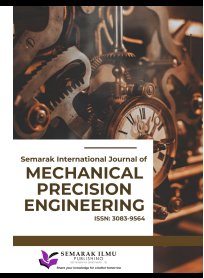




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Utilizing Gamification in Lean Six Sigma Yellow Belt Training: A Survey-Based Study on Enhancing Learning in Higher Education

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ABSTRACT

Lean Six Sigma is a methodology for improving processes and reducing waste. In higher education, traditional teaching approaches struggle to engage students and promote lasting knowledge retention. This research aimed to explore the effectiveness of gamification in the Lean Six Sigma Yellow Belt training program at Universiti Sains Malaysia (USM), focusing on its impact on engagement levels, knowledge retention, and the usefulness of gamified elements. A survey-based approach using pre-training and post-training questionnaires was designed and distributed to 24 students participating in the Lean Six Sigma Yellow Belt Wave 12 training. The collected data were analyzed using paired t-tests and descriptive statistics, including mean, median, and standard deviation, with SigmaZone software. The results showed statistically significant improvements in all measured areas. Engagement levels rose, especially through fun and motivating activities like the M&M Game and Jeopardy quiz. Knowledge retention increased, supported by simulations such as Legoliv and HELP Simulation, which helped transfer Lean concepts into practical application. Gamified elements such as simulations and interactive cooperation were rated most useful by participants. Overall, the findings confirmed that gamification is a valuable tool for improving student engagement, knowledge retention, and learning satisfaction in Lean Six Sigma training within higher education.

1. Introduction

Lean Six Sigma is a methodology that combines the principles of Lean manufacturing and Six Sigma to promote waste elimination and continuous process improvement [1]. In higher education, integrating innovative teaching methods such as gamification—defined as the application of game elements in non-game contexts to enhance engagement and motivation [2]—has shown potential to make complex industrial concepts more accessible and memorable.

The Lean Six Sigma Yellow Belt training at Universiti Sains Malaysia (USM) equips students with essential Lean tools and problem-solving skills. However, traditional teaching methods often fail to

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sustain engagement or ensure lasting knowledge retention [3]. Classes relying heavily on slides and lecture notes provide minimal opportunities for active participation, leading to low involvement and rapid knowledge loss. In contrast, the Yellow Belt program incorporates gamified elements—such as simulations, interactive quizzes, and team-based challenges—that foster participation, collaboration, and practical application of concepts.

Previous research highlights that gamification can enhance engagement through rewards and achievements, motivating learning experience, instant feedback on learning progress, social interaction and collaboration, fun learning environment, and challenging tasks that promote critical thinking [4-9]. Furthermore, gamification supports knowledge retention by promoting interactive and collaborative learning strategies, clear learning objectives and outcomes, problem-solving activities that promote critical thinking, transferability of knowledge across contexts, immersive learning environments, and connection of theoretical concepts to practical applications [9-14]. Additionally, the incorporation of gamified components such as simulations, storyline tasks, points, rewards, gamified quizzes, challenges and feedback mechanisms, and interactive cooperation has proven effective in creating a dynamic and interactive educational environment [15].

This research investigates the role of gamification in fostering a Lean culture and preparing students to meet industry expectations. It first examines how gamification is applied within the Lean Six Sigma Yellow Belt program at USM and evaluates the outcomes of gamified training. It then explores engagement levels, knowledge retention, and the perceived usefulness of gamified elements based on feedback from students who participated in the Wave 12 training, using a survey-based approach. Finally, it analyzes the effectiveness of gamification through quantitative statistical methods, with data processed and interpreted using SigmaZone software.

2. Material And Methods

A research framework serves as the fundamental structure that guides how the study is designed to achieve its objectives. This research has been conducted in three phases as illustrated in Figure 1.

