Ergonomics Through the Lens of Gamification

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Our paper explores the connection between ergonomics and gamification in order to understand the relationship between the two areas and their impact on employee health, comfort and productivity. We outline the key ergonomic principles for creating an ergonomically designed work environment, such as maintaining a neutral posture, encouraging movement and stretching, and managing excessive workload. In addition, we look at gamification – a strategy that uses game-specific concepts, including badges, leaderboards and challenges – to motivate and engage employees. This paper provides use-case examples that enable organizations to integrate ergonomics through engaging, game-like elements by linking ergonomic principles with different gamification methods. With this approach, organizations can cultivate a proactive well-being culture that ultimately improves employee satisfaction and overall organizational performance.

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1 Introduction

Nowadays, ergonomics plays an important role in workplace design, because the companies that invest in the right work experience for their employees are ahead of others. An ergonomically designed workplace increases the performance and efficiency of the organization. Poorly designed workplaces cause most of the employee health problems, which lead to absenteeism and presenteeism. In the long term, this leads to unnecessary costs for the company and employee dissatisfaction (Balantič et al., 2016). Appropriate ergonomic measures such as adapting the workplace, optimising work equipment and tailoring work processes have proven to be effective in reducing physical strain, minimising musculoskeletal disorders and promoting employee satisfaction. These adaptations not only ensure that workers avoid injury, but they also improve productivity and overall morale by meeting both the physical and cognitive demands of workers (Silva et al., 2024).

Teaching occupational health and safety in engineering is a challenge because it is a multidisciplinary subject, and it is difficult to reach workers using traditional methods. A study by Rodeghiero Neto & Amaral (2024) suggests that the use of active learning strategies: problem-based learning, project-based learning and gamification helps in introducing various ergonomic principles to employees who were previously unaware of their benefits. That is why the combination of ergonomics or human factors and gamification has gained popularity in recent years – Figure 1 shows the graph with the growth of the documents over the years.

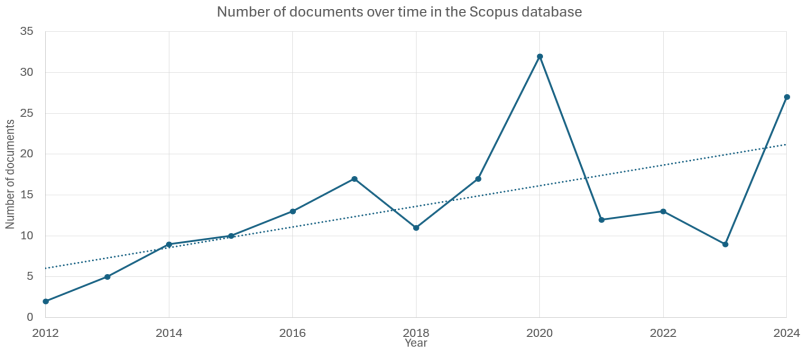

Figure 1: Gamification of ergonomics over the last 12 years
Source: Own

Gamification is usually described as the application of game-specific concepts of game design to a non-game context (Deterding et al., 2011b, 2011a). The primary purpose of gamification and its most potent observed effect is fostering, growing, and capturing the motivation of gamified systems' users, followed closely by encouraging engagement and participation. Gamification can be applied to various application domains, including but not limited to smart and sustainable mobility (Okreša Đurić, 2022), demand-responsive transportation systems (Martí et al., 2024), conducting surveys (Schatten et al., 2022), education (Khaldi et al., 2023), banking, trading, marketing, task facilitation (Antonaci et al., 2019).

We argue herein towards using gamification to encourage employee engagement, knowledge retention and ergonomic skill development. Using the VOSviewer programme (Van Eck & Waltman, 2023) and preliminary research, we found that the above areas are interlinked (Figure 2). We combine ergonomic principles with different gamification methods and provide guidelines and ideas for organizations to create a healthier, more productive, happier workforce.

