7 was constructed, in which it can be seen that the category **learning** was highlighted and is directly linked to two main codes: **assessment of participant’s training learning**, and **actions taken if learning is not satisfactory**.

From the analysis of the codes related to the evaluation of participants’ learning (i.e., test, practical evaluation, behavioral change and participation), there are indications that, even though tests are the most cited as a method of learning assessment, managers are dissatisfied with this procedure:

“Unfortunately, the evaluation method is through tests.”  
[Participant 29]

In the study, some managers use subjective assessments, e.g., observation of trainees during training, perception of maturity of doubts presented, and analysis of trainees’ behavior when training is run in a practical activity. None of the participants reported any technique for measuring trainees’ aptness during this observation,

“I evaluate the change in posture after training.”  
[Participant 3]

“Through the field practice of their activities.”  
[Participant 30]

“Well-elaborated questions and participation with personal examples.”  
[Participant 10]

For the actions taken when the manager realizes that the trainee has not absorbed the knowledge satisfactorily, measures involving motivation through real situations, replication of the training by other trainees and changes in the application method of training were mentioned:

“I try to motivate the worker. I also ask for possible topics of interest to the worker. I also ask if he/she or a colleague has been through real situations. But sometimes it is not possible to motivate the trainee and depending on his/her performed role, the change of employee should be evaluated.”  
[Participant 7]

“I replicate the training at the next opportunity.”  
[Participant 3]

“I try to change how I teach and make that person understand!”  
[Participant 12]

Finally, it was observed that there is an indication of dissatisfaction with this tool, since participants pointed to “conventional lectures” as an important factor observed in the low level of interest on the part of the trainees. This happens even though lectures are the method most used by participants to provide the trainees with a learning experience:

“For conventional lectures, medium to low level of interest. The more elaborate methodologies using media resources, the more interest increases.”  
[Participant 3]

**SR2 - Do the trainees absorb and apply the knowledge presented in training?**  
Managers make use of written tests and subjective evaluations, such as trainee observation. If the training has not been effective, managers make an effort to retransmit the information, but without any concrete measures.

#### 4.3.4 Level 3 - Behavior Evaluation

Regarding **SR3 (Behavior evaluation - “Does the training trigger the desired behavioral changes?”)**, participants’ answers for question SRQ9 of the questionnaire were analyzed. 83% of respondents (25 participants) stated that they could observe changes in behavior in trainees, against 17% (5 participants) who reported that they could not notice such a transformation.

However, when investigated in more detail based on the connection tree (Figure 8) between the category **Behavior** and the codes related to **Behavior changes**, one can note that participants who respond positively to SRQ8 link the change in behavior to a deadline for it to occur, i.e., the samples indicate that changes in behavior are not immediate. This opinion is also supported by the participants who answered SRQ8 negatively,

“Objectively yes, but it must be considered that the cultural change of some practices is slow and does not occur in the first opportunities that trainees participate.”  
[Participant 25]

“Over time yes.”  
[Participant 6]

“Not possible in the short term.”  
[Participant 22]

“Not immediately.”  
[Participant 14]





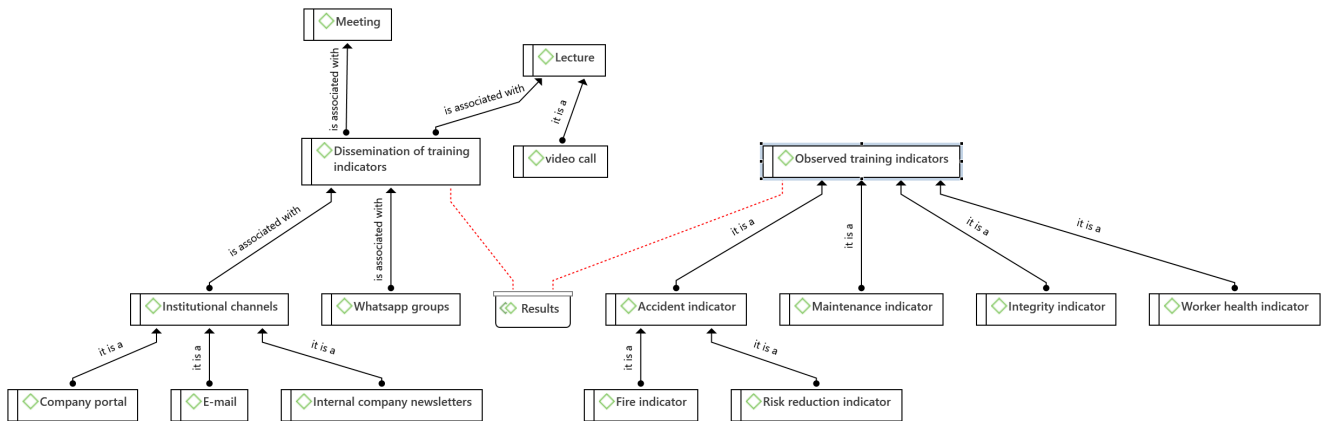


Figure 9. Codes and relations associated to the result level.

indicators were impacted by the training they provide (SRQ10) and how they are disclosed (SRQ11):

When asked about which business indicators related to training in risk situations they observe in their respective organizations, the participants described **indicators of the number of accidents, indicators related to workers' health, indicators of integrity, and maintenance indicators**. The last two relate to the integrity and maintenance of industrial plants:

*“Accidents with and without removal and fire outbreaks.”*  
[Participant 15]

*“Accident and incident indicators, in addition to maintenance and integrity indicators.”*  
[Participant 3]

*“Statistical data of accidents and fire outbreaks are pretty basic.”*  
[Participant 5]

When asked about how these indexes are disseminated, the participants mentioned **institutional channels**, such as internal bulletins, emails and portals with internal information, **meetings** with colleagues and leadership for results disclosure, face-to-face and remote **lectures**. Some participants said they received information about the business indexes through non-institutional channels, such as groups in messaging applications:

*“SMS Lectures and Video Conference.”*  
[Participant 2]

*“Commonly these events are presented by management in face-to-face meetings and lives.”*  
[Participant 25]

*“They are published in the WhatsApp groups of each course module in which all the instructors of that module participate.”*  
[Participant 19]

*“Multi-level critical analysis meetings.”*  
[Participant 14]

**SR4 - How are the training results verified before the interested company or institution?**  
The results of risk situation training are indirectly measured through indicators such as the number of accidents or incidents. Both the indicators and the means for dissemination appear to be well established.