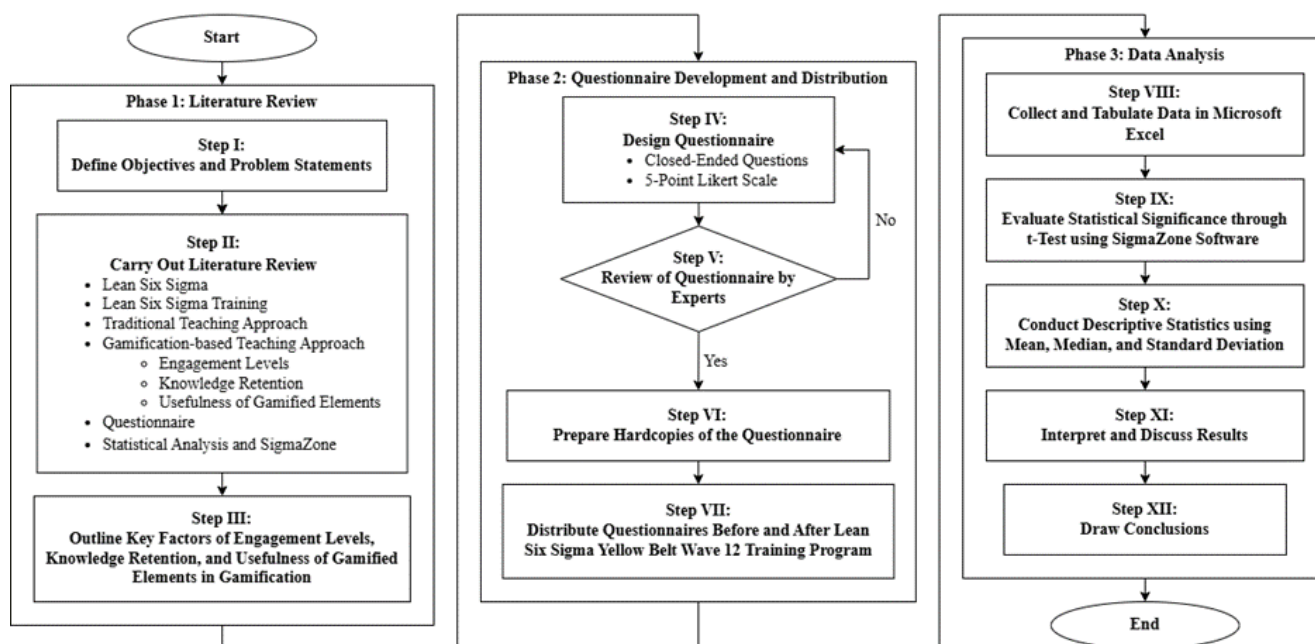


Fig. 1. Flowchart of the research methodology

2.1 Phase 1 - Literature Review

This phase establishes the foundation of the study. It includes defining the research objectives and problem statement, conducting a comprehensive review of relevant literature, and identifying key factors related to engagement levels, knowledge retention, and the usefulness of gamified elements as shown in Table 1. These steps guide the development of the research instrument.

Table 1

Key Factors of Engagement Levels, Knowledge Retention, and Usefulness of Gamified Elements

Category	Key Factors
Engagement Levels	Rewards and achievements
	Motivating learning experience
	Instant feedback on learning progress
	Social interaction and collaboration
	Fun learning environment
Knowledge Retention	Challenging tasks that promote critical thinking
	Interactive and collaborative learning strategies
	Clear learning objectives and outcomes
	Problem-solving activities that promote critical thinking
	Transferability of knowledge across contexts
	Immersive learning environments
Usefulness of Gamified Elements	Connecting theoretical concepts to practical applications
	Simulations
	Storyline tasks
	Points
	Rewards
	Gamified quizzes with competition, time pressure, points, or rewards
	Challenges and feedback mechanisms
	Interactive cooperation

2.2 Phase 2 - Questionnaire Development and Distribution

The questionnaires were developed to align closely with the research objectives. Questions were designed to be clear, straightforward, and logically organized to minimize confusion among respondents. Double-barrelled questions and double negatives were avoided to reduce ambiguity. The wording was carefully adjusted to suit both the pre-training and post-training contexts of the Lean Six Sigma Yellow Belt program. Additionally, complex terms were simplified to enhance clarity and ensure that students could easily understand the content.

