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How Has Gamification in the Production Sector Been Developed in the Manufacturing and Construction Workplaces?

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Abstract: This paper investigates how gamification in the workplace has developed from 2016 to 2023 in the production sector and what ethical safeguards have been adopted. The paper presents a state-of-the-art Systematic Literature Review (SRL) performed in the Scopus and Web of Science databases to identify empirical studies involving the adoption of gamification solutions in the manufacturing and construction industries. Twenty-three articles were found and examined regarding the problems evidenced in each workplace, the methodological perspective, the gamification elements considered, the reported psychological and organizational impacts, and the ethical aspects of the research. The SRL highlighted two research gaps: the lack of ethical discussion around the gamification of workplaces and the lack of gamification applications in the construction industry. Only four studies mention ethical issues concerning the participants, and only four studies are related to construction. On the other hand, there is a tendency to use collaborative platforms to share knowledge and increase engagement.

Keywords: gamification; production; industry; manufacturing; construction; management; ethics; innovation; human–intelligent interaction

Citation: Leite, R.M.C.; Alves, L.R.G.; Cardoso, L.d.S.P.; Neto, H.M.M. How Has Gamification in the Production Sector Been Developed in the Manufacturing and Construction Workplaces? *Buildings* **2023**, *13*, 2614. https://doi.org/10.3390/buildings13102614

Academic Editor: Fabio Rizzo

Received: 12 July 2023
Revised: 9 October 2023
Accepted: 11 October 2023
Published: 17 October 2023

1. Introduction

With the increase in the adoption of gamification techniques in the workplace, gamification came to be seen by professionals and scholars as an attractive solution, able to increase the performance of workers who deal with repetitive activities [1–3]. In the context of the construction industry, given the need to make the work more transparent to improve communication between managers and workers, the use of gamification strategies appears to be an innovative solution with the potential to promote motivation and engagement of the production team, helping to enhance performance [4–6].

If well designed, gamification can have a positive impact, such as providing immersion, mental flow, enjoyment, presence of mind, and motivation, which are desirable characteristics for performing any activity. It is important to note that, despite using game elements, gamified applications are not exactly games; rather, they use game elements in non-game contexts to engage people so they are motivated and behave like a player [7]. Therefore, gamification in the workplace is not intended to distract the individual; instead, the goal is to create a more enjoyable and interactive environment, positively influencing motivation and behavior to achieve individual goals aligned with those of the organization [1,8–11].

Alves, Minho and Diniz (2014) define gamification as the use of game mechanics in non-game contexts to develop cognitive, social, and motor skills [12]. Hence, gamification strategies may be indicated to meet the need for analytical, technical, social, and digital skills expected of the Worker 4.0 to enable future smart factories [13,14] mention the need for training within the workplace itself and propose gamification as a solution for developing

skills and competencies. Ref. [15] state that Industry 4.0 requires high-level qualifications and knowledge sharing in the workplace and suggest gamification to encourage this transformation. In this sense, the Systematic Literature Review (SLR) presented in this paper was conducted to identify empirical studies involving the adoption of gamification solutions in the manufacturing and construction industries in the last few years (2016 to 2023). The results can inspire other researchers and new ideas in the decision makers of these sites.

An increased interest in the subject was noticed, as evidenced by the large number of scientific studies published in journals and conference proceedings. What was once a specific topic in the field of computing has become a multidisciplinary approach over the last decade. However, despite increasing discussions on the subject, interest in gamification in the production sector appears narrower [16]. This is partly due to the Taylorism convention in factories [17] and mainly due to a lack of tenable proof of gamification's effect.

When considering implementing a gamified experience, ethical issues such as exploitation and exposure of the participant emerge as a matter of concern, especially in work environments. The substitution of intrinsic rewards for extrinsic rewards may, in the long term, reduce the motivation to work, which is undesirable; also, there are apparent potentially negative consequences of the misuse of gamification, such as stimulating competition among coworkers and promoting a "witch hunt" for workers who need to improve their performances [18].

Therefore, in manufacturing and construction workplaces, it is necessary to investigate how gamification has been developed, what problems it was intended to solve, and what guidelines have been adopted to evaluate the ethical framework of the research. This paper aims to provide a state-of-the-art review of the adoption of gamification in the aforementioned industries.

2. Materials and Methods

A systematic literature review (SLR) was conducted in March 2023 using keywords such as gamification, production, industry, manufacturing, and construction, to understand the situation of gamification in manufacturing and construction workplaces. For this purpose, the following guiding questions were used: What are the existing scientific studies on gamification in manufacturing and construction workplaces? Have the studies been concerned with ethical issues?

To answer these questions, the databases searched were Scopus and Web of Science. Scopus is a multidisciplinary database with a broader range of bibliographic references with abstracts and citations of peer-reviewed scientific literature. Web of Science is a database that allows the retrieval of works published in the most important international journals.

The selection criterion adopted was title-abs-key gamif* and (production or manufacturing or construction or industry), the publication period was 2016–2023, and the language was English. The publications analyzed were conference articles, journal articles, or book chapters.

The exclusion criteria were as follows: duplicate articles in the databases; articles published in languages other than English; gamification studies in the areas of health, education, or areas other than manufacturing and construction; literature reviews; studies focusing only on administration; theoretical reflections; and exclusively conceptual approaches to gamification in the production sector.

As shown in Figure 1, 972 articles were retrieved from the search in the Scopus database. The exclusion criteria were articles on gamification in the areas of education and health, which represented 414 of the cases, and gamification in other areas and literature reviews, which represented 510 articles of the total. After excluding these cases, 48 articles remained for reading and analysis. The same procedure was used for the Web of Science. The results were 1162 articles, out of which 683 were on gamification in education or health, and 446 on gamification in other areas and literature reviews, leaving 33 articles for a full reading. There were 33 duplicates in the databases.