#### 4.3.6 Free Opinion

In **SRQ12**, participants were invited to provide a free opinion. This question is not mandatory for completing the form, so not all participants responded (19 out of 30 participants gave some comment - 63%). Respondents affirmed that training is a tool capable of guiding people towards appropriate behavior for safety standards and financial matters, such as agility at work and efficient use of resources:

*“Risk situation training for industries is very important to try to avoid as much as possible the loss of personnel, material and time.”*  
[Participant 20]

*“I have the perception that educational training and training of the workforce is essential to maintain an acceptable level of safety indicators.”*  
[Participant 26]

*“Training is one of the best tools for guiding employees.”*  
[Participant 4]

Once gain, the participants make it clear that training in industry requires investment. The topic **change in method methodology** was addressed in the respondents' discourse as the need for **training restructuring**, as well as the need for more **interactive** training and more **engaging** methods. It was pointed out that the frequent repetition of the training content and format, as well as the volume of training, may be linked to the lack of motivation of the trainees:

*“Training to be satisfactory requires heavy industry investment between Theory and Practice.”*  
[Participant 2]

*“I believe the training format needs to be restructured, something more practical, interactive and engaging. And*

*that you applied a kind of quiz before and after training so that the public could previously assess the content and then measure what was absorbed.”*

[Participant 5]

*“Workers are also motivated by novelty. Therefore, excessive repetitions of the same training ‘model’ demotivate the trainee. This frequently happens in the organization where I work.”*

[Participant 7]

*“In my modest opinion, I realize that companies ‘mistreat’ their employees, who in our discussion would be our ‘training clients’ in the same way that the education system treats its students. We didn’t really look at the problem. We intensified the amount of training and masked the rates to satisfy the ego of the company’s management.”*

[Participant 9]

*“It is important to develop techniques that make training as interactive as possible and, in the end, invariably seek feedback from participants, through available means, such as filling out questionnaires and free testimonials.”*

[Participant 14]

Once the classical training methods do not motivate and engage people, the use of games can support these aspects, being an eventual approach to risk situation training. Therefore, we made a rapid review to look into studies in this context.

## 5 Digital Games with a Purpose to Risk Situation Training in Industry

According to Cartaxo et al. (2018), a Rapid Review is an adaptation of traditional systematic literature reviews, aiming to bring academic methodological practices closer to the real problems and perceptions of professionals who experience them in practice. A rapid review must be born from a practical problem observed in the real world (organizations, market etc.). Therefore, it is common to associate study planning with the knowledge of people who are directly involved and interested in solving a problem, such as managers, instructors and performers.

A rapid review should deliver results faster than systematic literature reviews. Usually, they are limited to research on a single scientific basis, being conducted by only one researcher, and no evaluation is undertaken regarding the quality of the findings (Cartaxo et al., 2018).

In this work, we also conducted a rapid review based on (Cartaxo et al., 2018) and (Motta et al., 2021), aiming to identify relevant works as well as extract and interpret information that can answer the research questions. According to Cartaxo et al. (2018), the method is divided into four steps (Figure 10): interviews, planning, execution, and results.

### 5.1 Interview

For this study to be entirely based on a real problem, three managers of an oil industry were invited to contribute to the interview stage, in which a diagnosis was run. All participants have completed higher education and worked in the company for over 13 years. Individual interviews were conducted, lasting approximately 30 minutes each, with questions about risk activities and training in the respective organizations to which they belong. The answers can be summarized as:

**“How often do you participate or give training focused on risk situations?”** – The participants reported that they participate in weekly training focused on risk situations, such as safety briefings, face-to-face normative training, and online reading standards directed by the company. Participants provide lectures and emergency simulations.

**“Describe the risk activities that occur in your organization, the characteristics of the team, and what are the main challenges for the application of training for this team.”** – There were reports of risks of explosion, risks related to the handling of loads, maintenance and operation of equipment, dynamic equipment and environmental hazards. The teams were described as multidisciplinary and highly diverse. The challenges in applying training to these teams are the difficulty in adapting to different technical levels and the training hours to the scale routine.

**“Free opinion:”** – Managers reinforced their interest in digital games applied to training and highlighted the need for more engagement power and a greater possibility of adapting training to the trainee. Managers mentioned that they were interested in knowing how much training with digital games is better compared to their counterparts in traditional methods, especially if there is an increase in cost and production time when games are adopted as a training methodology.

The interview stage was essential to the rapid review for adding knowledge about the needs of those who live the

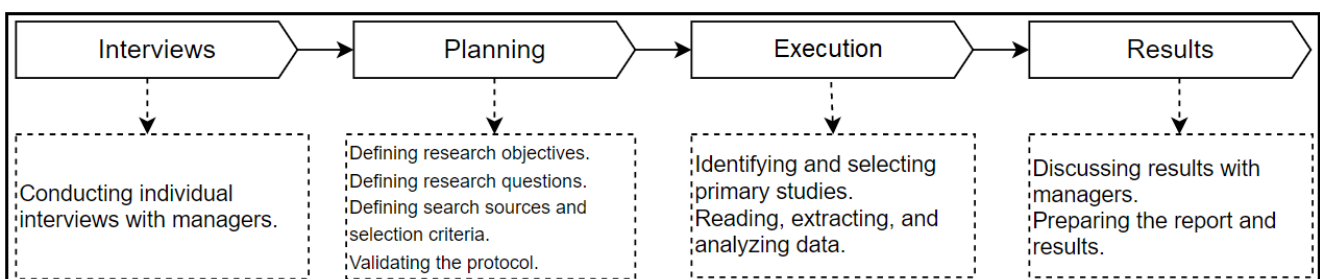


Figure 10. Rapid Review stages.

routine of activities and risk training. Contributions to modeling from the research questions to the execution protocol were diverse. The RR’s protocol (comprising planning and execution) and results were validated with the managers.

