Management Systems in Production Engineering

2026, Volume 34, Issue 4, pp. 606-613

Date of submission of the article to the Editor: 05/2026
Date of acceptance of the article by the Editor: 10/2026

DOI 10.2478/mspe-2026-0051



GAMIFICATION IN QUALITY CONTROL IN PLASTICS PRODUCTION: IMPACT ON EMPLOYEE ENGAGEMENT AND PROCESS EFFICIENCY

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Abstract:
The aim of this study is to assess the impact of gamification on employee engagement and the effectiveness of quality control processes in a company producing plastic components for electronic devices. Changes in employee engagement in reporting nonconformities, reporting improvements, response times to quality issues, and the number of nonconformities undetected during quality control were analyzed. The study was conducted among production and quality control employees, divided into experimental and control groups. The experimental group implemented a gamification system, including points for reporting nonconformities, activity badges, and rankings recognizing employees most engaged in quality-related activities. Data was collected before and after system implementation, using selected indicators. The results indicate increased employee engagement and improvements in selected quality indicators, including increased detection of nonconformities and reduced response times to problems. This confirms that gamification can be an effective tool supporting quality management in the production environment, provided it is properly designed, implemented, and adapted to the specific needs of the company.

Key words: gamification, quality control, plastic production, nonconformities, employee engagement

INTRODUCTION

Modern manufacturing companies operate in an increasingly competitive environment with increasingly stringent product quality requirements. This is particularly important in the electronics industry, where even minor nonconformities can impact the functionality of final products and generate additional costs related to complaints, rework, or material losses. Therefore, organizations are seeking new methods to increase the effectiveness of quality control processes and engage employees in detecting and eliminating production errors.

One solution that has been gaining increasing attention in recent years is gamification [1, 2]. It involves the use of game-like mechanisms, such as point systems, rankings, badges, and rewards, in an environment not directly related to entertainment [3]. The goal of gamification is to increase participant motivation, activity, and engagement by influencing their needs for competition, achievement, and a sense of development.

In manufacturing companies, gamification can be a tool supporting quality management by encouraging employees to actively participate in the process of identifying nonconformities and quickly responding to quality issues. However, to date, most research on gamification has focused on areas such as

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marketing [4], education [5], and sales [6], while relatively few studies address the use of gamification in quality control processes in small manufacturing companies.
The aim of this study is to analyze the impact of using selected gamification mechanisms on employee engagement and the effectiveness of quality control processes in a small enterprise manufacturing plastic enclosures for electronics. This objective involves analyzing changes that occur after implementing gamification mechanisms, such as a point system, rankings, and motivational badges. The study was conducted as an experiment using pretest and posttest methodology, dividing employees into experimental and control groups.
The novelty of this work lies primarily in the application of gamification in a small manufacturing enterprise operating in the electronics plastics industry. The practical nature of the research conducted in real-world production conditions is also a significant element. The work also demonstrates the potential for using simple and relatively low-cost gamification mechanisms to support quality processes in SMEs, which often have limited financial and human resources.
The limitations of this work stem primarily from the small number of participants and the short duration of the experiment, as well as the novelty effect associated with implementing the gamification system, which may weaken over time, as well as the effect of "playing on purpose" by employees and the risk of excessive competition between employees.

LITERATURE ANALYSIS

Gamification is an innovative business technique involving the use and introduction of game logic, atmosphere, and technical elements in almost all areas of life and business. The term is attributed to Nick Pelling, a game designer who, in 2002, was tasked with creating game-inspired interfaces for ATMs and vending machines [7]. Gamification emphasizes the process of providing offers of experiences available during gameplay, which is intended to support the overall process of creating value for the customer [8]. Gamification is the phenomenon of adapting selected social, psychological, and technical aspects of game creation and development to various social situations in order to encourage individuals to engage in desired behaviors (activities) or to develop attitudes that will translate into such behaviors [9].
The following types of gamification can be distinguished based on their application area [8]:

- product gamification, the aim of which is to increase the attractiveness of a product,
- marketing gamification [10, 11], the aim of which is to create a community that is engaged in a marketing campaign for a product or brand,
- work environment gamification, the aim of which is to motivate employees and teams through mechanisms of remuneration, communication, and cooperation, and thus – to improve employee job satisfaction and job satisfaction [12, 13, 14, 15, 16],
- social gamification, the aim of which is to develop specific social attitudes, e.g., behaviors related to ecology [17, 18], physical culture, or safety [19], and this type of gamification is mainly encountered in public organizations such as schools [20, 21, 22, 23] or healthcare facilities [24, 25, 26]
- personal gamification, which is addressed to individuals and is related, for example, to training programs.

Many companies implement gamification mechanisms in various areas of their operations [27, 28, 29, 30, 31] to, among other things:

- improve work efficiency and effectiveness,
- increase employee job satisfaction and, consequently, greater engagement in task performance,
- encourage employee integration and teamwork.