To maintain uniformity and facilitate quantitative analysis, the questionnaire was designed using closed-ended questions. This format helped minimize bias and provided a structured response framework that encourages participant engagement. The response format adopted a 5-point Likert scale, which enabled respondents to express their level of agreement or disagreement. This scale was selected because it offered a balanced range of response options, effectively capturing varying degrees of opinion while keeping the questionnaire easy to understand and interpret.

The questionnaires were reviewed and evaluated by instructors of the Lean Six Sigma Yellow Belt program to ensure their suitability and relevance. Consultations with experts were conducted through email and WhatsApp to gather feedback and suggestions. Based on their input, several revisions and improvements were made to refine the questionnaires before distribution.

2.3 Phase 3 - Data Analysis

2.3.1 Evaluate Statistical Significance through Paired t-Test using SigmaZone Software

A paired t-test was used to compare the pre-training and post-training responses for each question in different sections of the questionnaire, which are Engagement Levels, Knowledge Retention, and Usefulness of Gamified Elements. A one-tailed paired t-test was conducted in this research to test whether the post-training scores were significantly greater than the pre-training scores. The hypotheses were defined as follows:

- **Null Hypothesis, H_0 :** $\mu_{\text{post}} - \mu_{\text{pre}} \leq 0$. The mean of post-training scores is less than or equal to the mean of pre-training scores, indicating no improvement or even a decline.
- **Alternative Hypothesis, H_1 :** $\mu_{\text{post}} - \mu_{\text{pre}} > 0$. The mean of post-training scores is greater than the mean of pre-training scores, suggesting a statistically significant improvement after the Lean Six Sigma Yellow Belt training.

If the p-value is less than 0.05, the null hypothesis is rejected in favour of the alternative, concluding that the training significantly improved the measured outcome.

2.3.2 Conduct Descriptive Statistics using Mean, Median, and Standard Deviation

Descriptive statistics were applied to analyze the questionnaire responses by calculating the mean, median, and standard deviation for each question across the different sections. The mean provides a general idea of the overall response level for each question corresponding to the point of the Likert scale. Furthermore, median is particularly useful for identifying the most typical or common response, especially in Likert-scale-based survey data. Additionally, a low standard deviation indicates that most responses are close to the average, suggesting consistency among participants.

3.0 Results and Discussion

3.1 Questionnaire Data Collection

The response rate is 100% for both phases. All respondents answered every question in both the pre- and post-training questionnaires. There were no missing, duplicate, or ambiguous responses, which ensured the dataset was clean and reliable for analysis. All responses were considered valid and usable for further statistical interpretation.

3.2 Comparison between Pre-Training and Post-Training Results

As shown in Table 2, all p-values obtained were less than 0.05, confirming that the improvements observed in all factors are statistically significant and valid for further analysis.

