

Localized Leaderboards Improve Motivation, Engagement, and Skill Learning in Employee Training

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Abstract: This paper presents a preliminary study comparing the educational impact of localized and global leaderboards through an experiment on phishing awareness training in a government organization. The primary contribution shows that narrowing the leaderboard scope to departmental levels can improve employee motivation, engagement, and training performance compared to traditional global and no-leaderboard conditions. An experiment was conducted with 24 participants, uniformly assigned to three groups: localized leaderboard, global leaderboard, and a control group with no leaderboard. Participants completed a web-based phishing awareness training using an online platform developed specifically for this study, consisting of 12 sequential modules, including three gamified quiz activities. Leaderboard scores were calculated based on quiz performance, rewarding both accuracy and response speeds. Motivation was assessed through training completion rate and the Intrinsic Motivation Inventory survey. Engagement was assessed through the number of attempts, usage of coaching hints, and the User Engagement Scale survey. Performance increase was measured using pre- and post-test scores, and group differences were examined via a contrast analysis. The localized leaderboard group showed the highest motivation (100% completion rate compared with 75% for the global leaderboard and control conditions), and the highest engagement (average of 8.13 attempts compared with 3.25 for the global leaderboard and 3.0 for the control), along with a 23.7% improvement in phishing detection performance (compared with no improvement in global leaderboard and a decline of 2.7% in the control group). The analysis showed a statistically significant difference between localized leaderboards and the global leaderboards, no leaderboards, and their combination ($p < 0.05$). These findings offer preliminary evidence that localized leaderboards can improve motivation, engagement, and learning in phishing awareness training by promoting socially relevant comparisons among colleagues. Even though the small sample size limits generalizability, it suggests large-scale, organizational studies on localized leaderboard use in training.

Keywords: Localized leaderboards, Phishing training, Social comparison theory, Employee training, Cybersecurity education

1. Introduction

The last 10-15 years have seen phenomenal growth in phishing activity, a form of social engineering in which attackers trick users into disclosing confidential or sensitive information (Jensen et al., 2020). According to the Federal Bureau of Investigation's (FBI's) Internet Crime Complaint Center (IC3), in 2023 alone, over 298,000 complaints were filed about phishing schemes, which accounted for roughly 34% of all Internet crime complaints reported (FBI, 2024), with total potential losses exceeding \$12.5 billion (FBI, 2024). To tackle phishing schemes, organizations have implemented technology-oriented safeguards (e.g., firewalls, intrusion detection systems) and employee training programs (Alqahtani & Kavakli-Thorne, 2020). However, these approaches have limitations, as phishing ultimately targets human vulnerabilities rather than technical vulnerabilities (Naqvi et al., 2023), and the training programs are overly reliant on static, one-time modules, focusing on knowledge rather than behaviour, lacking real-world contexts, and relying on generic assessments that are not sufficiently motivating to ensure sustained learning (Prümmer et al., 2024). Therefore, Leijman and Svensson (2025) proposed interactive and recurring methods for phishing training.

Gamification is an alternative approach to improve engagement and learning in cybersecurity training (Malone et al., 2021). Among other gamification elements, leaderboards are increasingly being used to help users set goals, boost competition, social comparison, and provide feedback (Park & Kim, 2021). While ranking all players can increase motivation for some, it can also generate anxiety for others. Participants reported higher motivation and satisfaction when competing against people they know (e.g., close friends, colleagues) rather than anonymous strangers (Jia et al., 2017). This highlights the importance of designing leaderboards that focus on users' close social proximity (i.e., localized leaderboards rather than global ones). Alternatively, Wen et al. (2024) found that the structure of leaderboards comparisons by showing those just above and below the user vs. traditional top-down formats significantly improves learning, self-efficacy, effort, and satisfaction.

This paper presents the design and preliminary evaluation of a localized leaderboard for phishing awareness training at the government organization level, which can improve employee engagement, motivation, and training performance compared to traditional global and no-leaderboard conditions.