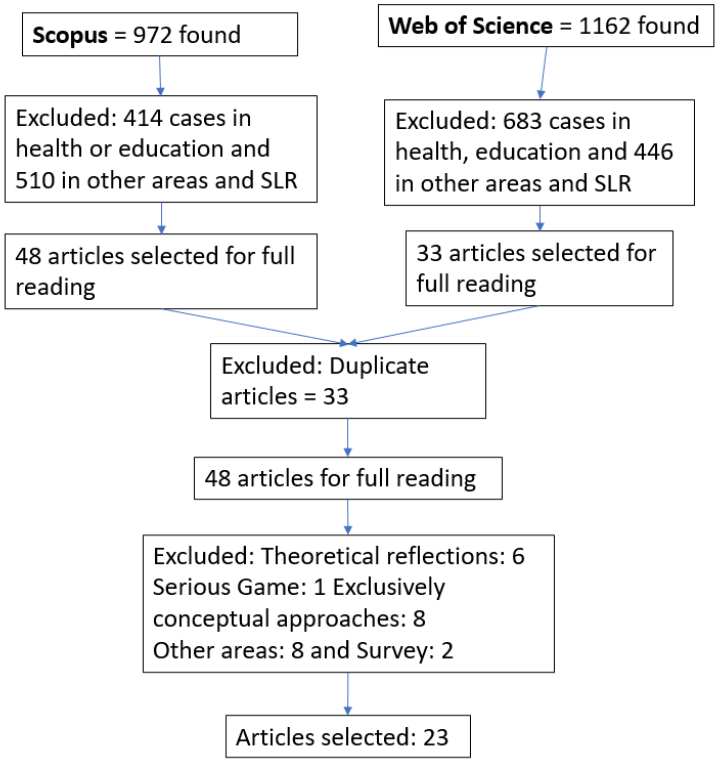


Figure 1. Flowchart of the SLR.

Of the 48 articles found, after reading, 25 were excluded. Six were excluded because they were only theoretical reflections on gamification in the production sector—this type of study, despite dealing with gamification in production, does not meet the requirement of being an empirical study. One was disregarded because it was a serious game in manufacturing—serious games are for non-entertainment purposes and can be distinguished from gamification in that they are complete, while gamification only has game parts [7].

Eight were eliminated because they were case studies of gamification in administration (human resources, finance, business, etc.)—they were studies applied to office personnel who perform tasks solely by computer. Eight were excluded because they were an exclusively conceptual approach proposing the insertion of innovations (IoT, AR, sensors) in manufacturing to increase productivity—conceptual studies that mentioned gamification as one of the innovations that can be used but did not further develop any implementation. Two surveys were excluded because their focus was investigating workers' opinions about gamification and its potential impact on manufacturing and human resources. That left a total of 23 articles to be analyzed.

Figure 2 displays the research progress after reading the 23 articles. The following topics were examined in each article: the objectives of implementing gamification in the context of the production sector, the research methodologies used, the gamification elements used or considered in the studies reviewed, psychological outcomes and behavioral and organizational impacts, and ethical considerations in gamification. This allowed for the identification of research needs in the situations explored, as well as an understanding of the state of the art in the manufacturing and construction industries.

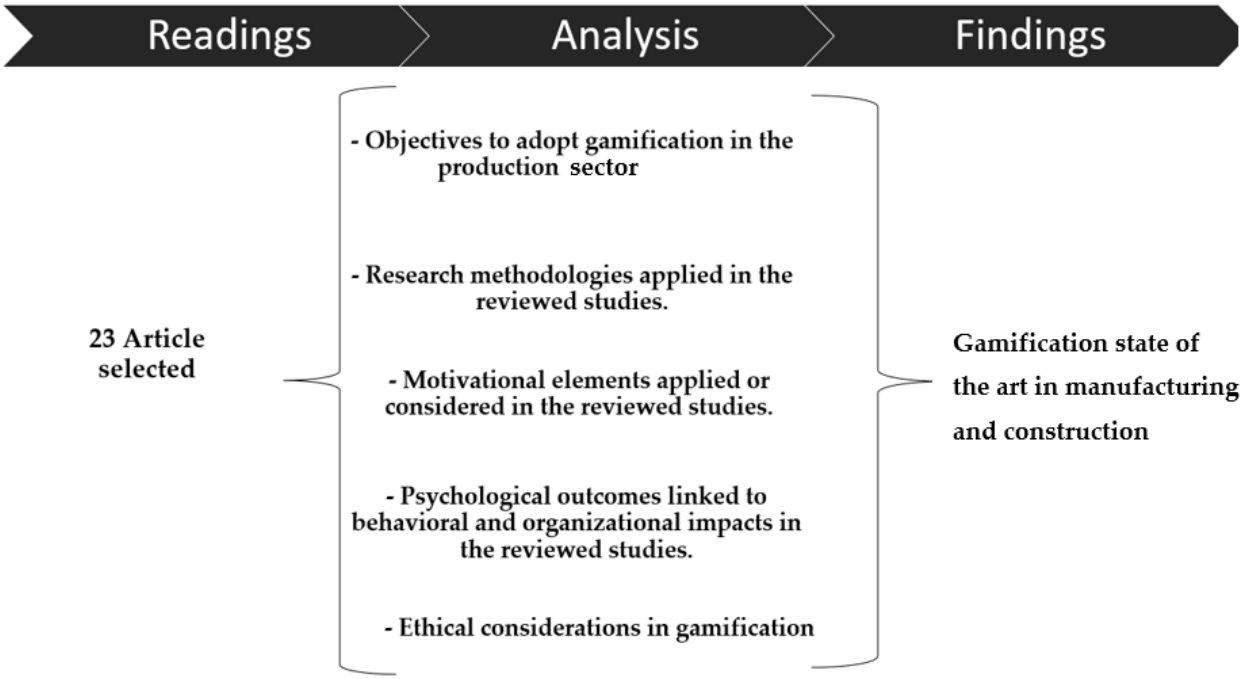


Figure 2. Research outline.

3. Production Sector and Gamification

To support the results and discussions about the findings in this SLR, the theory related to the themes of this research is presented in this section.

3.1. Lean Production and the Factory of the Future

Lean production is a management philosophy with the primary objectives of waste reduction, enhancing customer value, and streamlining processes. Its goal is to perceive value from the customer's perspective, organize value-adding activities in the most efficient sequence, execute them without interruptions, and continually pursue improvement. A fundamental principle of lean production is a "pull" system, where actions are taken only in response to demand.

Since the 1990s, various industries globally have embraced lean production as a foundational management approach. Based on the same philosophy, Ref. [19] developed an adaptation of these guidelines for the construction industry, calling it Lean Construction, resulting in 11 principles and emerging changes in processes and tools.

Numerous innovations, including the Internet of Things, big data, the use of sensors, and the development of robotics, were brought to manufacturing in the 21st century. As a result, the industry was forced to adapt to the factory of the future, also known as Industry 4.0 or Smart Manufacturing [20,21]. Interoperability, virtualization, decentralization, real-time capabilities, services, and a modular orientation are the core elements of Industry 4.0 [22,23].