### 5.2 Planning

The rapid review aimed to answer the research question RQ2 (How can digital games with a purpose help in risk situations training in industry?). Thus, we used the GQM (Goal/Question/Metric) paradigm (Basili and Rombach, 1988) to the **definition** of this study’s objective, as follows: **analyze** the existence of primary studies, **with the goal of** identify games with a purpose **regarding** risk situation training, **from the point of view of** researchers, in industrial **context**. The **research questions** (Table 3) were defined based on the *checklist* 5W2H (Motta et al., 2021).

Table 3. RR questions.

N°	Research Questions
Q1	What is the understanding regarding games as a tool in risk situation training?
Q2	How can games be used in risk situation training?
Q3	Where are the activities that are the target of possible games for risk situation training located?
Q4	Who are the potential workers who should receive training for risk situations involving games?
Q5	When can games for risk situations training be applied?
Q6	What is the cost of developing a game with a purpose for risk situation training?
Q7	Why should games be implemented in risk situation training?

Once the questions were defined, the **search strategy** was structured. Following the proposal by Cartaxo et al. (2018), this research used the Scopus database, as it indexes other relevant digital libraries in the computing field. The **search string** was defined using the PICOC (Population, Intervention, Comparison, Outcomes, Context) strategy (Wohlin et al., 2012). The terms adopted for each dimension were: (i) **Population** - risk; (ii) **Intervention** - games with a purpose; (iii) and **Outcomes** - training. For each term, synonyms and variations were addressed. **Context** was set to “industries”; nonetheless, this term was not used in search string because the search strategy was based on identifying studies on games for risk training in a comprehensive way and, subsequently, filtering the results by this context in the complete reading stage. **Comparison** was not used because comparisons and output evaluations are not part of the scope of this study (RR). So, the search string was defined as in the following:

(“risk\*” OR “danger\*” OR “hazard\*” OR “threat”\*)  
 AND  
 (“serious game” OR “game\* with a purpose” OR “game\* with purpose”)  
 AND  
 (“training” OR “instruction\*”).

The inclusion (IC) and exclusion (EC) criteria (Table 4) were used in the analysis of the studies.

Table 4. Inclusion and exclusion criteria.

ID	Criteria
CI-1	Study addresses the use of serious games aimed at risk situation training in industry.
CE-1	Study with no access for complete visualization in scientific databases.
CE-2	Study with less than 4 pages.
CE-3	Duplicate study.
CE-4	Study does not address the use of serious games aimed at risk situation training.
CE-5	Non-primary study (reject systematic literature reviews or systematic mapping studies).
CE-6	Study is not written in Portuguese or English.
CE-7	Study is a preface, book, editorial, abstract, poster, panel, lecture, round table, workshop, keynotes, tutorial, or demonstration.

### 5.3 Execution

The execution of the study began with a **search for studies (step 1)** in the Scopus database, retrieving 326 studies<sup>3</sup> (Figure 11). Next, the **removal of duplicate studies (step 2)** was performed, excluding 4 of them (1.2%). Then, the **selection (step 3)** was achieved. Each study’s title, abstract and keywords were analyzed concerning the criteria established in Table 4. From 158 studies remained (48%), a **full reading (step 4)** was performed, applying the criteria in Table 4 and analyzing whether the studies were within the industry context. In the end, only 14 (4.3%) studies were accepted (Table 5). Only one researcher performed the full reading of the studies and extracted information (step 5) to answer rapid review questions, later discussing results with other two researchers with experience in empirical studies, systematic reviews, and research on games.

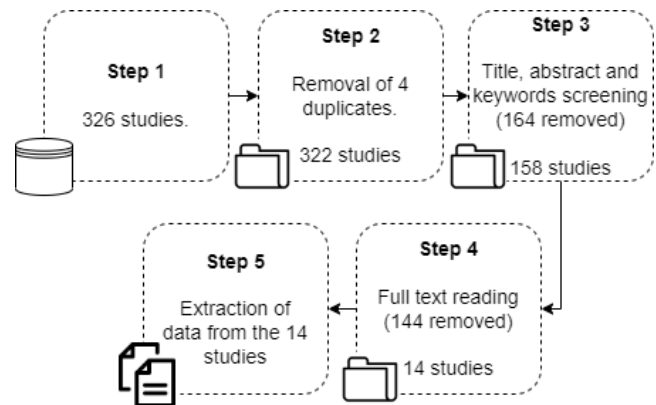


Figure 11. Rapid review filtering steps.

### 5.4 Results

In rapid reviews, researchers usually create reports with the main findings of the study to deliver the information quickly. Next, we will present the central questions of the rapid review with their discoveries, which are also available in the rapid review report<sup>4</sup> in a summarized way.

#### Q1) What is the understanding regarding games as a tool in risk situations training?

This question focuses on the understanding of the influence a game with a purpose can have when applied to risk situation training. We observed that the studies (indicated as

<sup>3</sup>Rapid review data: <https://doi.org/10.5281/zenodo.7902811>

<sup>4</sup>RR report: <https://doi.org/10.5281/zenodo.7896322>

Table 5. Selected studies.

ID	Title	Reference
S1	An Immersive Virtual Reality Training Game for Power Substations Evaluated in Terms of Usability and Engagement	Mondragón Bernal et al. (2022)
S2	An intelligent and persistent browser-based game for oil drilling operators training	Brasil et al. (2011)
S3	Comparing the effectiveness of fire extinguisher virtual reality and video training	Lovreglio et al. (2021)
S4	Development and validation of a confined space rescue training prototype based on an immersive virtual reality serious game	Lu et al. (2022)
S5	Interactive tools for safety 4.0: virtual ergonomics and serious games in real working contexts	Lanzotti et al. (2020)
S6	Learning efficacy of the 'hazard recognition' serious game: A quasi-experimental study	Mayer et al. (2013)
S7	Measuring the Learning Effectiveness of Serious Gaming for Training of Complex Manufacturing Tasks	Li et al. (2017)
S8	Modeling Process of a Third Dimension Universe for Transportation Simulation: Application to Railway System	Lamotte et al. (2019)
S9	Serious games as enablers for training and education on operations on ships and off-shore platforms	Bruzzo et al. (2013)
S10	Serious games for training occupants of a building in personal fire safety skills	Chittaro and Ranon (2009)
S11	SimTJS: A model for developing serious games for training	Trindade et al. (2014)
S12	Simulation-Based Safety Training for Plant Maintenance in Virtual Reality	Kwegyir-Afful and Kantola (2020)
S13	Towards the development of a 3D serious game for training in power network maintenance	Rosendo et al. (2011)
S14	Use of serious gaming and virtual reality applications improves students' learning retention and reduces safety risks and costs associated with training activities	Gallerati et al. (2017)