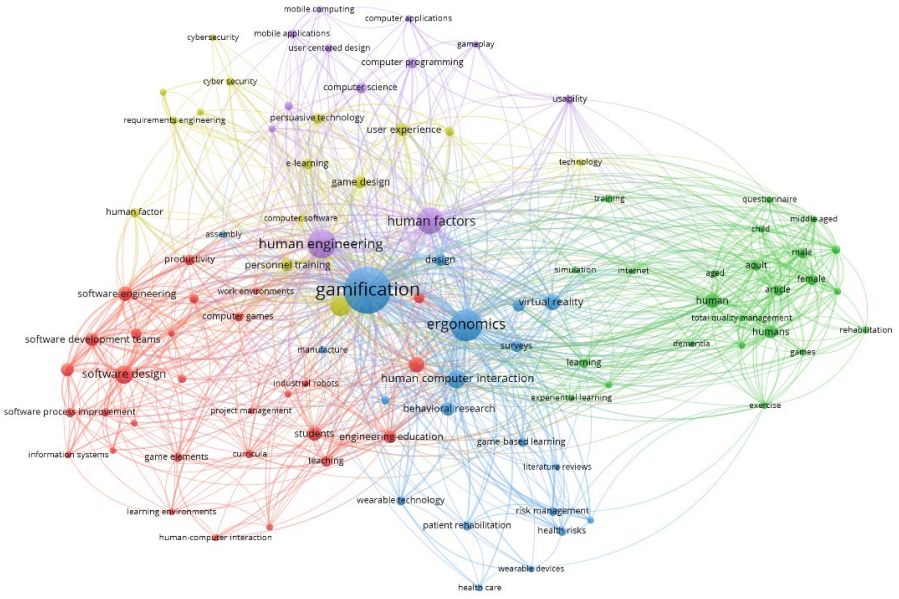

Figure 2: Network visualization map of the keywords for the fields of ergonomics and gamification made with VOSviewer

Source: Own

The rest of the paper is structured as follows: Section 2 provides a literature review on the topics of ergonomics and gamification, Section 3 presents the methodology used in the process of preparing this paper, Section 4 consists of the comparison of the sets of ergonomic principles and gamification methods to see how one can complement the other, followed by a discussion on use-case examples of gamification for ergonomics. The conclusion is given in Section 5.

2 Literature Review

2.1 Ergonomic Principles

Ergonomic principles are derived from the properties of the human body, and the environment should adapt according to them. New technologies are becoming cheaper and are being incorporated into the design of the various devices we use to operate and help ourselves at work. For example, the chairs we sit in nowadays are much more variable than they used to be, have become highly variable over the years, and adaptable to the physiological characteristics of the human being. The rigid seat bases have been replaced by flexible seating surfaces with a variety of adjustments and surface tilt resistances. Chairs aside, innovators around the world are taking ergonomic principles into account in all these solutions - below are eight of the most important principles when considering worker's health (Balantič et al., 2016).

Maintaining a neutral posture focuses on the proper arrangement of the environment where we stand or sit. A major problem nowadays is the high number of pain or injuries caused by inadequate loading on the spine. These problems are solved by a dynamic workplace and the correct choice of sitting height. They can be alleviated by lumbar and sacral support, and standing on an ergonomic mat. In addition to the spine, which is the most problematic in most cases, we also need to pay attention to the correct position of the joints, head and limbs. Sherman et al. (2024) discuss the importance of maintaining ergonomic principles, such as ideal working height and neutral postures, to reduce overuse injuries among orthotics and prosthetics practitioners in the U.S.

Performing work in the area of maximum comfort states that the loads we lift should be held as close to the body as possible. Objects that are farther away from us should be of lighter weight. If we do not follow the rules for lifting loads, we run the risk of muscoskeletal disorders. A study by Moradi & Barakat (2020) found that lifting heavy loads manually, especially when exceeding recommended weights or distances, significantly increases the risk of musculoskeletal disorders.

The human body is made to move, that's why it's important to **allow movement and stretching**. We can do that by providing breaks when doing static and repetitive work. The aim of breaks is to move the body to a neutral position for a while, or to the opposite of the stressed position at work. This relaxes certain muscles and allows better muscle coordination. Because of this static work, it is important to adapt the workplace to suit the majority of people or to consider adapting the work surfaces. A study by Vitoulas et al. (2022) demonstrates that active micro-breaks, including stretching and strengthening exercises, reduce pain and fatigue while improving mood in employees engaged in static and repetitive work.

