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# The Classification of Game Elements for Manufacturing

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**Abstract.** Gamification is the application of game elements in non-game contexts, and in manufacturing this can be applied on the shopfloor, with intralogistics, and for training. The term "game elements" is commonly used when describing an instance of gamification. In the manufacturing context, "game elements" describe the pieces of an implementation that allow the scenario to be considered *gamified*. In research, various publications have used differing terms to describe these "game elements," including mechanisms, components, technology, and various others. Since these terms are not used universally across the field, it is important to develop a framework which describes how these terms relate to one another and how they are defined in relation to gamification. This research aims to review currently used game elements from gamification for manufacturing and to classify the identified game elements more discretely for the gamification community. The resulting framework of this research will serve the gamification community in i) developing a foundation of well-established language and diction used within the field to allow for clear communication and research and ii) providing context for implementing gamification across different scenarios in the manufacturing context.

**Keywords:** Game elements, gamification, manufacturing, production.

## 1 Introduction

With the shift of manufacturing research to focusing more intently on human-machine interactions and human factors on the shopfloor, gamification has been a growing topic of interest for the field. Gamification is defined as "the application of game elements to non-game context" [1]. Its application has been seen in various scenarios in our daily lives, including *points programs* created by restaurants, *incentive programs* in the workplace, or *game-like effects* on language learning apps. Gamification is often implemented into scenarios that strive to improve morale and motivation, increase productivity and efficiency, and enhance learning [2]. Within the manufacturing context, gamification is still a topic of research in its infancy, particularly from a shopfloor operations perspective. To expand upon the field of gamification for manufacturing (GfM), we must consider how gamification may be effectively incorporated into particular manufacturing settings.

This paper focuses on classifying the game elements often involved in GfM scenarios. The purpose of the classification framework is to provide a concrete method of identifying game elements to be used in and matched to gamified scenarios in manufacturing. Game elements are the attributes or pieces of the gamified scenario which create the game-like environment. To identify the game elements commonly mentioned in GfM research, the game elements were extracted from the results of a separate in-depth literature review recently conducted by our team [3]. A total of 35 papers, which focused on the gamification of shopfloor operations for manufacturing, production, and intra-logistics, resulted in a subset of 44 unique game elements to be considered in the development of the classification framework described in this paper.

Following this introduction, section 2 describes the methodology used for gathering the game elements from literature, as well as the development of the classification framework. Section 3 provides the details and explanation of the framework. Section 4 showcases two different GfM scenarios in literature and how the framework can be used to develop a gamified scenario in manufacturing, thus validating the framework. The final section, section 5, completes the paper by drawing final conclusions and providing future work recommendations.

## **2 Methodology**

This paper stems from an in-depth literature review previously conducted by the research team [3]. In the literature review, a methodical investigation was conducted to review all papers related to our topic of interest: gamification for manufacturing. We began the literature review with searching the Scopus database with the search string: TITLE-ABS-KEY((gamif\*) AND (operation\* OR manufactur\* OR production\* OR logistic)). After systematically reviewing the search results and identifying relevant papers, a subset of 35 papers were reviewed in-depth for the literature review. This literature review is not discussed further in this paper because, as it relates to this paper, it was used for the sole purpose of identifying the 44 unique game elements related to GfM. The purpose of this paper was to analyze the 44 unique game elements to establish a classification framework.

After reviewing the list of game design elements identified through our previous literature review, different categories were identified that the game elements could be grouped into based on their characteristics. The characteristics were categorized by simple vs. complex, individual vs. group, and intrinsic vs. extrinsic. These categories were chosen for the classification framework because the first two categories are important considerations of the scenario prior to implementing gamification, while the third category is more of a choice that can depend on personal preference or history of what has seemed to work well in the past. In general, the use of these three categories provides sufficient consideration of the current state (pre-gamification) of the scenario, as well as how the gamification designer and team desire the scenario to function. Additionally, all three categories included game elements which were classified into both categories.