Sx, where x is the study's identification) present around five main characteristics (Figure 12), so that games are: effective for learning processes and risk scenarios (**process learning**) (7 - 50% - S1, S2, S3, S6, S7, S12, S13); **promote engagement** of instructors and trainees (5 - 35% - S2, S3, S5, S7, S9); offering the opportunity to become familiar with the risk scenario (**familiarization with risk**) without actually risking (4 - 28% - S3, S4, S6, S8); effective for simulating highly complex situations (**complexity simulation**) (4 - 28% - S9, S10, S11, S14); and measure **individual performance** of training participants (1 - 7% - S1).

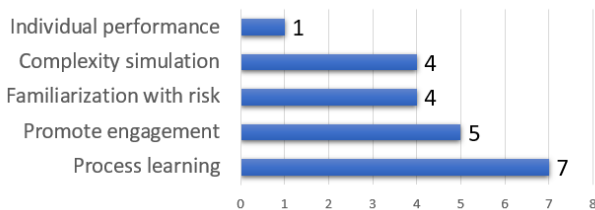


Figure 12. Characteristics of training that uses games.

**Q2) How can games be used in risk situation training?**

In this question, the way researchers in the selected studies implemented games with a purpose was investigated. All analyzed studies use 3D work environment simulation (Figure 13). As such, 7 (50%) studies use computer applications (S5, S6, S7, S9, S10, S13, S14) and 5 (35%) studies used virtual reality games (S1, S2, S3, S4, S12). The remaining two studies use specific technologies, such as S8 (Lamotte et al., 2019), in which a locomotive cabin simulator built along the lines of the real equipment was used, and S11 (Trindade et al., 2014) whose study focuses on describing an architecture for the application of digital games in training at an industrial plant.

**Q3) Where are the activities that are the target of possible games for risk situation training located?**

The question sought to answer the most frequent places where training that applied games is used (Figure 14). Among the 14 selected studies, 10 (71.4%) are about applications related to **final productive activity**, i.e., the activity closely linked to the purpose of the company (S1, S2, S6, S7, S8, S9, S11, S12, S13, S14), 2 (14%) studies

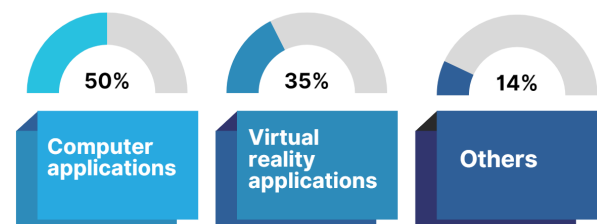


Figure 13. The way games be used in risk situation training.

that contemplate **evacuation of buildings** in case of fire (S3, S10), 1 (7%) of **cargo handling** by the work environment (E5), and 1 (7%) of **rescue in confined space** activity (S4). There is a concentration of games used in activities in the **oil industry** (5 - 35% - S2, S6, S9, S11, S14) and activities of **electricity transmission and distribution** (3 - 21% - S1, S12, S13).

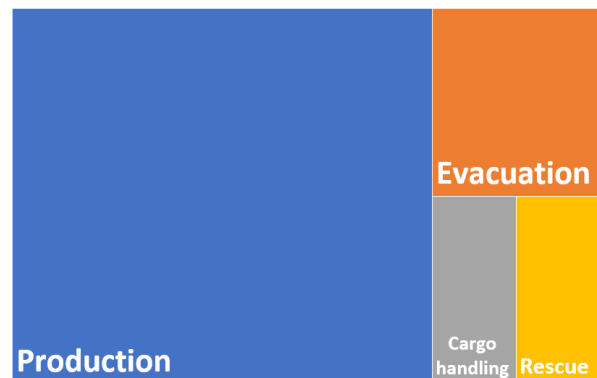


Figure 14. Where games for training are used.

**Q4) Who are the potential workers who should receive training for risk situations involving games?**

This question sought an overview of which functions or jobs are the target of training using games with a purpose (Figure 15). The workers who are most cited as targets of games developed for training are **industrial system operators** (6 - 43% - S1, S2, S5, S6, S7, S8) and **maintainers** (2 - 14% - S12, S13). S3, S10 and S11 are addressed for firefighting in administrative buildings; therefore, they are directed to **all occupants (all team)** of a given establishment. In addition, S9 and S14 studies are

focused on **all crew** on ships and oil rigs (Bruzzone et al., 2013) and all onshore drilling field workers (Gallerati et al., 2017). In these studies (5 - 36%), games are intended for all occupants of a given facility. Only Lu et al. (2022) (1 - 7% – S4) describe a game used to train a **rescue team**, which works specifically in confined space work situations.

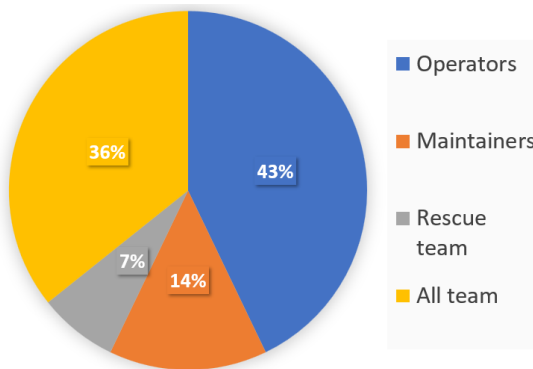


Figure 15. Main workers that use games for training.

**Q6) What is the cost of developing a games with a purpose for risk situation training?**

Although 10 of the 14 selected studies (71%) contemplate the subject, none of them is exhaustive regarding the cost of applying a digital game in risk situation training. There is also no relationship between digital games and traditional training.