2. Literature Review

Gamification in Cybersecurity Training leads to better security policy compliance, higher intrinsic motivation, deeper understanding, and experiential and active learning (Bitrián et al., 2024). User engagement increased as measured by time spent on training modules and training module completion rate (Abdul & Mat, 2024), number of logins or sessions (Donekal Chandrashekar et al., 2024), number of clicks/interactions with learning elements (Silic & Lowry 2020), advancement through levels/stages (Amjad et al., 2025), drop-out rates (Hostettler & Van Maurik, 2020), and compliance with assigned training tasks (Ukgoda, 2025). In Abdul and Mat (2024), in a 6-week experiment, the researchers note that participants in the gamified group completed 92% of assigned modules vs. 76% in the control, spending an average of 45 minutes per module vs. 30 minutes in the control. In Lungu et al. (2025), across a total of 240 participants in three organizational settings, the researchers found that an adaptive gamified cybersecurity training increased completion rates by 73% compared to traditional training.

However, the effectiveness of gamification depends heavily on how motivational mechanisms are designed within the system. Dahlstrøm (2012) argues that poorly designed gamification systems tend to introduce superficial competition without focusing on intrinsic motivation, leading to 'novelty effects' that diminish over time. Hostettler and Van Maurik (2020), on the other hand, note that some competitive elements (e.g., global leaderboards that publicly rank all participants) can produce unintended stress or demotivation among lower-ranked participations.

Social Comparison Theory is the theoretical foundation for the use of leaderboards, which visually display social comparison results (Bai & Hew, 2025). Created by Festinger (1954), the theory posits that people tend to evaluate their own circumstances by comparing themselves to others, thereby improving motivation, especially when they perceive the comparison as relevant and attainable.

Self-Determination Theory posits that human motivation, growth, and well-being are influenced by the of three psychological needs: autonomy (choice), competence (mastery), and relatedness (connection) (Deci & Ryan, 2000). As Philpott and Son (2022) note, leaderboards influence perceived competence as they provide performance feedback; relatedness when comparisons occur within meaningful social groups. In addition, choice is supported by leaderboards that allow self-improvement and growth with reasonable effort. Nonetheless, when rankings are overly broad and highly competitive, they can undermine intrinsic motivation by emphasizing extrinsic rewards and unattainable performance gaps (Philpott & Son, 2022).

Studies focusing on the effectiveness of leaderboard design are not specifically based on phishing or cybersecurity training in general (Bai et al., 2021; Balci et al., 2022; Cigdem et al., 2024). For instance, Bai and Hew (2025) focused on how different gamified leaderboards affect individual students' learning perceptions, performance, strategies, and engagement in online classes, with relative leaderboards (i.e., comparing neighbouring competitors) leading to a higher level of performance and engagement, in addition to encouraging constructive competitiveness, which motivated the students to prioritize knowledge mastery over mere task completion (Bai & Hew, 2025).

In another study with 429 participants in an organizational setting, Kwak et al (2025) examined the relationships among leaderboard affordance, perceived role importance in a team (PRIT), satisfaction of three psychological needs (relatedness, competence, and autonomy), and two types of stress (eustress and distress). Affordance refers to the action possibilities a technology offers users; in essence, it is what users can potentially do with a technology. The researchers observed that leaderboard affordance positively influences PRIT, and that both leaderboard affordance and PRIT increase needs satisfaction and eustress, whereas the implications for distress were minimal.

Na and Han (2023) observed that high ranks on the leaderboard include complacent behaviour, wherein users chose easy ways to maintain their position, whereas low ranks made users stick to the right process of the task with intensified motivation round after round, even though neither of the motivations appeared to be intrinsic in nature. This may explain the limited effectiveness of global leaderboards, where broader ranking can amplify both complacency at the top and discouragement or pressure among lower-ranked users. In comparison, localized leaderboards might mitigate these implications by maintaining narrower performance gaps and more attainable comparison targets, thus encouraging continuous effect without triggering extreme behavioural responses.

3. Experiment Design

Hypotheses. This paper analyses the effect of localized leaderboards in cybersecurity training, around three hypotheses: Incorporating localized leaderboards into the training generates (H1) *higher engagement*, (H2) *higher motivation*, and (H3) *improved knowledge and skills* to detect phishing situations by the participants as compared with global leaderboards and no leaderboards.