Intending to achieve harmony and balance between intelligent systems and people, Industry 5.0 initially surfaced in Japan in late 2017. Contrary to popular assumption, Industry 5.0, often known as Society 5.0, does not aim to further replace humans with machines or robots. Instead, Industry 5.0 is the combination of humans and artificial intelligence, whether virtual or robotic, in a coworking environment that fosters interdisciplinary collaboration, i.e., people from different fields and segments working together in the same workplace. Compared to Industry 4.0, which lays more emphasis on the digitalization of processes to boost production efficiency, Industry 5.0 places more emphasis on integrating social and human values in the industrial process [24,25].

In this context, the construction industry has also been pursuing the same objectives as the so-called Construction 4.0 [26,27]. Ref. [13] present a literature review summarizing the profile required for worker 4.0. The worker must be able to: "Execute digital and sensorial guided physical work procedures, e.g., assembly, maintenance, inventory, quality control". and "execute complex cognitive tasks focused on decision-making, implementation, and innovation using visual tools".

Additionally, they must have the following skills: "Analytical, creative, and innovative skills to implement new tools and strategies for production systems"; "Social skills for teamwork and collaboration, including communication skills and intercultural competencies"; "Technical skills to interact and collaborate with modern assisting technologies, e.g., human-machine interfaces, augmented and virtual reality, robots"; and "Digital skills to handle the increasing amount of data and information to support decision-making in management processes".

According to [14] "The central idea for fostering competence development within a gamification environment is to link job-relevant competencies with game design elements and to transpose these competencies on the game level". Therefore, operational changes are needed, including introducing new techniques and training, which will need to be accepted by the workforce to avoid demotivation and a drop in productivity. In this context, gamification promises to increase engagement and motivation, rethinking the design of interfaces and operational processes.

3.2. Gamification in the Production Sector

Gamification involves the use of game elements in non-game contexts to invoke experiences like those of games to affect people's behavior [7]. There are many definitions for the term gamification. Refs. [8,28] refer to this technique as adding game elements in everyday life contexts aiming to provide enjoyable experiences and improve the motivation of those involved. Gamification in the production sector began to be studied in 2012, but as it involves motivating actions in nonvirtual contexts, only in recent years has it called the attention of scholars. In 2012, Korn and Schmidt introduced the first concept of gamification in a manufacturing workplace. The motion EAP research project (2013–2015) explored ways to improve assistance systems in the automotive industry.

This study analyzes gamification based on three dimensions related to the focuses of interest: gamification design (affordances), intermediate psychological outcomes, and behavioral outcomes [28], as shown in Figure 3. The affordances can help communicate abstract ideas without many instructions; for example, points, ranking, medals/badges, progress/challenges, and levels are the affordances of a gamified system.

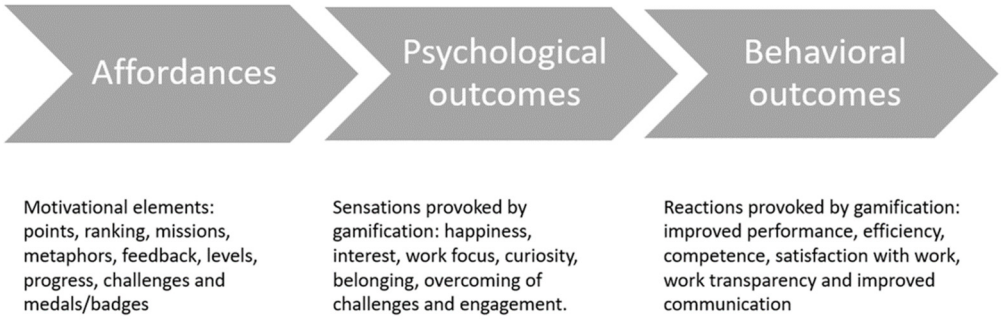


Figure 3. Dimensions of gamification (adapted from the definition by [28]).

Every gamified experiment should be designed to achieve a well-defined goal; once it is determined to implement gamification, the next step is determining the desired user behaviors [29]. The response to the stimulus given by the gamification elements becomes sensations that lead to psychological outcomes, provoking reactions by the participants that have behavioral and/or organizational impacts.

Ref. [11] highlights several advantages associated with gamification in the workplace. Firstly, it employs non-monetary incentives with symbolic value, signaling status to motivate employees. Secondly, it leverages cognitive biases to stimulate desired behaviors among workers. Lastly, in the context of the "Gamer Generation", it aligns with expectations for a work environment resembling games characterized by well-defined objectives, rules, game visuals, language, and positive feedback mechanisms.

In the era of intelligent workplaces driven by data-centric approaches and artificial intelligence, the integration of gamification into collaborative work environments can significantly reduce operational costs and enhance coordination activities. As a result, organizations can harness the power of data to predict and understand their behavior, ushering in a new era of transparency in management [11].

3.3. Ethics in Gamification

Ethics can be defined as a "set of concepts and principles that guide us in determining what behavior helps or hampers sentient creatures" [30]. Integrating gamification into the workplace raises a significant ethical concern that demands careful consideration.

Authors such as [31–33] argue about the negative results of gamification strategies if they are not correctly applied. Ref. [18] mention in their research studies on gamification in the marketing area that the technique has been used to identify and dismiss employees with unsatisfactory performance. Therefore, gamification is a fine line between a positive tool to motivate employees and a source of stress and pressure that could affect the workplace's social and mental well-being [20].

The negative side effect of gamification is generally understated in many studies. For example, little emphasis has been given to the ethical use of gamification in companies [20], and it is necessary to analyze ethical norms for gamification in human resource management. Studies on ethics are still preliminary, with [34] standing out; those authors analyzed gamification as a source of exploitation and manipulation and evaluated the violation of values such as autonomy, reason-responsiveness, and fairness. The study analyzed aspects such as dignity, self-esteem, and physical or psychological harm gamification could have over the participant.

Refs. [34,35] recommend that gamification designers pay attention to moral commitment, putting themselves in the place of workers. In the same line of thought, Ref. [20] analyze the gamification applied to the organizational environment and recommend evaluating the gamification for the following categories: as a tension generator at work, as an invasive monitoring mechanism, as a privacy violator, as a way of exploitation and as an opposition to the individual and cultural values of the worker.

Ref. [35] analyzes the ethics of gamification in marketing and draws attention to the need for transparent rules for all participants to meet the principles of honesty, truthfulness, and social responsibility. Furthermore, the author suggests carrying out an ethical review at each stage of development and implementation. For [36], two requirements are essential to consider a gamified system ethical: the system must have total transparency for what is intended, and the user must consent to participate in the gamification.