Lu et al. (2022) state that the technology used in training the rescue team is a low-cost solution but also point out that lectures disseminated by electronic means may have an even lower cost. Bruzzone et al. (2013) treat the game developed in the study as an alternative that saves time, risks and costs in its training but does not provide development values or relation with the previously used method, similarly to Rosendo et al. (2011), who add monetary optimization from the ease of repetition of tasks by trainees. Finally, Gallerati et al. (2017) also infer that virtual environments decrease overall costs by reducing the possibility of errors in training conducted within the workplace in complex activities, also without evidences to prove this statement.

**Q7) - Why should games be implemented in risk situation training?**

From the selected studies, 8 (57%) compare conventional training for risky situations and their versions using games with a purpose. All the comparisons made placed the training using digital games at a higher level of quality. Table 6 shows the main features highlighted.

**6 Discussion**

This work aimed to investigate the following problem: **how to make risk situation training in industry more playful, engaging and motivating**. To answer this main question, two research questions were defined: “How is risk situation training applied in industry?” and “How can digital games with a purpose help in risk situation training in industry?”.

Table 6. Advantages of use games for training.

ID	Results obtained with the use of games with a purpose in training
S3	Training using games proved to be more effective when compared to video training in acquiring and retaining knowledge and self-efficacy.
S4	The group trained for confined space rescue through a digital game made 63% less errors than the group trained through reading on digital equipment.
S5	The success rate of 100% with training using a digital game, while a safety “talk” meeting achieved 85%.
S6	The study observed improvement in competence and risk perception of workers with and without experience.
S7	There was an improvement in the interpretation and retention of knowledge, confidence and engagement when comparing training using a digital game with reading one.
S10	The study highlighted the opportunity to explore various possibilities in fire scenarios, flexibility not achieved in evacuation simulations.
S12	95% of participants report realizing greater effectiveness in safety training that uses a digital game.
S14	77% of the participants evaluated the training using a digital game as good or excellent, and 62% considered that the topics covered by the virtual training were learned more efficiently than the equivalent in traditional training.

To answer both questions, a survey was conducted and comprised responses from 30 training managers in industry, followed by a rapid review with the help of three industry managers, in which 14 studies were selected and analyzed.

**6.1 “How is risk situations training applied in industry?”**

According to what was expressed by the participants, training on risk situations in industry is applied in the most diverse ways, from face-to-face training to online learning sessions. According to reports, risk situation training follows a basic recipe: lectures, handouts, slides and videos are applied repeatedly for the most diverse learning sessions, such as firefighting training, rescue in confined spaces, personal protective equipment, and maneuvers with residual energy, among others.

Even though these methods are well established since they are widely used (Li et al., 2017; Gao et al., 2019), the effect caused cannot go unnoticed: the participants who answered the questionnaire make convergent reports on the lack of interest, engagement, motivation and resistance to receiving new knowledge, the same explanation heard from the industrial leaders interviewed for the rapid review. These same participants also converge in attributing this behavior of part of the trainees to the lack of novelty in the content and the lack of methods to disclosing knowledge.

The training managers describe the learning evaluation as unsatisfactory since they have in the written tests the main instrument for investigating the effectiveness of the knowledge transfer. Comments such as “unfortunately, the assessment method is through tests” support the idea that there may be room for other assessment strategies. This possibility was cited by Chittaro and Ranon (2009) when they present digital games as an alternative for monitoring individual performance due to the system’s interactivity with the player.

Kirkpatrick and Kirkpatrick (2016) describe that evaluating the change of behavior of who receives training is not a trivial task. To perform such changes, running for the medium to long term is necessary. The narrative of the survey’s participants points in the same direction, since most of them stated that it is possible to observe changes in

behavior in the long term. The rapid review did not retrieve studies that performed a longitudinal study of games for risk situation training to measure their medium and long-term impact, opening an opportunity for further studies.

The participants affirmed that the evaluation of the training results applied to the interested organizations is well-founded in indexes of accidents, integrity and health of the workers. However, none of them mentioned any tool for evaluating these results that considers training directly, such as return on investment or means that can cover the before and after training within the referred organization. This fact indicates that these management tools may exist at a higher management level than the one addressed in this work.

## 6.2 “How can digital games with a purpose help in risk situation training in industry”

According to the selected studies, there is indication that digital games with a purpose can be very useful in risk situation training in industry. The reasons for this statement go through the **active involvement** of a trainee, since games have an interactive nature, which encourages players to participate in the proposed activities, instead of simply watching a lecture or video (Kwegyir-Afful and Kantola, 2020). Moreover, there is a possibility of **risk situations simulation**, since games can be customized to more realistically simulate risk situations and consequences of faulty acts, making employees experience and learn to act in such cases (Mayer et al., 2013).

From the selected studies, it is observed that the existence or not of gain in learning, engagement and acceptance with the use of digital games is not a concern, but its magnitude, since all claimed some good results. The games applied to training point to rescue contexts, cargo handling, building evacuation and especially in actions involving productive activity. It is not by chance that there is a concentration of studies on activities involving electricity and oil installations, which are the highest risk activities according to Regulatory Standard NR-4 Ministério do Trabalho e Previdência (2022).

Another benefit that can be added to risk situation training using digital games is the possibility of objective evaluation. According to Chittaro and Ranon (2009), digital games can assess employees’ knowledge and skills concerning risk situations, allowing trainers to identify weaknesses and areas that need improvement. This possibility also makes room for immediate feedback to a trainee on his/her performance since games can instantly inform the player about it, allowing him/her to correct mistakes and improve skills more quickly.

In summary, digital games with a purpose can be a powerful and effective tool to train employees in risk situations in industry. It can help them learn engagingly and prepare to face these situations safely.

## 6.3 “How to make risk situation training in industry more playful, engaging and motivating”

Some findings obtained from the survey and the rapid review point to risk situation training being applied with methods that may be linked to poor performance in interaction, learning and transfer of knowledge applied to the workplace. Participants in both studies agreed that this area lacks innovation and increases the active involvement of trainees, even if the current tools used in everyday life (e.g., videos, lectures, slides, among others) are well established.