The fourth ergonomic principle is the so-called **reduction of physical overload**. When designing workplaces, we need to pay attention to critical points where overloading can occur. We need to try to prevent such situations from happening, but if this is not possible, we can think about various tools or machines to help us with difficult tasks, such as in the case of Sarmiento-Ortiz et al. (2024). Their study highlights the implementation of a load elevator in workplaces, which significantly reduces the risk of musculoskeletal injuries by minimizing manual handling.

Reducing the occurrence of inappropriate movements is an important factor when we are trying to reduce fatigue, ill health, musculoskeletal disorders and other negative effects. The most common inappropriate movement type is repetitive movement, which is defined as repeating the same or a similar movement two or more times within a 30-second period. If these movements are problematic, they should be eliminated as soon as possible through automation or the use of machines and tools. When designing work activities, care must be taken to avoid these types of tasks or to ensure that frequent breaks are taken. One example we can give is from Chan et al. (2020): they developed a deep learning approach to classify risks associated with repetitive movements using 2D human pose estimation, enabling fast and accurate ergonomic evaluations.

We need to be aware of the direct physical pressure of various external elements when we are working and take the necessary precautions in order to **reduce point pressures on the body**. For example, sitting incorrectly, with the lower thigh resting too much on the edge of the chair, causes improper blood circulation. We should also beware of kneeling postures and too small working spaces. Antle et al. (2018) highlight that prolonged improper postures, like sitting with uneven pressure distribution, lead to poor blood circulation and discomfort in the lower limbs.

Reduction of excessive vibration is also an important principle employees need to follow, because vibration has a bad effect on blood flow, which in turn leads to pain, tendinitis or, for example, inflammation of the carpal tunnel. A study revealed that vascular disorders, nerve malfunctions, and musculoskeletal issues are also common with excessive vibration (Vihlborg et al., 2017). Such work activities should be avoided, at least reduced in the time a worker spends on them.

When carrying out work, most of the information a person obtains is through visual perception. That's why we need to pay attention to **ensuring adequate lightning**, as failure to do so will lead to more errors, headaches and reduced concentration, which directly affects productivity. Golmohammadi (2021) found that inadequate illumination and poor colour temperature contribute to visual discomfort, reduced concentration, and lower productivity.

2.2 Gamification Methods

One of the crucial points in keeping up with good practice examples of ergonomics and observing the beneficial effects of applying the mentioned principles of ergonomics is consistency. Consistency can be built in several manners, including through building habits, through repeated patterns of their use in everyday behaviour enforced by a third party, such as a manager or a human resources personnel, or by creating a positive motivational environment wherein the user wants to participate in upholding the standards of the workplace by keeping up to the standards and requirements of the employer wherein the requirements of ergonomic behaviour at one's workplace is included. The latter is an idea that aims at modelling and implementing a positive and encouraging environment that does not feel forced upon the employee but is solidified and steered by the user's motivation and

willingness to participate in the described system. Various ways can be used to foster motivation, one of which is the process of gamification.

The game-specific concepts that gamification applies to non-game contexts come from the domain of game design. Four fundamental elements of game design are usually considered to be the story, aesthetics, mechanics, and technology (Schell, 2019). The story is a concept that binds all the other concepts together, provides motivation for them, and gives them a specific place in the game. Aesthetics encompasses all aspects of the visual and audio experience the game aims to provide its players. Mechanics define how players interact with the in-game world, the implemented environment, and the game in general. Lastly, the technology element observes the game through the constraints, differences, and opportunities of technological requirements, abilities, and power. This element is responsible for modelling a game as a virtual reality (VR) system, a mobile experience, or a gaming console software.

Some of the concepts described above can be considered gamification-ready concepts already, e.g., the element of the story. Other fundamental game design elements described above motivate and encompass further concepts that can be used in a gamified system, such as point and leaderboards, badges, quests, grouping mechanisms (e.g. guilds), role-playing, etc. Although the technological element defines and constrains how to implement a gamified system, the element of mechanics is essential in containing actionable approaches towards a game or non-game systems. The most commonly used elements (Antonaci et al., 2019; Ertan Şevk & Arkün Kocadere, 2024; Zainuddin et al., 2020) and mechanics include but are not limited to, points, badges, achievements, rankings, virtual goods, quests, levels, avatars, rewards, narrative, competition, etc. Some researchers (Ndulue et al., 2022) show that the effect of gamification elements and mechanics varies regarding the application domain where they are implemented, even if the observed element remains mostly or entirely unchanged.