It can be safely assumed that gamification advocates do not intend to cause physical or psychological harm to users. Their goal is usually to achieve some organizational goals using a motivational technique. According to [11], gamification works as a refinement of business practices in the choice of architecture, so in ethical terms it is essential to verify how the process works without gamification. Management practices in the manufacturing and construction workplaces already have well-defined ethical criteria and achievements of the workers themselves through union agreements; these rules cannot be broken with the insertion of gamification.

Thus, this study will analyze the articles from the perspective of the transparency of the system to the user, the consent of their participation, the exposure of the workers to their colleagues, and the ethical concerns with the participants, for example, prior

ethical evaluation of the system by an ethics committee, signature of consent forms or any comments on the subject throughout the text.

4. Results and Discussion

In this Systematic Literature Review, 23 articles were analyzed [5,6,15,17,23–25,37–51]. Since gamification is a multidisciplinary approach, the database search results show a growth in publications on the topic in all fields of study. However, the list of chosen papers contained no publications of empirical investigations in the production sector in 2021. This fact is related to the COVID-19 pandemic because, despite the increased need for improving communication, it was challenging to develop and test new tools in production and research environments at that time.

The comparison of these articles with the systematic review by [16] indicates an increase in the number of researchers interested in gamification in recent years. Five results are common to the two studies [5,48–51]. Also, there is an increase from two to four case studies of gamification in the construction industry [5,6,38,41], which is one of the focuses of this research.

Of the twenty-three articles, two [15,47] investigate gamification through a shop floor application for a chemical manufacturing plant. Eight [17,23,25,45,48–51] present gamification studies on the automotive manufacturing plant floor. One [38] presents a gamified solution in Building Information Modeling (BIM) for preparing a security plan, while another two [5,6] investigate the gamification implementation in construction sites. One paper [14] studies training in a simulated factory warehouse. Five papers [24,37,42–44] feature an app to be implemented on shop floors.

Two papers [39,40] are related to shop floor training, another one [46] refers to gamification for an equipment manufacturing plant and another [41] for offshore construction planning and control. Details of each study will be highlighted in the following sections.

4.1. Objectives to Adopt Gamification in the Production Sector

Table A1a–c in Appendix A presents workplace problems identified in selected articles reviewed and the proposed gamified solution adopted in each case. The grouping was based on the main objective of each implementation experience: (1) gamification for knowledge sharing, (2) gamification for lean production aid and (3) gamified environment to improve motivation. The data is presented in descending order of publication date.

The Tables in Appendix A also present an analysis of the associated skills that can be developed using gamification implementation, considering the SLR of [13] and displaying icons to indicate the different competencies. The questions shown in Figure 4 were asked in each case to identify the skills that can be stimulated through gamified solutions.

4.1.1. Gamification for Knowledge Sharing

Regarding the problems evidenced in the different production workplaces of the selected articles, Table A1a (Appendix A) shows nine papers where gamification aims to reduce resistance to knowledge sharing through gamified platforms and to increase the worker's qualifications [14,15,23–25,39,42–44], even preparing them for emergencies and the acquisition of new skills. Regarding the implementation process, three of them mention the difficulties related to the organizational culture [15,43,44], while two papers consider the importance of human factors due to the insertion of technology and automation with Virtual and Augmented Reality, AI, robots, etc., in the workplace [24,25].

All studies in Table A1a (Appendix A) speak of knowledge acquisition and sharing, aiming to implement Industry 4.0 through gamified training and using social networks to facilitate communication. The new knowledge can lead the worker to achieve analytical, creative, and innovative skills, and gamification can promote social skills for teamwork, networking, and collaboration, improving communication between participants.

Icons	Question for the paper
Analytical, creative, and innovative skills 	Does the solution involve understanding information to adopt new tools and strategies to do the job?
Social skills 	Does the solution encourage interaction between colleagues?
Technical skills 	Is the solution computerized or analog?
Digital skills 	Does the solution involve understanding a lot of information to support the decision?

Figure 4. Questions for the paper.

Naturally, the insertion of new technologies in a work environment will provide the growth in technical skills and, in addition, having the information available should provide the development of digital skills, improving decision-making capacity. However, due to the resistance to a new environment, gamification can be a stimulus to awaken the worker's curiosity to experiment and get involved.

4.1.2. Gamification for Lean Production Aid

In Table A1b (Appendix A), all six studies [5,6,38,40,41,45] use gamification with the primary objective of learning and implementing the concepts associated with lean production. Three observe the difficulty of communication in the workplace [5,6,41].

Three of the six studies were given analytical, technical, and social competencies because they provide technical information to promote better communication and employee involvement. Only one [38] was not considered to contribute to the development of social competence, as it uses the Building Information Modeling (BIM) platform (gamified) to facilitate the visualization and elaboration of a security plan. For now, this plan is not available to the public in gamified form.

Two studies [38,40] are related to decision support systems and involve understanding a large amount of information encouraged by gamification. For this reason, they were considered capable of developing digital skills.

4.1.3. Gamified Environment to Improve Motivation

In Table A1c (Appendix A), all eight articles [5,17,37,46–51] report that the lack of motivation combined with a negative and monotonous environment with repetitive activities are the main reason to investigate gamification as a solution. Ref. [9] states that while traditional work configurations are concerned with worker efficiency, gamification is concerned with their well-being, leading to positive experiences, which can lead to the desired result. Table A1c (Appendix A) shows studies focused on promoting employee motivation and changing the organizational environment. Therefore, all studies involve analytical, social, and technical skills except two [48,49]. One is a questionnaire for the supervisors to choose the tool to be applied in the study, and the other is the individual performance through sensors of the worker's performance; therefore, there is no social interaction.

4.1.4. Associated Skills and Synthesis Gamification Applications

Table 1 presents a Summary of Skills involved in the articles selected and analyzes the benefits of gamification for each skill, as outlined by [11]. It shows that all 23 studies attempt to encourage workers' conformity with objectives and rules, as well as to enhance technical abilities and stimulate analytical, creative, and innovative behavior. Only 12 research studies employ gamification to drive people to boost digital skills, whereas 19 promote collaborative and social activities.

Table 1. Summary of Skills involved in articles selected.

Worker 4.0. Skills [13]	Advantages to Using Gamification [11]	Articles Selected
Analytical, creative, and innovative skills 	Gamification uses cognitive biases which can stimulate the employee's behavior.	23 [5,6,14,15,17,23–25,37–51].
Social skills 	The incentive is not monetary, has symbolic value, and signals status. The use of gamification in collaborative work environments can reduce costs and bring improvements to coordination activities	19 [5,6,14,15,17,23–25,39–47,50,51].
Technical skills 	With the introduction of smart, data-driven, and artificial intelligence workplaces, objectives and rules become more explicit, allowing for positive feedback.	23 [5,6,14,15,17,23–25,37–51].