When grouping between simple and complex game elements, a distinction was made based on the intricacy of creating or implementing the game element. For example, *leaderboards*, *point systems*, and *badges* are most frequently used in a manner that only requires a relatively simple setup, allowing for universal use in a given scenario. For example, a *leaderboard* may display employee (or team) identifiers based on daily productivity in a manufacturing scenario where productivity is already a collected data point and reviewed metric. On the other hand, *feedback*, *storylines*, and *levels* often require more effort in the form of resources, time, and expertise for development and implementation, and in some cases may require personalization towards the user. For example, *storylines*, to be effective, require significant thought and development to ensure a clear and worthwhile result. Additionally, to provide automated feedback to users, it is likely that additional sensors and technology would need to be implemented into the scenario for data collection and accurate tracking of the employee's or team's work. In this comparison of simple vs. complex game elements, some elements were identified as being associated with both categories, where the complexity was dependent on the context in which it was used. An example of this is *badges*, as they could be made in a one-size-fits-all manner, or they could be individualized to each employee, team, or task.

Individual and group categorizations were decided based on the typical setting in which the game element is applied. Individual game elements can be applicable to a worker without the support or collaboration of anyone else. *Quests*, *progress bars*, and *achievements* are most often an individualized experience. On the other hand, group game elements include *leaderboards*, *contests*, and *competition*. These elements require more than one individual's participation to be implemented successfully and effectively.

Intrinsic motivation involves the completion of a task because of personal satisfaction, while extrinsic motivation comes from outside motivators such as prizes, money, or social status. To rank game elements between intrinsic and extrinsic motivations, it was important to take into consideration the differences between how they would be applied in a manufacturing scenario. Some elements were used as a means of enjoyment for an employee, whereas others may be used as an incentive in the workplace. For example, *strategies*, *avatars*, and *narratives* are a few game elements that primarily use intrinsic motivation. This is clear since these game elements do not lead to any external motivators. Contrarily, extrinsic motivators are elements like *leaderboards*, *levels*, and *rules*. These are known to be categorized as such because, when completed or used successfully, they lead to rewards such as increased social status, or other monetary and physical rewards. Some individual game elements could be considered either intrinsic or extrinsic motivators, depending on the context in which they were applied; *collaboration*, *interaction*, *teammates*, and *discussion boards* are a few game elements that could be considered either intrinsic or extrinsic depending on the context and objectives of the different scenarios. This was dependent on whether the collaboration was a personally rewarding experience or if it led to competitiveness, or other motivating factors.

Grouping game elements based on 'technological required' or 'technology optional' was considered, but after further assimilation, it was found that nearly every

game element could belong in both categories. While technology would likely be helpful in the application of most game elements, the majority of game elements were still capable of being developed and implemented without the use of technology. For example, while *leaderboards* are most easily updated and displayed using smart systems, leaderboards can also be implemented in a manual sense where data is reviewed at the end of each time period (e.g., end of each shift) and handwritten and displayed on a white board on the shopfloor.

With these three categories identified as the basis for our assimilation, a tabulation was created that separated these categories into eight distinct groups of game elements. This tabulation created a framework layout to facilitate the classification of elements. With the classification of the game elements into the framework layout, the resulting tabulation allows for manufacturers, researchers, and designers to follow the framework to identify and select relevant, use case specific game elements when interested in implementing a gamified scenario into their operations.

Finally, based on the groupings and visualizations, a qualitative review of the findings was conducted. Using the findings and context of the use of game elements in GfM (through literature), the game elements were classified. This classification framework is the main result of this research and provides the groundwork for future implementations of gamification in manufacturing.