Table 2

Statistical analysis of the data collection

Category	Key Factors	Pre-Training			Post-Training			p-value
		Median	Mean	Standard Deviation	Median	Mean	Standard Deviation	
Engagement Levels	Rewards and achievements	4.00	4.21	0.66	5.00	4.71	0.46	0.001
	Motivating learning experience	4.00	4.17	0.76	5.00	4.88	0.34	0.000
	Instant feedback on learning progress	4.00	4.25	0.68	5.00	4.67	0.56	0.015
	Social interaction and collaboration	4.00	4.33	0.70	5.00	4.79	0.41	0.004
	Fun learning environment	4.50	4.42	0.65	5.00	4.92	0.28	0.001
	Challenging tasks that promote critical thinking	4.00	4.17	0.76	5.00	4.54	0.59	0.013
Knowledge Retention	Interactive and collaborative learning strategies	4.00	4.13	0.80	5.00	4.71	0.46	0.006
	Clear learning objectives and outcomes	4.00	4.17	0.82	5.00	4.75	0.53	0.001
	Problem-solving activities that promote critical thinking	4.00	4.21	0.72	5.00	4.71	0.55	0.002
	Transferability of knowledge across contexts	4.00	4.17	0.64	5.00	4.83	0.38	0.000
	Immersive learning environments	4.00	4.04	0.62	5.00	4.63	0.49	0.001
	Connecting theoretical concepts to practical applications	4.00	4.25	0.68	5.00	4.75	0.44	0.001
Usefulness of Gamified Elements	Simulations	4.00	4.33	0.64	5.00	4.92	0.28	0.000
	Storyline tasks	4.00	4.17	0.82	5.00	4.58	0.65	0.028
	Points	4.00	3.92	0.83	5.00	4.50	0.66	0.002
	Rewards	4.00	4.29	0.81	5.00	4.67	0.56	0.005
	Gamified quizzes with competition, time pressure, points, or rewards	4.00	3.96	0.75	5.00	4.71	0.46	0.000

	Challenges and feedback mechanisms	4.00	3.92	0.93	5.00	4.63	0.58	0.000
	Interactive cooperation	4.00	4.21	0.78	5.00	4.92	0.28	0.000

The median score for all questions in the pre-training responses is 4.00, except for the factor “Fun learning environment” under Engagement Levels, which has a median of 4.50. In contrast, the post-training results show a median of 5.00 for all items. This indicates a shift toward Likert point 5 (Strongly Agree), reflecting a stronger level of agreement and higher satisfaction after the training. The increase in median values suggests that the gamified Lean Six Sigma Yellow Belt training had a positive impact on students' engagement, knowledge retention, and perception of the usefulness of gamified elements, with more participants expressing stronger agreement across all categories.

As presented in Table 2, all mean scores increased following the gamified Lean Six Sigma Yellow Belt training, indicating a general enhancement in participants' experiences and perceptions. In the Engagement Levels category, the highest increase in mean score was recorded for the factor “Motivating learning experience”, rising from 4.17 to 4.88, reflecting an improvement of 0.71. This suggests that gamification in Lean Six Sigma Yellow Belt training significantly contributed to students feeling more engaged and motivated than other courses. For the Knowledge Retention category, the most substantial increase was seen in “Transferability of knowledge across contexts”, with the mean score rising from 4.17 to 4.83 (+0.66), suggesting enhanced confidence among participants in applying Lean knowledge in various tasks and scenarios.

In the Usefulness of Gamified Elements category, the factor that exhibited the highest improvement was “Gamified quizzes with competition, time pressure, points, or rewards,” which increased from 3.96 to 4.71 with an improvement of 0.75. This suggests that competitive and time-sensitive quiz elements such as Jeopardy were particularly effective in enhancing learner engagement and perceived usefulness in Lean Six Sigma Yellow Belt training than other courses. In this study, the comparison between pre-training and post-training responses shows a notable overall reduction in standard deviation across most factors. This trend indicates that participants became more consistent in their perceptions and evaluations after the gamified Lean Six Sigma Yellow Belt training. The decrease in variability suggests a more uniform understanding and shared learning experience among the trainees.

3.3 Analysis of Engagement Levels, Knowledge Retention, and Usefulness of Gamified Elements in Post-Training

For Engagement Levels, the factor “Fun learning environment” recorded the highest mean score of 4.92, followed closely by “Motivating learning experience” with a mean of 4.88, as presented in Figure 2. These results suggest that the participants highly valued the enjoyable and inspiring atmosphere created during the training. Gamified activities such as the M&M Game and Jeopardy quiz competition likely contributed to these outcomes by offering a relaxed, stress-free environment that encouraged active participation and sustained attention. These games made learning more enjoyable and engaging, fostering a positive emotional experience that enhanced student motivation and receptiveness to Lean Six Sigma concepts.