Recent studies in production engineering, system safety and operational excellence literature also emphasize that the effectiveness of quality control in manufacturing is increasingly supported by data-driven quality prediction in injection moulding [32], maturity-oriented Quality 5.0 concepts [33], integrated quality management systems in SMEs [34], Lean-based visual and behavioural improvement frameworks [35], cloud-based quality reporting [36], and human-centred Industry 5.0/Quality 5.0

operational excellence [37]. These contributions provide an up-to-date context for analysing gamification as a complementary mechanism that strengthens employee involvement, accelerates reporting of nonconformities and supports continuous improvement in production processes.
Gamification mechanisms primarily include:
- awarding points for each submitted idea, with additional points for ideas that are implemented,
- badges for achieving a certain number of submitted or implemented ideas,
- rankings of the most active employees or teams,
- thematic challenges, e.g., "waste reduction week,"
- development paths or "skill trees" (acquiring new competencies unlocks subsequent development branches),
- quizzes and knowledge tests with points and rankings.

RESEARCH METHODOLOGY

The study was conducted at an SME [38, 39] operating in the plastics processing industry. Located in the Silesian Voivodeship, the company manufactures, among other products, housings for electronic devices. The study was conducted in the first quarter of 2026, in a real-world production environment, among 34 employees of the production and quality control departments [40].
In the studied company, employees were divided into an experimental group (where gamification elements were implemented) and a control group (this group performed their duties in the same manner, without gamification elements). This division made it possible to determine whether any changes in employee activities or activity could be a result of the implemented gamification elements. Employees were assigned to the experimental and control groups using simple random allocation. Both groups worked on comparable production places, used the same machinery, and operated under similar production and quality targets – to reduce organizational bias.
The experimental group consisted of 17 employees, while the control group also included 17 employees. Both groups had comparable structures in terms of job position, work experience, and participation in quality-related activities.
In the experimental group, 12 employees worked directly in production and 5 in quality control. In the control group, 11 employees worked in production and 6 in quality control. The average work experience was 4.5 years in the experimental group and 5.1 years in the control group.
The study was conducted using the pretest-posttest method, which involves measuring the dependent variable twice in the same study group:
- before introducing the independent variable (pretest),
- once after introducing the independent variable (posttest).

In this study, the independent variable was the implementation of selected gamification mechanisms in quality control processes, such as:
- point systems, i.e., awarding employees points for reporting nonconformities, developing or submitting improvements, and quickly responding to quality problems,
- leaderboards – summarizing employee performance (individual or team),
- badges – awarded for achievements, such as implementing an improvement previously reported by an employee.

The gamification system in the company was implemented as a simple point-based structure integrated with existing quality reporting procedures. Employees received:
- 5 points for reporting a confirmed nonconformity,
- 3 points for submitting an improvement proposal,
- an additional 10 points for improvement proposals accepted for implementation,
- 2 bonus points for reporting a quality issue within 10 minutes from detection.

The system also included digital badges such as:
- "Quality Observer" – awarded for 10 confirmed reports,
- "Improvement Initiator" – awarded for 5 submitted improvements,
- "Rapid Responder" – awarded for the shortest average response time.

Weekly rankings were displayed on internal information boards accessible to study participants. Feedback was provided during short weekly production meetings.
No financial rewards were introduced. The system relied mainly on social recognition, feedback mechanisms, and competitive elements.
The dependent variables, however, were related to the level of production employee engagement and the effectiveness of quality control.
The level of production employee engagement was assessed based on the number of nonconformities they detected and the number of improvements they reported, while the effectiveness of quality control was assessed based on the response time to quality problems and the number of defects that were passed on.
To improve comparability between groups, the indicators were normalized relative to production activity. Reported nonconformities and undetected defects were calculated per 1000 produced components, while improvement submissions were calculated per employee participating in the study.
In the first stage of the pre-test, before the implementation of gamification elements, data was collected on the number of nonconformities, the number of improvements reported by production employees, as well as data on the response time to quality issues occurring in the process, and the number of defects that persisted despite quality control. This data came from quality reports, complaint systems, and Kaizen dashboards. To reduce the risk of excessive or low-quality reporting, only reports verified and confirmed by the quality department were included in the analysis.The gamification system was then implemented in the experimental group for four weeks. During this period, employees received points and badges for reporting nonconformities, submitting improvements, and quickly responding to quality issues.
After the gamification system's implementation period ended, a post-test was conducted, which included re-measuring the same indicators analyzed before the solution's implementation. The results were compared between the experimental and control groups. This allowed us to assess the impact of the gamification mechanisms on employee behavior and the effectiveness of quality measures.
The implementation process of these mechanisms was designed to be consistent with the company's goals and not disrupt standard production processes.
During the experiment, no additional training programs, organizational changes, or modifications to the quality management system were introduced that could have influenced the results.
Due to the pilot nature of the study, the relatively small sample size, and the use of aggregated operational data, the analysis was limited mainly to descriptive analysis and comparison of changes between the pretest and posttest measurements.