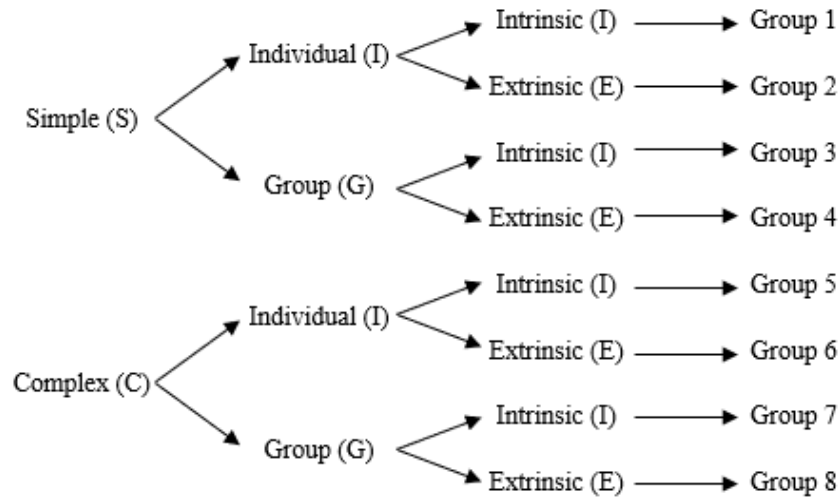
### 3 Results and Discussions

First, the classification framework (**Fig. 1**) was developed by determining the most logical order of the columns as when reading left to right.

The first column is simple vs. complex since this is often the first stipulation of the scenario: determining and understanding the available resources of the project for implementing gamification. This is a crucial step where the designer would consider if there were sufficient time, money, expertise, etc. to warrant a complex scenario, as well as to consider if a complex scenario is currently worth the resource investment.

The second column is individual vs. group because this then considers the current state of the workforce by scrutinizing how the shopfloor employees interact and work with one another. In some cases, group work may entice and encourage additional efforts, while in other cases, group work may lead to arguments and stress.

Lastly, intrinsic vs. extrinsic motivation is considered as a third column. This was determined to be the last question to ask because this is solely based on the designer's preferences, what they believe would be best, and how they desire the scenario to look and function.



**Fig. 1.** Classification framework depicting the 8 groups for game elements.

Following the completion of the framework, which resulted in eight discrete categories, the game elements were classified into their respective group(s) (**Table 1**). The results show a near even split of simple and complex motivators amongst the overall 44 game elements considered, with 24/44 (54.5%) classified as simple and 28/44 (63.6%) classified as complex. (Note that the percentages exceed 100%. This is due to the repeat of game elements in both categories.) This is beneficial to the gamification designer as the near even split indicates that making one choice (simple or complex) does not immediately rule out the possible use of a wide variety and selection of elements. This also helps to quickly narrow down the list of possible game elements, reducing the decision complexity at later states of the framework.

In the next step, far more game elements were classified as individual than group. 32/44 (72.3%) were classified as individual game elements, while 15/44 (34.1%) were considered to be group game elements. It is interesting to note that nearly all of the elements that fell into the group category were classified as such because they include a competitive element and thus contribute to extrinsic motivation because of a possible prize or other positive outcome, such as social status.

There are far more extrinsic (33/44 = 75%) motivators amongst the game elements than intrinsic (16/44 = 36.7%). Implementing extrinsic motivators in GfM creates a simpler and more easily measurable study for developers and implementors, because people tend to respond much faster to rewards that are offered to them than they do to intrinsic motivators. Many of the game elements that were classified in both categories were dependent on the context in which they were applied and how the individuals may interpret the tasks. For example, having *teammates* could be either intrinsic or extrinsic, because an employee may simply find personal enjoyment from the social aspect of teammates, but the employee may also find outside motivation of social status when they are seen as the team leader.

**Table 1.** Game elements classified into their respective classification.

Group	Descriptor	Elements
Group 1	SII	Notifications, personal goals, increasing complexity, constraints
Group 2	SIE	Progress bars, goals, strategy, time constraints, increasing complexity, loss aversion, displaying performance, badges, rewards, achievements, awards
Group 3	SGI	Collaboration, interaction, teammates
Group 4	SGE	Displaying performance, collaboration, interaction, leaderboards, competition, teammates, ranking, awards, point system, scoring system, contests
Group 5	CII	Constraints, story elements, avatars, emotion, narrative, problem solving, puzzle games, scenarios
Group 6	CIE	Badges, rewards achievements, awards, levels, feedback, quests, virtual goods, boss fights, challenges, mission, rules, content unlocking, performance groups
Group 7	CGI	Discussion boards
Group 8	CGE	Awards, point system, scoring system, contests, performance graphs, discussion boards, betting, social recognition

#### 4 Validation of the Framework

To consider the efficacy of the framework, two publications which involved detailed scenarios of GfM implementations were reviewed in parallel with the framework. Using the understanding of the scenario of the first publication [4], we worked through the framework to determine possible game elements to be used. With the second publication [5], we considered the chosen game elements used in the paper alongside the framework to show that the classification framework can be used for considering additional game elements that could be used in a similar scenario.