Table 1. *Cont.*

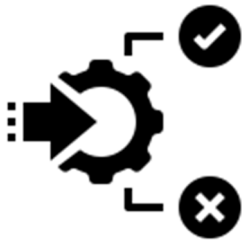
Worker 4.0. Skills [13]	Advantages to Using Gamification [11]	Articles Selected
Digital skills 	With the arrival of intelligent workplaces, the use of gamification in collaborative work environments can bring transparency to management process improving decision making.	12 [14,15,23–25,38,39,41–44,51].

Figure 5 best illustrates the observations outlined and shows a synthesis of gamification applications in the production sector in the reviewed articles.

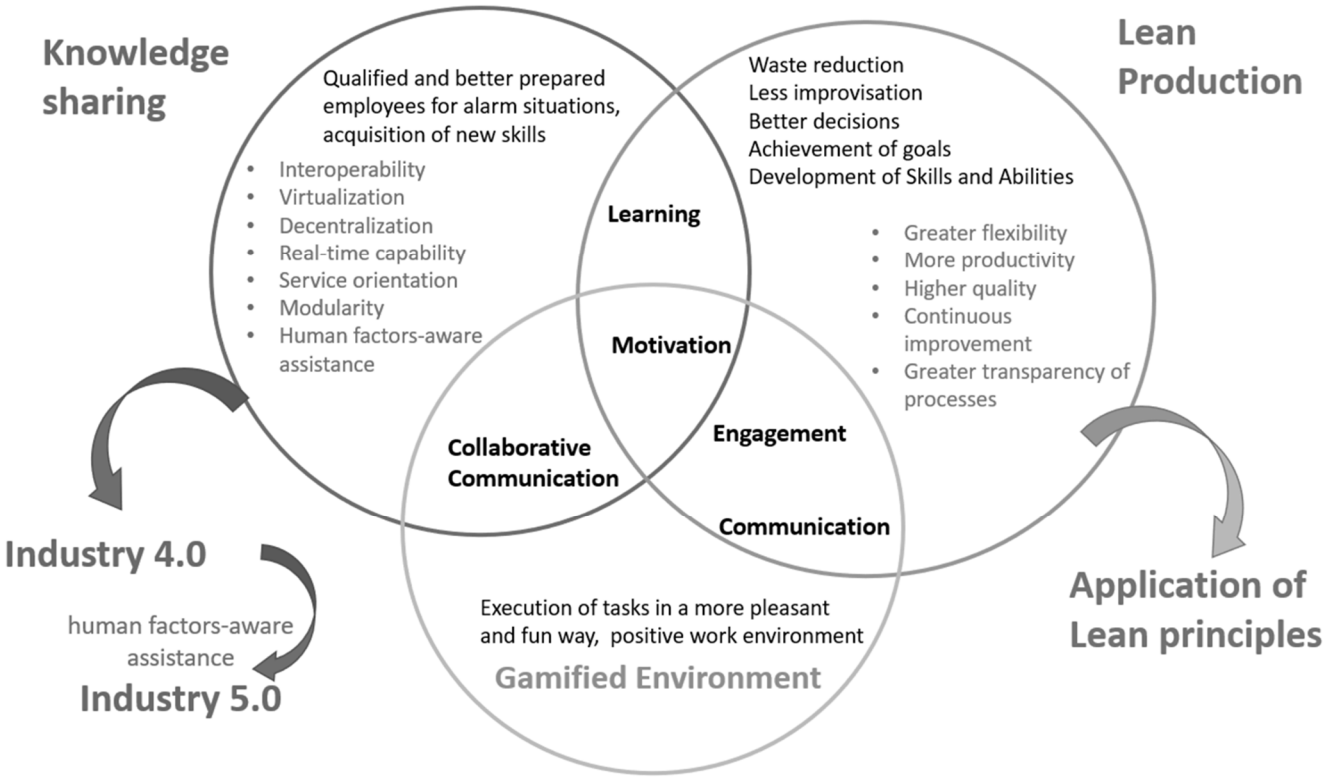


Figure 5. Synthesis of the application of gamification in the production sector in the reviewed articles as Table A1a–c.

4.2. Research Methodologies Applied in the Reviewed Studies

By analyzing the studies from a methodological perspective as outlined in Table 2, it is observed that most studies are empirical (18 of 23 studies), 9 reviewed studies fall into the training category, and 15 are in the category of production planning, execution, and control.

The most common workplaces in the literature analysis are manufacturing (19) and construction (4). Some studies present a gamification design or proposal; one presents a gamified method based on Building Information Modeling (BIM) that can be used in the planning of safety, logistics, and other stages of the building [38]; three present a proposal of gamification platforms for training on the shop floor [23,45,47] and another assesses

the acceptance of three gamification mechanisms by the supervisors of an automotive components factory [49].

Table 2. Research methodologies applied in the reviewed studies.

	Design-Conceptual or Proposal	**Empirical Study**	
		Implementation with Evaluation in a Real Environment	**Experiment or Quasi-Experiment**
Training	[23,45,47]	[15,42–44]	[14,40]
Production planning	[38]	[5,41]	
Production execution and control	[49]	[5,15,41]	[6,17,24,25,37,39,46,48,50,51]

Three studies present experiments: one compares the performance of 18 participants using a narrative gamification system with a conventional gamification system using only points, badges, and a leaderboard (PBL) in a bolt-tightening (BT) operation [17]; another involved students and factory workers in a Lean Manufacturing training process using five games with different levels of complexity [40]; and the last performed an experiment in a room configured as a warehouse created for testing and training. A total of 103 students participated, who were divided into groups: 52 participated in the gamified experience, and 51 were part of the control group. The experiment to evaluate the development of competencies, autonomy regarding task significance and autonomy concerning decision freedom had a duration of 28 min for each group [14].

There are studies using quasi-experiments as a research design [17,46,48,50,51]. This is an approach indicated when it is not possible to use a random distribution of subjects per treatment, or control groups to enable an experimental approach. It is a suitable method to observe the effects of a given induced change in a system, but it is limited because it does not involve random samples, thus requiring stricter controls to ensure its validity. In the abovementioned studies, the rigor of the results is assessed through statistical methods; however, these are short experiments lasting up to 8 h, which is a limitation because they do not reflect an actual situation on the shop floor.

Considering the 23 studies selected in terms of the number of people involved in the experiments, it is observed that most studies have small samples, ranging from 5 to 60 participants, making it necessary to study larger samples to obtain more significant results. Only one study had 114 participants [40], but it referred to a one-time application of 5 games lasting up to 6 h. Another presents a significant sample (135 participants), but the duration of the experiment was short (27 min) [39]. The same happens with [25] (150 participants and 27 min).