Participants. A total of 25 employees were recruited from a Saudi Arabian local government educational organization through an open invitation.

Inclusion Criterion. Participants' computer literacy was assessed using a computer self-efficacy questionnaire at the time of study registration. Following the recommendation of Murphy et al. (1989), individuals with a mean score of 3.0 or higher were classified as having basic computer literacy and considered eligible for inclusion in the study. The results indicated that 24 out of 25 respondents (96%) met this criterion, while one participant (4%) did not.

Group Demographics. Participants were uniformly assigned (based on the registration order) to one of three groups (n = 8 each): localized leaderboard, global leaderboard, and no leaderboard (control). The experimental conditions were used to appraise the way leaderboard design impacts the participants' behaviour and learning outcomes. Among the 24 eligible participants, 16 (66.7%) were males, and 8 (33.3%) were females, as shown in Table 1. All participants were from one of three departments: Human Resources (HR), Information Technology (IT), and Educational Affairs, as shown in Table 2. None of the participants had previous experience with the training platform, and participation was voluntary.

Table 1: Distribution of Participants by Gender and Leaderboard Type

Gender	Localized Leaderboard	Global Leaderboard	No Leaderboard	Total & Percentage	
Male	6	5	5	16	66.7%
Female	2	2	4	8	33.3%
Total	8	7	9	24	100.0%

Table 2: Distribution of Participants by Department and Leaderboard Type

Department	Localized Leaderboard	Global Leaderboard	No Leaderboard	Total & Percentage	
Human Resources (HR)	3	3	2	8	33.3%
Information Technology (IT)	3	2	2	7	33.3%
Educational Affairs	2	3	4	9	33.3%
Total	8	8	8	24	100.0%

In the *Localized Leaderboard* group, the participants were confined to viewing leaderboard scores only for users within their department, who were already familiar with one another prior to the study. As the training games proceeded, the leaderboards were also updated with the changes to reflect the trainee's performance. Thus, the competitive comparison remains limited to a smaller group of peers, which, in turn, has the potential to facilitate the attainment of higher ranks and motivate sustained engagement (Bai & Hew, 2025).

In the *Global Leaderboard* group, participants were shown the scores of all other participants in the study, who had little prior familiarity with one another. Each participant's ranking was updated whenever the leaderboard was viewed, reflecting their cumulative scores. Global leaderboards are used extensively in online training and learning systems. However, it is also acknowledged that global competition creates considerable performance disparities among users, which in turn discourages meaningful participation, particularly for those who repeatedly achieve lower scores (Bai & Hew, 2025). This provides a comparison element in the appraisal of the implications of the scope of leaderboards for users' engagement with training.

In the *Control Condition (No Leaderboard)* group, no leaderboard or ranking was shown, and participants had no visibility into how their scores compared with those of others. Their individual scores were visible, and they underwent the same training as the other groups. This condition offers a baseline measure of engagement and learning outcomes in the absence of competitive aspects of gamification.

4. Experiment Design

Training Description. Each participant underwent individual, self-paced training on a gamified web-based phishing awareness platform, as shown in Figure 1. They follow a sequence of 12 tasks, as shown in the left-hand-side menu (Figure 1a), with tasks locked until the preceding ones were completed, ensuring participants progressed through all content in a sequential order. A visual progress bar and bubble navigation system were also included within long tasks to allow participants to monitor their progress (Figure 1b). There are three learning tasks: (1) task 3 - phishing foundations and impact, including psychological triggers, deception, and AI-driven scams; (2) task 5 - phishing attack types, including email phishing, vishing, smishing, and Business Email Compromise; and (3) task 7 - detection and protection strategies such as spotting red flags (Figure 1c), inspecting links, practicing safe responses, and reporting suspicious activity. The learning tasks contained a challenge question that required a correct answer before the participant could advance to the next one, checking understanding. Feedback was immediate after each challenge question, correct answers triggering a green highlight, while incorrect answers triggered a red highlight and a shake animation.