RESULTS ANALYSIS

The analysis of the study results was conducted based on data collected before the implementation of the gamification system (pretest) and after its implementation (posttest). The comparison of the results obtained between the experimental and control groups made it possible to assess the impact of gamification mechanisms on employee engagement and the effectiveness of quality control processes.
Table 1 shows the number of reported quality nonconformities.

Table 1

Number of reported quality nonconformities (per 4 weeks)

Group	Pretest	Posttest	Change
Experimental	28	47	+67.9%
Control	30	32	+6.7%

The data presented in Table 1 shows that before the implementation of gamification mechanisms, the experimental and control groups achieved similar results in terms of the number of reported quality nonconformities. However, after the implementation of the gamification system, the number of reported nonconformities in the experimental group increased significantly. Employees were more likely to identify and report nonconformities occurring during the production of plastic components for electronics. An increase in the number of reported nonconformities does not necessarily indicate deterioration in process quality. Instead, it may reflect increased employee vigilance and engagement in reporting quality-related issues. Therefore, the increase in reporting activity should be interpreted together with the reduction in undetected defects and shorter response times.In the control group, the level of reports remained similar to that before the study began. The next indicator analyzed was the number of reported improvements by production workers (Table 2).

Table 2

Number of reported quality improvements (per 4 weeks)

Group	Pretest	Posttest	Change
Experimental	41	63	+53.7%
Control	39	42	+7.7%

The data presented in Table 2 indicate that, as with the number of reported nonconformities, before the implementation of gamification mechanisms, the experimental and control groups achieved similar results in terms of the number of reported quality improvements. However, after the implementation of gamification mechanisms, a significant increase in the number of reported improvements was observed. The data obtained indicate that the use of gamification elements increased employee engagement, motivation to participate in the quality improvement process, and awareness of the importance of reporting improvements within the organization. In the control group, no significant changes were observed in the number of reported improvements among production employees.

Next, the average response time to quality problems in the production process was analyzed. The data are presented in Table 3.

Table 3

Average response time in the production process to quality problems (in minutes)

Group	Pretest	Posttest	Change
Experimental	18 min	11 min	-38.9%
Control	17 min	16 min	-5.9%

Table 3 shows that after implementing gamification, the experimental group experienced a significant reduction in response time to detected quality issues. Employees reported nonconformities to the quality department or their supervisors more quickly, allowing for earlier corrective action and reducing the number of defective products leaving the production line. In the control group, response time remained similar to the results obtained during the pre-test.

The study also included the number of nonconformities that persisted despite quality control. The results are presented in Table 4.

Table 4

Number of nonconformities that were not detected during quality control

Group	Pretest	Posttest	Change
Experimental	28	17	−39.3%
Control	27	25	−7.4%

The data presented in Table 4 indicate that before implementing gamification mechanisms, the experimental and control groups achieved similar results in terms of the number of nonconformities undetected during quality control. However, after implementing gamification mechanisms, a significant decrease in the number of undetected nonconformities was observed in the experimental group. In this group, the number of nonconformities decreased by 39.3%, while in the control group, the decrease was only 7.4%. The obtained results suggest that the use of gamification mechanisms may have contributed to increased effectiveness of control activities and increased employee awareness of potential nonconformities. Consequently, this reduced the number of errors undetected during quality control, which may indicate improved efficiency of quality processes within the organization.

SUMMARY AND CONCLUSIONS

The obtained results indicate a potential influence of gamification mechanisms on employee engagement and selected quality-related indicators; however, they do not allow for drawing definitive causal conclusions. The study demonstrated that the use of gamification elements can positively impact the functioning of quality control processes in a small manufacturing enterprise. Analysis of the results obtained in the pretest–posttest study indicates that implementing the gamification system contributed to increased employee engagement in reporting quality nonconformities and improved the efficiency of quality control activities. The most noticeable changes were an increase in the number of reported quality issues and an increase in the number of reported improvements. This means that employees exposed to the gamification system demonstrated greater engagement in the error identification process and more actively participated in activities aimed at improving production quality.

At the same time, the study identified certain limitations associated with the use of gamification. The most important include the small sample size and the relatively short duration of the experiment. These limitations mean that the obtained results cannot be directly generalized to all manufacturing enterprises. Another significant problem may be the novelty effect, whereby the initial increase in motivation may diminish over time as employees become accustomed to the system. The study also found that excessive competition between employees can lead to tension within the team and a focus on earning points rather than on truly improving process quality. This means that implementing gamification systems should be carefully planned and tailored to the company's organizational culture and the nature of the work performed.

Future research should include a larger number of companies, longer follow-up period and more advanced statistical methods, such as significance testing and difference-in-differences analysis. This would allow for the assessment of the sustainability of gamification's effects and the effectiveness of various motivational mechanisms, depending on the specific organization. Further research could also analyze the impact of gamification on team collaboration, employee turnover, and job satisfaction.

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