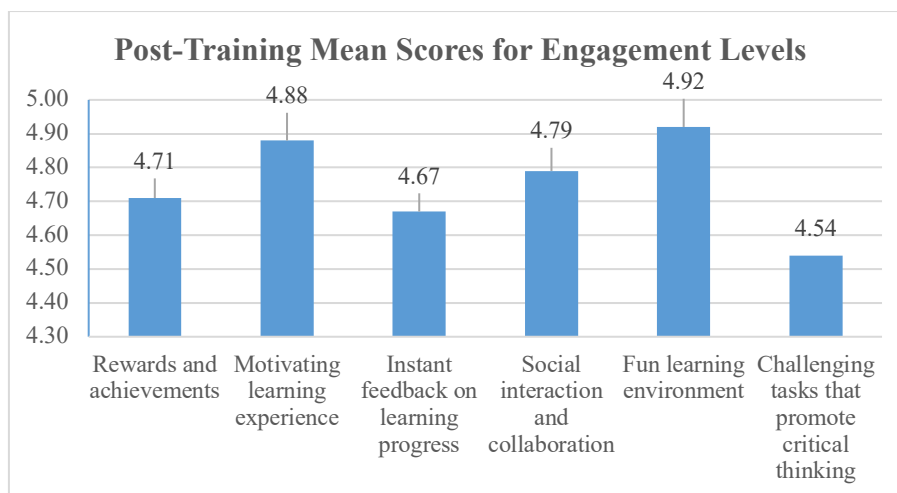


Fig. 2. Mean scores of each factor for Engagement Levels after training

As shown in Figure 3, the factor with the highest mean score for knowledge retention after training is “Transferability of knowledge across contexts”, with a mean of 4.83. These findings indicate that students found the gamified activities highly effective in helping them understand, retain, and apply Lean Six Sigma concepts in various contexts. For instance, the Legoliv simulation provided hands-on experience with core Lean tools such as SMED, 5S, Pull System, Level Loading, and Takt Time. Through active participation in this game, students were able to internalize these tools, enabling them to recall and apply them in subsequent tasks, assessments, and even real-world scenarios. Similarly, the HELP Simulation emphasized the PDCA cycle, allowing students to understand its application and importance, which they later applied in their PDCA project assignments.