To make learning more engaging, motivating and playful, creating an interactive, collaborative, visual and practical learning experience is necessary, using several different techniques and strategies to involve employees and make training more relevant and impactful (Gallerati et al., 2017; Lanzotti et al., 2020; Mondragón Bernal et al., 2022). An alternative that brings together the attributes mentioned above is digital games with a purpose, which can offer interactive simulations that allow users to experience real security situations and make decisions in real-time (Mondragón Bernal et al., 2022), present challenges and missions that require users to apply their security expertise to resolve issues (Lu et al., 2022), and provide instant feedback to users, allowing them to see the result of their actions immediately (Chittaro and Ranon, 2009).

As stated by Forbes magazine (Forbes, 2022), using digital games for training sessions can pose challenges, such as developing systems capable of providing the correct experience to the player and the variety of information required for the development. However, it also reported benefits such as superiority compared to traditional methods (Lovreglio et al., 2021), the reduction of human errors in the work environment (Lu et al., 2022), the variety of scenarios and situations that games can be explored (Chittaro and Ranon, 2009), and the perception of greater efficiency on the part of players (Gallerati et al., 2017) are indications of a scenario where these games are viable.

## 7 Limitations and Threats to Validity

Limitations and threats to the validity of a **survey** may be linked to the participation of third parties (Nascimento et al., 2018). The questionnaire was sent out to training managers in the energy sector. Thus, there may be a bias in the answers since there is a possibility that the working conditions of the participants are similar. Another factor that may represent a limiting factor is the size of the responses. Many participants gave short answers, thus making it challenging to extract more deep interpretations. According to Pinto and Santos (2012), researchers involved in a given scientific work may unwittingly convey personal biases in their interpretations, which may threaten the study. This factor may have been inserted in the coding stage, which depends on the researchers’ understanding. However, the double check made by researchers can decrease the bias in this threat.

Due to the method aimed at speeding up results (Motta et al., 2021), a **rapid review** has features that limit it and may threaten its validity. First, the search for studies was conducted in only one database, which may have limited the number of primary studies in the analysis. After this step, the selection procedure was performed by only one researcher, increasing the possibility of bias in the choice of articles. Choosing studies was carried out without being evaluated for their quality, which may impact the reliability of the selected studies. The validation of the results by industry managers may represent a threat, given that they are professionals far from academic rigor and they got a two-page report for evaluation without the research details, only with the outcomes (findings). Even with all the efforts to perform the analysis and discussion, due to the subjectivity of the process, other researchers may achieve more complete results with the study of the findings.

According to Wagner et al. (2020), surveys conducted with open invitations can pose self-selection biases, where individuals interested in the research topic are more likely to participate, resulting in a biased sample and a lack of control over the sample size, which can lead to non-generalizable results. There is also a threat of a lack of verification of participants' identities, which may allow individuals who do not meet the inclusion criteria of the study to participate. In an attempt to mitigate these threats, context factors were taken into account during the response analysis stage to filter out possible non-representative participants.

Finally, the survey study may present threats to internal and external validity. Internal validity may be threatened due to participant engagement and specific training content influence. External validity may be threatened by a lack of generalizability of results to other contexts and non-representativeness of participants. Specific contextual limitations should be considered in future studies to ensure result validity.

## 8 Final Remarks

This article sought to investigate **how to make risk situation training in industry more playful, engaging and motivating**. Two studies were conducted to answer two questions: a survey to answer **“how is risk situations training applied in industry?”** and a rapid review to answer **“How can digital games with a purpose help in risk situations training in industry?”**.

The survey participants reported that there is a noticeable lack of interest on the part of the trainees in the training sessions. Their statements show that engagement and interaction in training using traditional teaching methods are lower than the level targeted by the trainers. It is difficult to accurately measure the level of knowledge absorbed during the sessions and the behavioral changes in the trained community, if any, in the medium and long term. In the organizations where they work, some indexes measure aspects that the quality of risk situation training may impact some indexes may indirectly.

In search of methods that may add playfulness,

motivation and engagement to training sessions, the use of digital games with a purpose was presented as a suggestion. A rapid review was conducted to investigate such games from the researchers' point of view. As a result of the analysis of the studies, it was possible to observe that games with a purpose applied to risk situation training are perceived as more effective than traditional methodologies. Different technologies support the games application, especially computer applications and immersion in virtual reality. In this research, it was also possible to notice that the main target of the analyzed studies is productive activities, such as production plants and assembly lines. So, the most frequent target audience of this training is workers, operators, and maintainers of industrial systems. Finally, the cost-benefit of a game for use in training is often cited as advantageous, although no strong evidences were provided.

In conclusion, there is indication that practical learning makes training more playful, engaging and motivating in industry. The selected studies apply several techniques to involve learners and may result in more relevant training. Among the options for making risk situation training more interactive and impactful, games with a purpose are seen as attractive and innovative, besides having several studies that endorse qualities such as effectiveness for complex scenarios and the opportunity to monitor individual performance. As future work, this work opens some opportunities, such as investigating game-based training techniques, developing game design methodologies for training games, and providing technological support (software and other tools) to the game design process.

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## References

- Abbad, G., Gama, A. L. G., and Borges-Andrade, J. E. (2000). Treinamento: análise do relacionamento da avaliação nos níveis de reação, aprendizagem e impacto no trabalho. *Revista de Administração contemporânea*, 4:25–45.
- Agarwal, N., Pande, N., and Ahuja, V. (2019). Expanding the kirkpatrick evaluation model-towards more efficient training in the it sector. In *Human Performance Technology: Concepts, Methodologies, Tools, and Applications*, pages 1092–1109. IGI Global.
- Almeida, F. and Simoes, J. (2019). The role of serious games, gamification and industry 4.0 tools in the education 4.0 paradigm. *Contemporary Educational Technology*, 10(2):120–136.