Some of the above-mentioned gamification elements and mechanics have been organised in frameworks for more straightforward mapping, planning and implementation of gamified systems (Denden et al., 2024). One of the modern ideas related to gamification is personalised gamification, which is used to exert additional motivation, engagement, and retention from the observed users. While personalised

gamification is somewhat of an umbrella term that subsumes all the others, exceptional cases of personalised gamification can be mapped to a position between a static and an environment.

Gamification is tightly tied to the concept of persuasive strategies – both share the primary goal of influencing the behaviour of users via eliciting user-driven change. Regarding persuasion, some of the most commonly used strategies in persuasive games and gamified systems include competition, rewards, and social comparison (Orji et al., 2017). Personalisation is another concept often related to gamification (Rodrigues et al., 2020). Personalised gamification is found to have a positive effect on users' motivation. Still, the impact of personalised gamification depends on various factors that define how a person reacts and behaves.

3 Methodology

We conducted a focused review of articles and reports on ergonomic principles and gamification methods. We searched online databases (for example, MDPI, IEEE, and ScienceDirect) using terms such as "ergonomic principles", "workplace well-being" and "gamification methods". We chose sources that gave clear guidance on improving health with different ergonomic principles, such as maintaining a neutral posture, reducing overload and providing adequate movement or stretching. We also looked at sources that explained how to use points, challenges, or other forms of gamification to motivate people to cooperate with positive changes to their everyday work environment.

4 Results and Discussion

This section presents use-case examples that show different gamification method combinations supporting a particular ergonomic principle. We base these examples on points in the reviewed literature about practicality and ease of use in a workplace setting. Only one example is provided per the ergonomic principle to illustrate the possibilities, although additional use cases may be developed.

To motivate employees to **maintain a neutral posture**, we propose a system that prompts employees to respond to a prompt to assess their current posture on a scale from bad posture to excellent posture, each level enriched by a description and a

visual cue of its features. The employee receives the prompt at random intervals during their working hours. Responding to the prompt should be easy and fast so as not to distract the employee from their job. The longer the posture is maintained in a good or better posture, an optionally publicly visible streak builds and motivates the employee to continue this good practice. Accruing *posture points* based on the employee's responses can be exchanged for elements of prestige based on the individual's perception, e.g. a spot on a list, a bragging right or similar.

To ensure **maximum comfort in their work area**, an employee is commonly expected to fulfil several expectations. A checklist is an obvious choice to streamline the setup to ensure maximum comfort and, therefore, productivity of an employee. A gamified checklist modelled as a quest comprising a set of tasks wrapped up in a narrative with automated status messages based on the level of quest completion might motivate the employee to ensure a comfortable work area, in addition to their intrinsic motivation. Some of the elements of the checklist may expire over time and need to be repeated in specified intervals to ensure continuous support.

A sedentary or stationary position is common nowadays, so providing a system for **promoting movement and stretching** is an intriguing prospect. Introducing the employees to a system that would alert them regularly, e.g. similar to the Pomodoro technique, to take a break and do some exercises or stretches could help them introduce healthy habits in their everyday jobs. Utilising role-playing, employees can choose a fictional character or the archetypes they identify with most from a set, where each has the most suitable exercises and stretches (e.g. Hercules from Disney's 1997 cartoon would differ from Elsa from Disney's 2013 cartoon). Special rewards may be unlocked by stretching in the company of other employees. Additionally, tracking step counts during working hours could be implemented to foster the healthy habit of walking. Providing incentives for all but scaling those based on the rolling average of a single employee and a group of them can entice healthy competition.

Reducing physical overload is advisable by utilising ergonomic tools (e.g. load elevators, rolling carts, lifting straps) when physical activity is necessary. In this less-is-more situation, the goal is to motivate employees to minimise physical labour whenever possible. A system that tracks employee activities and rewards them

inversely relative to the weight, distance, and occurrence of physical labour is argued to be able to reduce overload where ergonomic tools are available.