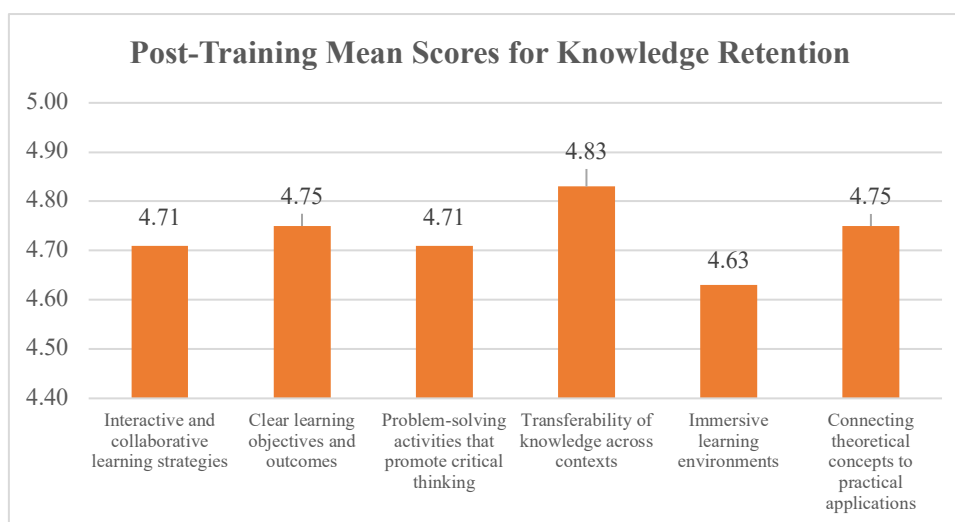


Fig. 3. Mean scores of each factor for Knowledge Retention after training

In the area of Usefulness of Gamified Elements as illustrated in Figure 4, the highest mean scores were recorded for the factors “Simulations” and “Interactive cooperation,” both receiving a mean of 4.92. These results suggest that participants found these two elements particularly effective in enhancing their learning experience during the Lean Six Sigma Yellow Belt Wave 12 training. Simulation-based activities such as the Legoliv and HELP Simulation provided students with

immersive and hands-on opportunities to apply Lean concepts in practical scenarios. These simulations enabled learners to better understand abstract principles by actively engaging with them in a realistic context, which in turn contributed to deeper learning and retention.

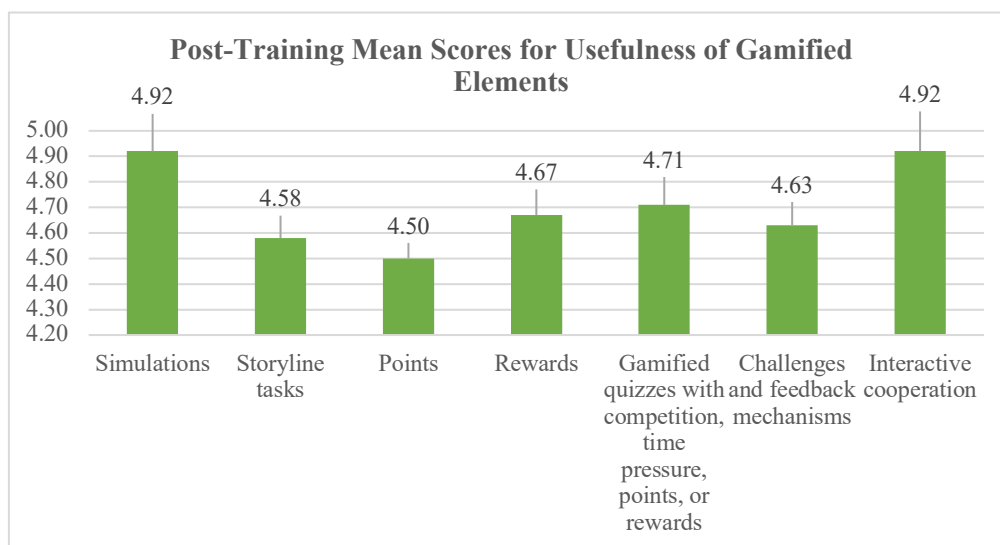


Fig. 4. Mean scores of each factor for Usefulness of Gamified Elements after training

4. Conclusions

This study successfully examined the use of gamification in Lean Six Sigma Yellow Belt training at Universiti Sains Malaysia (USM), investigating its impact on engagement levels, knowledge retention, and the usefulness of gamified elements. Gamified activities such as Legoliv, HELP Simulation, the M&M Game, and Jeopardy were found to meaningfully enhance the learning experience. Using pre- and post-training questionnaires completed by 24 participants, statistical analysis with SigmaZone revealed significant improvements across all measured areas. Engagement was most influenced by enjoyable, low-stress activities; knowledge retention benefited most from simulations that allowed concepts to be applied in varied contexts; and simulations and interactive cooperation were rated as the most useful gamified elements.

These results confirm that well-designed gamified training can make technical concepts more engaging, memorable, and applicable, bridging the gap between academic learning and industry needs. However, the small sample size and the focus on short-term outcomes limit the generalizability of the findings. Future research should involve larger, more diverse participant groups and include long-term follow-up assessments—both in academic settings and during internships—to evaluate the sustained impact of gamification on practical skill application.

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