One publication [4] observed a lab-based environment in which two teams completed a three-step assembly process on an assembly line. The first team worked on the assembly line with gamified information, including a leaderboard, where each employee got a score for the number of products they assembled and allowed communication amongst employees, while the second team did not receive a score and were not allowed to communicate. The purpose of the game was to assemble as many test objects as possible within the allotted time frame, completely and accurately. The group that had a leaderboard to track the number of completed product produced significantly more than the group that did not. Comparing the work of this publication with the developed framework, it is clear that leaderboards were used in a simple and group environment. Based on the reactions of the gamified team, it is shown that extrinsic motivators of the leaderboard were well received due to the gamified team's discussion of their status on the leaderboard during the break. By understanding the specific situation that the researchers had (simple, individual, extrinsic), our framework would have led them to using leaderboards to incorporate a



gamified experience into their production processes. This evaluation result indicates that our framework is aligned with recent implementations and experimental outcomes.

In another study conducted by Korn [5], emotion recognition is used to determine whether employees in a production work setting were “happy” or “unhappy” when applying gamification methods. They were given a 10-task repetition without gamification, then the process was repeated with gamification. Participants were given real-time feedback, received performance displays, and saw their scores. Using our proposed framework, it is shown that feedback and point systems are both associated with group 4 (simple, group, extrinsic). Following this, it is likely that teammates, rankings, and leaderboards would have had the same effect on the process as the two chosen game elements. Feedback is a group 6 (complex, individual, extrinsic) element, which suggests that game elements such as levels, badges, and rewards may have had similar effects on the process. This aspect of the validation process expands on the possible use of the proposed framework as a tool for implementing additional game elements that are comparable to game elements already used in a scenario.

## **5 Conclusions, Limitations, and Future Work**

The formation and organization of this chart creates a foundation for those in industry and research to have a basis of application for GfM by providing guidance on the game elements to use. Since gamification is a growing application in manufacturing, this framework facilitates the future growth by providing concrete guidelines for implementation by considering the current state (pre-gamification) of the process.

By compiling a list of 44 game elements used across various publications, it was determined that the game elements could be separated into groupings of simple or complex, individual or group, and intrinsic or extrinsic. Using these categories, eight groups of differing game elements were created. The classification framework was validated using two different publications of GfM scenarios to exemplify two ways the framework can be utilized by stakeholders: i) in examining the pre-gamification scenario to understand potentially relevant game elements for the specific use case, and ii) in understanding the current gamified scenario to consider additional game elements which may produce similar results.

One limitation of this research is that the publications used for the validation step were part of the 35 papers from which the 44 game elements were extracted from. Thus, it is possible that a slight bias was introduced since the game elements and framework application for these publications were not entirely independent of one another. However, since the game elements were only extracted and then compiled separately into the proposed framework, the potential bias is limited. Another limitation of the research at this stage is that the evaluation is based on secondary data (publications) and the proposed framework has not yet been validated using primary research data (case studies or experiments). Additionally, the framework included in this paper does not include considerations for making decisions based on

characteristics of the production system or operators involved, but only considerations which are under the control of the gamification designer. These limitations are addressed in the planned future work.

The proposed framework allows for future manufacturers to apply gamification techniques into their production processes and for GfM researchers to further explore gamification by understanding the benefits of each group of elements for manufacturing. Following the creation of this framework, the next step in the process is to validate the framework with industry partners through a case study. From this, adaptations can be made to improve the organization and implementation of the process. Additionally, one area that GfM struggles is in understanding the concrete, empirically-based benefits of gamification. This framework hypothesizes that benefits for elements within the same group are comparable, and thus the empirical testing of GfM benefits could be centered around the eight groups, as opposed to the 44 unique elements, resulting in significantly less experimentation. Another area for future research revolves around the development of a framework based on characteristics of the production system or operators involved. To support the development of this type of framework, significant research regarding the effectiveness of particular elements in different scenarios is fundamental.

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Certain commercial software products are identified in this paper. These products were used only for demonstration purposes. This use does not imply approval or endorsement by NIST, nor does it imply these products are necessarily the best available for the purpose.

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