Education is often a good approach and is argued here to be the optimal approach to **reducing the occurrence of inappropriate movements**. Introducing employees to simple, informative, yet minimalistic training, serious games followed by quizzes, crosswords and puzzles enriched by a daily tournament in scoring points seems like a decent approach to fostering knowledge and awareness of inappropriate and repetitive movements.

Once set up, features of the ergonomic principle that **reduces point pressures on the body** are not expected to change soon. Maintaining those features and keeping the employees aware of their importance is crucial. Daily generated fictional short story narratives focussing on the features of this principle remind employees of the fundamental concepts related to this principle.

While the causes of **excessive vibrations** may be numerous, it is essential to rule out the machine itself as faulty equipment causing the vibrations. Providing simplified schematics with labelled key points and a list of tasks that must be performed in a defined sequence while related to each other by a generated story is argued here to make it easier for employees never to miss a step in configuring the machine and avoiding it being the cause of excessive vibrations.

Several features constitute **adequate lighting** in a work area. Employees replying to their colleagues' requests for information using predefined questions can help them ensure the proper working conditions based on this principle. Rewarding them relative to the number of requests received and replied to and optionally publishing the score is argued here to promote care about other employees and provide more focus on this principle. Furthermore, this approach can promote socialisation and inter-group dynamics as well.

Figure 3 represents a visualization of the eight use-case examples.

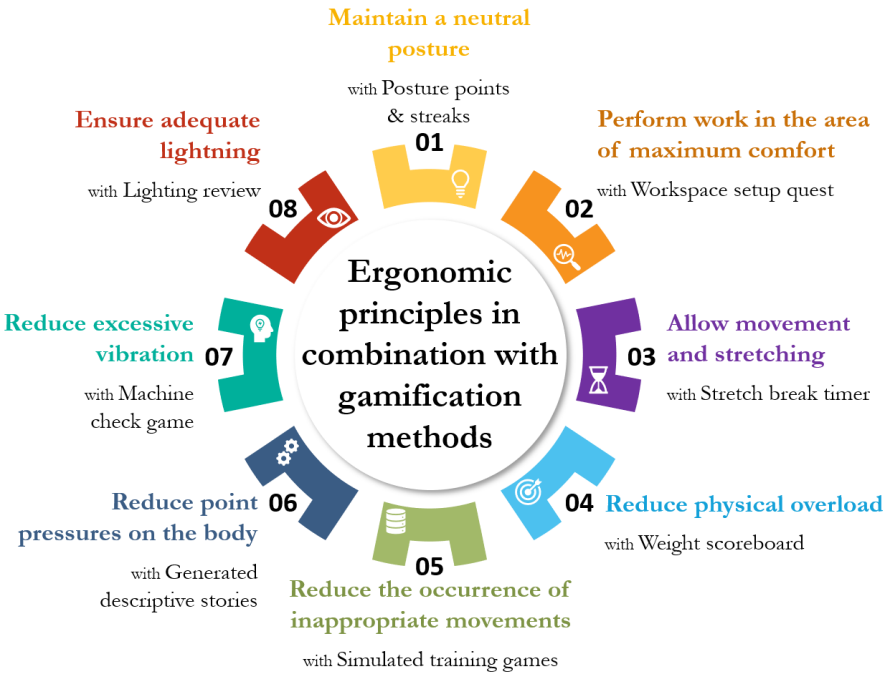

Figure 3: Gamified use-case examples per ergonomic principle
Source: Own

5 Conclusion

This paper presents a short overview of the main principles of ergonomics, followed by a quick look at the concept of gamification and the related methods. Based on the observations gained through the literature review, several use-case examples are provided, covering all the ergonomics principles, suggesting how gamification might be applied in an ergonomics context to promote healthy and safe behaviour.

While the examples provided in this paper are not numerous, the authors argue that game-related concepts should be used to promote and ensure a more satisfying and motivating working experience. Future work is foreseen as delving deeper into the possible combinations of gamification with each ergonomic principle, possibly ensuring a practical and measurable approach.

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