Table 2 also shows that studies used gamification to motivate learning in an industry training setting or to share knowledge in the workplace. Because gamification is a technique that has been studied for longer in education, some already-explored practices of knowledge sharing are adopted in training programs for promoting learning by workers, which facilitates the implementation of the technique in work environments.

Three studies are experiments performed in real environments with random groups: one refers to the implementation, for 3 months, of a social collaboration tool with workers from the research center of the chemical industry [15]; another presents a 4-month experiment on the use of gamification with engineers in offshore construction [41], the last report a 3-month experiment with construction workers at a construction site. Therefore, there is a need for more extended studies with larger samples so that the behavior of the production worker toward gamification strategies can be known and evaluated [5].

4.3. Gamification Elements Applied or Considered in the Reviewed Studies

Table 3 shows the gamification elements applied or considered in the reviewed articles in descending order of occurrence. The gamification elements most used in the reviewed

studies are objectives and goals, which appear in all studies because they are an essential part of the gamification strategy, followed by points, credits, achievements, and rewards, and, lastly, feedback. These three gamification elements appear in over 70% of the reviewed studies.

Table 3. Gamification elements applied or considered.

Gamification Elements	Articles
Goals and objectives	23 [5,6,14,15,17,23–25,37–51].
Points, credits, achievements, and rewards	19 [5,6,14,15,17,23,24,37,39–47,50,51].
Feedback	18 [5,6,14,15,17,23–25,37,39–44,47,48,50].
Levels—progress	13 [5,6,15,17,23–25,37,43,44,47–49].
Competition Leaderboard and Ranking	13 [5,6,14,15,17,39–46].
Metaphorical representation	10 [6,14,17,38,40,47–51].
Collaboration	7 [6,15,40,42–44,47].
Challenges and missions	7 [6,15,43,44,46,47,50].
Social elements	6 [5,6,24,47–50].

Four main factors are necessary to implement gamification: (1) short feedback cycles, (2) clear goals and rules, (3) compelling activity, challenging yet achievable tasks, and (4) voluntary participation [48,49]. Similarly, Ref. [52] suggests that the gamification process should always include essential elements: a way of measuring and presenting progress, a form of feedback (often linked to progress), and it must have challenges because, according to the author, the key for engagement is to have the challenge to overcome.

Next, the competition leaderboard and level progression appear in more than 50% of the cases reviewed. Studies still adopt only points, badges, and leaderboards (PBL), which have been widely criticized as a gamification strategy [36]. According to [53], this persuasive gamification strategy is easier to find because it aims to motivate behavior and direct subjects to specific actions. For [53], the PBL approach is a reductionist view of gamification and functions as something superficial and of low innovative power [53].

The gamification element, called metaphorical representation, has less relevance in the results shown in Table 3 and corresponds to fewer than 50% of the studies. Using metaphors in the workplace is often not well accepted because it conveys little seriousness. Ref. [17] state that the narrative (use of metaphors) might occur via any influence on beliefs, attitudes, or actions brought about by the narrative message through psychological processes associated with narrative comprehension or engagement. PBL´s gamifications would not trigger this process, and they may be less likely to engage emotions or create vivid mental imagery.

Seven studies use gamified social collaboration as an interface [6,15,40,42–44,47]. The platform has a flexible configuration to enable its use in various production environments, focusing on the concept of Industry 4.0, aiming to disseminate knowledge among workers. Four studies offer self-training tutorials integrated into augmented reality technology [15,23,43,47]. Gamification is a process that, when viewed systemically, allows the incorporation of various technological resources to involve the user. The idea is interesting but may not suit all workplaces due to the rules of each organization.

In the construction industry, using a gamified social collaboration system can be challenging because the target audience, field workers, may have little formal education and perform manual labor, which does not require a computer [5]. Although most have and use smartphones at the construction site, especially the younger ones, managers are careful to avoid any worker distractions caused by this type of activity. Therefore, in this case, using interactive platforms during work should not be encouraged.

Table 3 also reveals that thirteen studies use competition, leaderboards, and ranking as gamification elements, three of which are case studies in construction [5]. Seven use collaboration, which—theoretically—opposes the thought of competition in the workplace.

For [54], competition fills a deep internal need of the player to determine the skill level relative to another person in the social circle. It allows the use of strategies and choice of more complex behaviors, all possible due to the intelligence and skill of the opposing player. In workplaces, many professionals face challenges competently and take their perception of peers as opponents to an extreme [54].

Gamification should not seek to reinforce this personal characteristic of the worker; on the contrary, it should serve as a resource for an analysis of one's performance from the feedback provided by the process, making the worker aware of the desirable level and encouraging him/her to achieve it simply by wanting to contribute, being part of the team, without the fear of threats or punishments.

In the study of the gamification of construction sites, gamification appears to increase the transparency of the worker evaluation performed by managers. Previous studies showed that 83% of workers rarely or never receive feedback on their work, so construction workers are rarely motivated by positive feedback [5].

According to [54], collaboration is the "other way" of interacting with each other. It allows participating in actions and employing game strategies that are impossible with only one person, in addition to providing deep enjoyment that arises from solving group problems and being part of a successful team. Collaborative games follow the model of team sports, which allows for all the pleasures of collaboration and competition at the same time [54].

According to [1], competition and collaboration must be combined in the workplace to ensure that gamification is aligned with the desired solutions. Competition can evoke feelings of belonging to a group [55], while cooperation can promote the desire to work together towards a common goal [14,33]. Ref. [1] suggests the creation of a team structure within gamification where the participants can collaborate, and the groups can compete. Considering this perspective, several platforms presented in these studies are already prepared for the individual or multiuser approach [6,15,40,43,44].

Only seven studies incorporate the challenges and mission elements. The missions and challenges are important elements because they lead to the empowerment of teams, an essential aspect in cases where collaboration and cooperation are desired [53]. While collaboration requires learning to work with others, cooperation means performing mental operations with others within the spaces of interaction [53].

4.4. Psychological Outcomes Linked to Behavioral and Organizational Impacts in the Reviewed Studies

Intrinsic motivation refers to the performance of a given activity for the pleasure it can provide. These are experiences and effects usually induced by games, for example, senses of mastery and competencies, relationships and sense of community, creativity, pleasure, and flow [56,57]. In the flow theory, proposed by [57], the individual is fully immersed in the activity, with high motivation, concentration, energy, and performance. "Flow" is defined as the mental state where the body and mind flow in perfect harmony [57].