- Alsalamah, A. and Callinan, C. (2021a). Adaptation of Kirkpatrick's four-level model of training criteria to evaluate training programmes for head teachers. *Education Sciences*, 11(3):116.
- Alsalamah, A. and Callinan, C. (2021b). The Kirkpatrick model for training evaluation: bibliometric analysis after 60 years (1959–2020). *Industrial and Commercial Training*, 54(1):36–63.
- Baldwin, T. T. and Ford, J. K. (1988). Transfer of training: A review and directions for future research. *Personnel Psychology*, 41(1):63–105.
- Barbosa, L. O. and Ramos, W. (2012). Importância da prevenção de acidentes no setor de construção civil: um estudo de caso em Uberlândia, Minas Gerais, Brasil. *Revista Conhecimento Online*, 2.
- Basili, V. R. and Rombach, H. D. (1988). The Tame Project: Towards improvement-oriented software environments. *IEEE Transactions on Software Engineering*, 14(6):758–773.
- Bispo Jr, E. L., Fonseca, L. S., and Santos, S. C. (2021). Reflexões e desafios sobre a formação na ética em pesquisa na computação envolvendo humanos. In *Anais do XXIX Workshop sobre Educação em Computação*, pages 488–497. SBC.
- Brahm, F. and Singer, M. (2013). Is more engaging safety training always better in reducing accidents? Evidence of self-selection from Chilean panel data. *Journal of Safety Research*, 47:85–92.
- Brasil, I. S., Neto, F. M. M., Chagas, J. F. S., Monteiro, R., Souza, D. F. L., Bonates, M. F., and Dantas, A. (2011). An intelligent and persistent browser-based game for oil drilling operators training. In *International Conference on Serious Games and Applications for Health*, pages 1–9.
- Bruzzone, A. G., Massei, M., Solis, A. O., Poggi, S., Bartolucci, C., and Capponi, L. D. (2013). Serious games as enablers for training and education on operations on ships and off-shore platforms. In *Proceedings of the 2013 Summer Computer Simulation Conference*, pages 1–8.
- Burke, M. J., Sarpy, S. A., Smith-Crowe, K., Chan-Serafin, S., Salvador, R. O., and Islam, G. (2006). Relative effectiveness of worker safety and health training methods. *American Journal of Public Health*, 96(2):315–324.
- Cairo Junior, J. (2002). O acidente do trabalho e a responsabilidade civil do empregador. Master's thesis, Universidade Federal de Pernambuco.
- Cartaxo, B., Pinto, G., and Soares, S. (2018). The role of rapid reviews in supporting decision-making in software engineering practice. In *Proceedings of the 22nd International Conference on Evaluation and Assessment in Software Engineering 2018*, pages 24–34.
- Checa, D. and Bustillo, A. (2020). A review of immersive virtual reality serious games to enhance learning and training. *Multimedia Tools and Applications*, 79:5501–5527.
- Chittaro, L. and Ranon, R. (2009). Serious games for training occupants of a building in personal fire safety skills. In *2009 Conference in Games and Virtual Worlds for Serious Applications*, pages 76–83. IEEE.
- Cooper, H. M. (1998). *Synthesizing research: A guide for literature reviews*, volume 2. Sage.
- Creswell, J. W. and Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.
- Dias-Neto, A. C., Spinola, R., and Travassos, G. H. (2010). Developing software technologies through experimentation: experiences from the battlefield. In *XIII Ibero-American conference on software engineering*.
- Facchini, L. A., Weiderpass, E., and Tomasi, E. (1991). Modelo operário e percepção de riscos ocupacionais e ambientais: o uso exemplar de estudo descritivo. *Revista de Saúde Pública*, 25:394–400.
- Facundes, J. L., Arantes, T. A., Júnior, R. O. M., and Borges, M. T. (2016). Treinamento e conscientização para auxiliar na redução de acidentes na indústria da construção civil. *Revista Integralização Universitária*, 9(14).
- Ferreira, M. R. and de Classe, T. M. (2022). Design de pré-roteiros para jogos digitais baseados em processos de negócios. *iSys-Brazilian Journal of Information Systems*, 15(1):8–1.
- Forbes (2022). Futuro do trabalho: seu treinamento será um game. Disponível em: <https://forbes.com.br/carreira/2022/05/games-invadem-treinamentos-corporativos/>. Acesso em: 10 Dezembro 2022.
- Gallerati, P., Bagnato, S., Casciaro, D., Conte, A., and Maisano, M. (2017). Use of serious gaming and virtual reality applications improves students' learning retention and reduces safety risks and costs associated with training activities. In *Offshore Mediterranean Conference and Exhibition*.
- Gao, Y., Gonzalez, V. A., and Yiu, T. W. (2019). The effectiveness of traditional tools and computer-aided technologies for health and safety training in the construction sector: A systematic review. *Computers & Education*, 138:101–115.
- IBGE (2022). IBGE - Produto Interno Bruto. IBGE, 2022. Disponível em: <https://www.ibge.gov.br/explica/pib.php>. Acesso em: 06 Julho 2022.
- Kirkpatrick, J. D. and Kirkpatrick, W. K. (2016). *Kirkpatrick's four levels of training evaluation*. Association for Talent Development.
- Kitchenham, B. A., Budgen, D., and Brereton, P. (2015). *Evidence-based software engineering and systematic reviews*, volume 4. CRC press.
- Kraiger, K., Ford, J. K., and Salas, E. (1993). Application of cognitive, skill-based, and affective theories of learning outcomes to new methods of training evaluation. *Journal of Applied Psychology*, 78(2):311.
- Kwegyir-Afful, E. and Kantola, J. (2020). Simulation-based safety training for plant maintenance in virtual reality. In *International Conference on Applied Human Factors and Ergonomics*, pages 167–173. Springer.
- Laberge, M., MacEachen, E., and Calvet, B. (2014). Why are occupational health and safety training approaches not effective? Understanding young worker learning processes using an ergonomic lens. *Safety Science*, 68:250–257.
- Lacerda, É. R. M. and Abbad, G. (2003). Impacto do treinamento no trabalho: investigando variáveis

- motivacionais e organizacionais como suas preditoras. *Revista de Administração contemporânea*, 7:77–96.
- Lamotte, O., Galland, S., Koukam, A., Gaud, N., Shakshuki, E., et al. (2019). Modeling process of a third dimension universe for transportation simulation: Application to railway system. *IEEE Intelligent Transportation Systems Magazine*, 11(4):137–156.
- Lanzotti, A., Vanacore, A., Tarallo, A., Nathan-Roberts, D., Coccocorese, D., Minopoli, V., Carbone, F., d’Angelo, R., Grasso, C., Di Gironimo, G., et al. (2020). Interactive tools for safety 4.0: Virtual ergonomics and serious games in real working contexts. *Ergonomics*, 63(3):324–333.
- Laudon, K. C. and Laudon, J. P. (2004). *Management information systems: Managing the digital firm*. Pearson Educación, London.
- Li, K., Hall, M., Bermell-Garcia, P., Alcock, J., Tiwari, A., and González-Franco, M. (2017). Measuring the learning effectiveness of serious gaming for training of complex manufacturing tasks. *Simulation & Gaming*, 48(6):770–790.
- Lovreglio, R., Duan, X., Rahouti, A., Phipps, R., and Nilsson, D. (2021). Comparing the effectiveness of fire extinguisher virtual reality and video training. *Virtual Reality*, 25(1):133–145.
- Lu, S., Wang, F., Li, X., and Shen, Q. (2022). Development and validation of a confined space rescue training prototype based on an immersive virtual reality serious game. *Advanced Engineering Informatics*, 51:101520.
- Manzato, A. J. and Santos, A. B. (2012). A elaboração de questionários na pesquisa quantitativa. *Departamento de Ciência de Computação e Estatística-IBILCE-UNESP*, 17.
- Mayer, I., Wolff, A., and Wenzler, I. (2013). Learning efficacy of the ‘hazard recognition’ serious game. In *International Conference on Serious Games Development and Applications*, pages 118–129. Springer.
- Ministério do Trabalho e Previdência (2022). Norma regulamentadora no. 4 (nr-4). Disponível em: <http://www.guiatrabalhista.com.br/legislacao/nr/nr4.htm>. Acesso em: 07 Julho 2022.
- Mondragón Bernal, I. F., Lozano-Ramírez, N. E., Puerto Cortés, J. M., Valdivia, S., Muñoz, R., Aragón, J., García, R., and Hernández, G. (2022). An immersive virtual reality training game for power substations evaluated in terms of usability and engagement. *Applied Sciences*, 12(2):711.
- Motta, R., de Oliveira, K., and Travassos, G. (2021). Technical report: Rapid reviews on engineering of internet of things software systems. *arXiv preprint arXiv:2101.05869*.
- Mystakidis, S., Papantzikos, G., and Stylios, C. (2021). Virtual reality escape rooms for stem education in industry 4.0: Greek teachers perspectives. In *2021 6th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM)*, pages 1–5. IEEE.
- Nascimento, L. d. C. N., Souza, T. V. d., Oliveira, I. C. d. S., Moraes, J. R. M. M. d., Aguiar, R. C. B. d., and Silva, L. F. d. (2018). Saturação teórica em pesquisa qualitativa: relato de experiência na entrevista com escolares. *Revista Brasileira de Enfermagem*, 71:228–233.
- ONU (2022). Onu - acidentes de trabalho e mortes acidentais crescem no brasil em 2021. *onu news*, 2022. Disponível em: <https://news.un.org/pt/story/2022/04/1787092#>. Acesso em: 02 Junho 2022.
- Peiró, J. M., Nielsen, K., Latorre, F., Shepherd, R., and Vignoli, M. (2020). Safety training for migrant workers in the construction industry: A systematic review and future research agenda. *Journal of occupational health psychology*, 25(4):275.
- Pfleeger, S. L. and Kitchenham, B. A. (2001). Principles of survey research: part 1: turning lemons into lemonade. *ACM SIGSOFT Software Engineering Notes*, 26(6):16–18.
- Pinto, A., Nunes, I. L., and Ribeiro, R. A. (2011). Occupational risk assessment in construction industry—overview and reflection. *Safety science*, 49(5):616–624.
- Pinto, M. d. R. and Santos, L. L. d. S. (2012). A grounded theory como abordagem metodológica: relatos de uma experiência de campo. *Organizações & Sociedade*, 19:417–436.
- Robbins, S. P. (2005). Comportamento organizacional: teoria e prática no contexto brasileiro [organizational behavior: theory and practice in the brazilian context].
- Romero, Á., González, M. d. I. N., Segarra, M., Villena, B. M., and Rodríguez, Á. (2019). Mind the gap: professionalization is the key to strengthening safety and leadership in the construction sector. *International journal of environmental research and public health*, 16(11):2045.
- Rosendo, M., Buriol, T., de Geus, K., Scheer, S., and Felsky, C. (2011). Towards the development of a 3d serious game for training in power network maintenance. In *2011 Third International Conference on Games and Virtual Worlds for Serious Applications*, pages 16–23. IEEE.
- Strauss, A. and Corbin, J. (1990). *Basics of qualitative research*. Sage publications.
- Tanaka, E. H., de Almeida, L., de Freitas Gouveia, G. S., Clerici, R. P. S., Alves, A. H. F., and de Oliveira, R. R. (2023). A collaborative, immersive, virtual reality environment for training electricians. *Journal on Interactive Systems*, 14(1):59–71.
- Trindade, D., Dam, P., Raposo, A., and Santos, I. (2014). Simtjs: A model for developing serious games for training simtjs: Uma arquitetura para o desenvolvimento de jogos sérios para treinamento. In *Symposium on Virtual and Augmented Reality*, pages 131–134.
- Venturi, D., Konell, A. E., and Giovanela, A. (2021). Treinamento: importância e benefícios da disponibilização de treinamento nas organizações. *REVISTA CIENTÍFICA FAMAP*, 1(01).
- Wagner, S., Mendez, D., Felderer, M., Graziotin, D., and Kalinowski, M. (2020). Challenges in survey research. *Contemporary Empirical Methods in Software Engineering*, pages 93–125.
- Wohlin, C., Runeson, P., Höst, M., Ohlsson, M. C., Regnell, B., and Wesslén, A. (2012). *Experimentation in software engineering*. Springer Science & Business Media.
- Xexéo, G., Mangeli, E., Silva, F., Ouriques, L., Costa, L.

F. C., and Monclar, R. S. (2021). Games as information systems. In *XVII Brazilian symposium on information systems*, pages 1–8, Porto Alegre. SBC.