Behavioral impacts refer to any activities or behaviors that gamification seeks to support. Gamification is usually placed within a given context and attempts to select the type of behavior related to that situation [8,20,58].

The reported results indicate that three case studies show only positive outcomes of gamification [5,15,40], contributing to reinforcing the idea that gamification is a "magic formula" that solves all problems with the worker. Of the studies that report the implementation of gamification in the production setting, only three studies analyze negative aspects. One, which developed a gamified system for managing construction projects, mentions the discomfort of engineers when they are evaluated during the process [41], another raises doubts, through its results, about the capacity of gamification as a motivation mechanism

for the worker and states that the use of social media resources in workplaces requires changes in organizational policies, processes, and cultures [42], and another, which shows a quasi-experiment with a population of workers with motor and cognitive impairment in an assembly factory, mentions absolute or negative results of the inclusion of gamification relative to the different levels of impairment of the target audience [48].

Three papers show concerns regarding discretely presenting gamification to avoid the distraction of the worker in the workplace [5,15,48]. Unlike computer-based games or office work, the user's focus in the production workplace is not on software but a physical product, using various machines and tools. That is why the way of presenting the gamification must be simple, avoiding mobile elements on the screen. This also implies that direct interaction with the computer tool, whether by sending a message/notification or requesting input of the information by the worker, should be avoided.

Six articles show the design and implementation of flexible systems designed to gamify any manufacturing workplace and present results for user acceptance; five of those studies used the System Usability Scale (SUS) to evaluate the usability of the gamified tool [6,15,42–44,47]. All cases aim to create a platform for sharing knowledge in manufacturing workplaces. However, one highlights the concern with validating content posted by workers to avoid inaccurate and poorly written content [43].

It is possible to notice the difficulty of implantation on the factory floor to obtain real data proving the gamification's efficiency. The studies have not yet reached the maturity level needed to evaluate the impacts of these outcomes in the organizational context. More extended implementation periods, with a more holistic view of gamification's effects, are needed to investigate these impacts better.

4.5. Ethical Considerations in Gamification

Table 4 presents the survey results of some important criteria for ethical research in gamification. The transparency of the gamification rules for the user, the freedom to participate in the experiment and drop out at any time, the privacy of personal information, and ethical concerns, such as the signing of a consent form by the participants and submission to a research ethics committee, were considered. These criteria in the survey reflect the worker's concern in the gamification process.

Table 4. Survey of ethical considerations in gamification.

Ethical Criteria	Articles
Transparency of rules for the user	18 [5,6,14,15,17,24,25,37,39–44,46,48,50,51].
Voluntary participation in the experiment	8 [6,15,17,25,42,44,46,48]
Privacy of personal information	7 [6,14,15,40–42,44].
Ethical concerns	4 [6,17,42,48].

For this analysis, only the articles involving empirical studies were considered. The eighteen investigated articles make clear to the user the gamification rules. Only eight studies mentioned that participation was voluntary. Seven articles showed concern with the privacy of the participants' information, and only four expressed ethical considerations during the study.

Three mentioned the consent form during the study [6,17,42], and another adopted a motion detector, which led the authors to mention gamification ethics because using sensors in the workplace can lead to discomfort [48]. Any gamified solution must be evaluated to avoid exposing the participants negatively, which could affect their motivation and performance. As a result, investigations looking into gamification in the workplace should, at the very least, use these criteria to analyze its ethical framework.

5. Conclusions

In a broader context, gamification can achieve multiple objectives for businesses, including enhancing employee satisfaction, increasing innovation, skills development and changing behaviors.

This paper examined gamification in the production sector, specifically within the manufacturing and construction workplaces. Resulting from the SLR, it was able to group different gamification practices based on the main objective of each implementation experience: (1) gamification for knowledge sharing, (2) gamification for lean production aid and (3) the gamified environment to improve motivation.

From this analysis, the paper discovered that the incorporation of gamification techniques into production workplaces perfectly aligns with the idea of Industry 5.0, assisting in humanizing work settings and preserving professionals' physical and mental health. The chosen studies demonstrate that gamified approaches can be used to learn and apply lean concepts as well as to develop the workforce skills required to improve production processes and performance.

In the production sector, there is a prevalence of empirical studies with cases of implementation in the areas of production execution and control. The studies are preliminary, usually use small samples, and/or conduct short-term experiments. However, it was observed that a few studies have investigated the results of the implementation of gamification in the workplace (factory floor, construction sites, etc.).

Despite being incipient, it is noticeable in Table 3 that gamification in the workplace has been abandoning the initial model, called PBL, which is characterized by competition, and replacing it with another model that involves collaboration and cooperation. There is a tendency to use collaborative platforms, combined with gamification, to motivate shop floor workers to share knowledge and interact with colleagues. This approach aims to meet the profile required for industry 5.0 workers.

Another contribution of this research is to demonstrate the changes in the application of gamification from 2016 to 2023 in the manufacturing and construction workplaces, which are characterized by physical processes, and to facilitate a discussion of ethical issues related to deployment. The study points to a change in the reason firms may choose to gamify the production sector; previously, it was to modify the monotonous environment for the worker performing repetitive tasks, and it has now evolved to be used to improve information sharing and develop desired skills for the worker. Most recently, it has been used to attempt to make work more humanized.

From a practical perspective, this paper shows in Table 1 that the worker 4.0 skills [13] can be developed from the insertion of gamification in the workplace. It shows that gamification can promote a more pleasant working environment and motivate workers to exchange knowledge and experience, facilitating the acquisition of skills necessary for implementing the factory of the future.

The SRL highlighted two research gaps: the lack of ethical discussion around the gamification of workplaces and the lack of gamification applications in the construction industry.

Most of the studies presented do not address or are not concerned with ethical issues. Only four studies mention ethical concerns, two because they use sensors, and gamify the work environment targeting individuals with cognitive impairments. Most do not mention issues such as voluntary participation and confidentiality of worker information. This is one of the weaknesses of gamification in the production sector that should be considered in future studies, and this paper proposes a framework to assess ethical conditions in gamified experiences. The following criteria were taken into account and could be used in future studies: (1) the transparency of the gamification rules for the user, (2) the freedom to participate in the experiment and drop out at any time, (3) the privacy of personal information, and (4) other ethical concerns, such as the signing of a consent form by the participants and submission to a research ethics committee.

In the context of construction, this review presents only four studies: one assisted in planning the safety, logistics, and other stages of production; two were related to workers

at the construction site; and the last studied engineers working on offshore engineering projects. Therefore, further studies are needed to consolidate the knowledge of gamification in the construction environment, and this paper provides a state-of-the-art review that can be used for future corporations who intend to design and implement gamification in the workplace. From here, they can gather information about some of the typical objectives of implementing gamification in the workplace, the methodologies and gamification elements typically used or considered, the potential psychological and behavioral outcomes, and ethical considerations in gamification.

As for the parameters of this review, the searches are limited to the period between 2016 and 2023 in the Scopus and WoS databases. The evolution of the subject matter is the reason for this decision. Research on gamification in production environments emerged in 2012. Analyzing the articles by [16], studies before 2016 were in a preliminary phase. The interest was in more recent empirical studies.

Author Contributions: Conceptualization, R.M.C.L. and L.R.G.A.; methodology, R.M.C.L.; software, R.M.C.L.; validation, R.M.C.L.; formal analysis, R.M.C.L.; investigation, R.M.C.L.; resources, R.M.C.L.; data curation, R.M.C.L.; writing—original draft preparation, R.M.C.L., L.R.G.A., L.d.S.P.C. and H.M.M.N.; writing—review and editing, R.M.C.L., L.R.G.A., L.d.S.P.C. and H.M.M.N.; visualization L.d.S.P.C. and H.M.M.N.; supervision, L.R.G.A. and L.d.S.P.C.; project administration, R.M.C.L. All authors have read and agreed to the published version of the manuscript.

Funding: The APC was funded by Centro Universitario SENAI CIMATEC.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. (**a**–**c**) Workplace problems, gamified solutions, and competencies involved.

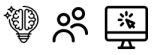
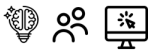
(a)

Articles	Workplace Problems	Gamified Solution	Competencies Involved
[24]	The existing assistance systems in the manufacturing sector are mostly equipped with rigid functional logic and do not provide individual experiences for users or adapt to their capabilities.	Integrating human factors into assistance systems, adjusting the hardware and instructions presented to the cognitive and physical demands of the workers (Industry 5.0)	
[25]	Need to combat increasing monotony on the shop floor due to repetitive and identical work tasks. These work tasks often lead to low interest and a one-sided burden on shop-floor employees. Monotony on the shop floor must be combated to increase employee motivation and reduce absenteeism.	A prototype MES application was integrated into the study design to investigate the effects of information provision and gamification concerning operational performance and work motivation. The prototype includes a human-centric performance-management approach to gamified information delivery.	
[15]	High level of qualification requirement and difficulty of employees sharing knowledge (tacit knowledge).	Gamified social collaboration platform to encourage knowledge sharing and registration	
[39]	Need to process shop-floor information properly to generate insights to motivate and empower workers and supervisors.	Gamified performance control system for shop-floor workers and supervisors	
[42]	High level of qualification requirement and difficulty of employees sharing knowledge (tacit knowledge).	Gamified social collaboration platform to encourage knowledge sharing and registration	

Table A1. *Cont.*

[43]	High level of qualification requirement and difficulty of employees sharing knowledge (tacit knowledge).	Gamified social collaboration platform to encourage knowledge sharing and registration	
[44]	Improvement of collaborative communication, lack of positive organizational culture	A collaborative social network for culture change: motivate knowledge sharing, exchange of ideas, and visualization of training content.	
[23]	Need to instruct manufacturing workers to acquire greater flexibility, speed, greater productivity and quality, less waste, and innovation to achieve the concept of an intelligent factory.	Gamified training system using simulation and augmented reality to motivate workers to achieve their goals, acquire and share knowledge.	
[14]	Need for obtaining new skills and learning within the workplace.	Gamified training system within the workplace to accelerate the development of new skills	
		(b)	
[6]	Lack of transparency of activities for the construction team. Workers lack understanding of the tasks to be performed. Lack of team engagement and lack of feedback to workers	Gamified environment to make work more interesting for both workers and engineers using narrative, facilitating communication and task understanding	
[38]	Need to understand the building's spatial requirements to plan the safety, loading, and unloading of materials or production processes.	A gamified method that can create planning environments based on the information model (BIM).	
[40]	Need for continuous improvement of employees' skills and knowledge.	Gamified training for acquiring lean concepts on the shop floor	
[41]	Imbalanced allocation of resources, improvisation, lack of control of results, lack of communication, and wrong planning decisions.	Gamified system for applying lean in planning and control (LPS) to offshore constructions.	
[45]	Need to incorporate new practices in routines to improve results and reduce waste.	Map the organization's needs and employee skills. Systematize activities and standardize routines. Gamify the system to promote engagement, commitment, and achievement of goals.	
[5]	Lack of transparency of activities for the construction team. Workers lack understanding of the tasks to be performed. Lack of team engagement and lack of feedback to workers	Gamified system to make the weekly schedule (LPS) transparent and provide feedback to workers on routine activities to motivate them and improve communication between managers and the workforce.	
		(c)	
[37]	Monitoring activities in highly digitalized and automated production plants offers few opportunities to satisfy psychological needs which can lead to low intrinsic motivation, psychological strain, and poor performance	The game elements were integrated into a control center dashboard through a gamified quiz containing activity-relevant multiple-choice questions about understanding the dashboard, the current plant situation, troubleshooting, and general production questions.	

Table A1. *Cont.*

[17]	The boredom related to work on the automotive assembly line creates other negative results that are related to human resources issues.	A gamified interface, in the workplace, using narrative persuasion to help manufacturing workers create self-directed behaviors.	
[46]	Need to retain talent in Chinese companies. Lack of motivation mainly for 'digital natives' (people born after the 1980s)	Gamified smartphone system to motivate employees.	
[47]	In an industrial environment, jobs tend to be repetitive and sometimes tedious, so there is a need to create challenges to involve workers.	Gamified system for social collaboration with a training module using augmented reality	
[49]	The processes in the manufacturing industry are repetitive, the automated solution is expensive so the manual solution in small batches still prevails.	Choosing with supervisors which gamification model applies best to the manufacturing environment: The Pyramid, Tetris, or the Circle	
[48]	The processes in the manufacturing industry are repetitive, the automated solution is expensive so the manual solution in small batches still prevails.	A gamified system with sensors to verify its effects concerning the motivation of workers with cognitive disabilities in the automotive industry.	
[50]	Lack of motivation due to the simplicity of screw-tightening tasks on the automotive industry's assembly line and negative work climate.	Gamified interface to encourage intrinsic motivation, improving relationships between colleagues, and reducing environmental negativity	
[51]	Lack of motivation due to the simplicity of screw-tightening tasks on the automotive industry's assembly line and negative work climate.	Gamified interface to encourage intrinsic motivation, improving relationships between colleagues, and reducing environmental negativity	

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