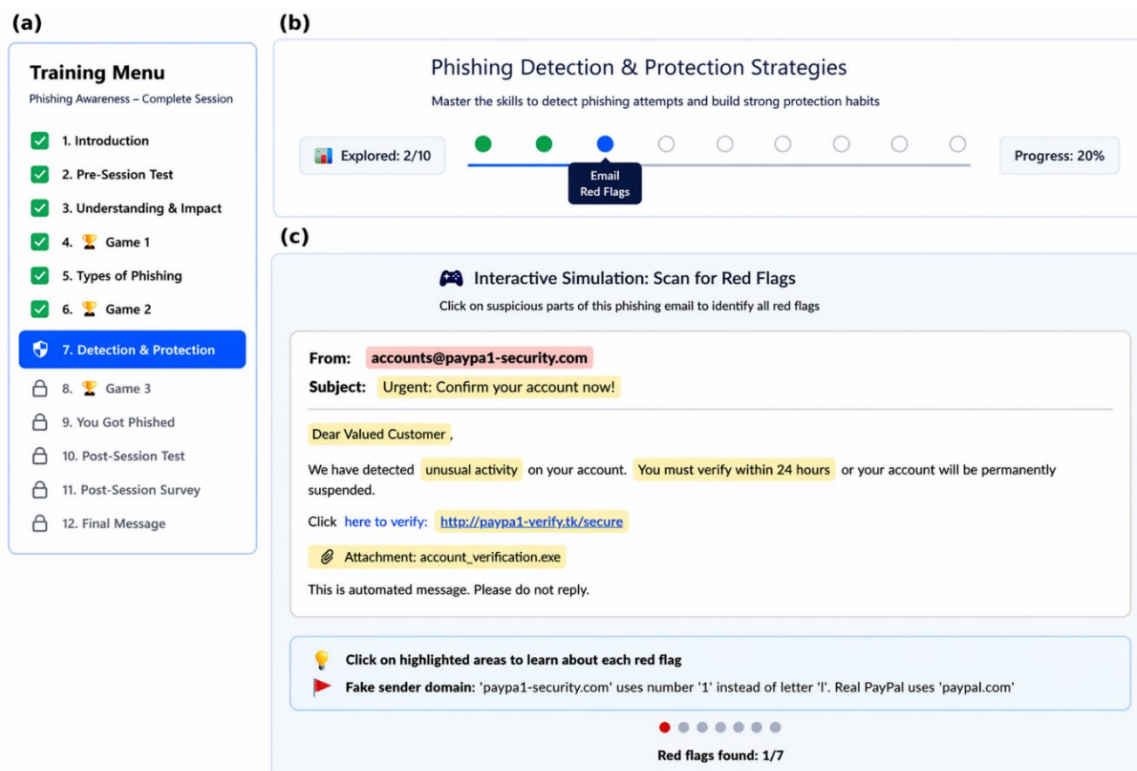


Figure 1: Training platform components showing (a) sequential 12-tasks, (b) progress bar and bubble navigation, (c) interactive simulation with highlighted indicators

After each learning module, there is a gamified quiz activity (Games 1- 3) as a summative assessment. A countdown timer is displayed for quizzes, turning red if less than 20 seconds remain, with automatic submission of the quiz after time expires. After submission, a personalized performance summary compares the current and previous attempts. A “coach” feature was incorporated to provide guiding hints, and usage was recorded in the engagement metrics. For local and global leaderboards, their ranking is updated and reflected on the leaderboard.

At the start of the training, participants complete a pre-session knowledge assessment before they are given training content to ensure a baseline for phishing detection competency. After completing all theoretical modules, they complete a post-session knowledge assessment to determine whether participation produced measurable improvements in phishing awareness. At the end, they complete a post-session survey to understand their perceptions of the training experience.

Training Platform. The phishing awareness training platform was developed as three separate single-page web applications, one per experimental condition, supporting a randomized comparison of localized leaderboards, global leaderboards, and a no-leaderboard control condition. The platform was implemented in both English and Arabic versions with the same content and structure. The platform uses standard web technologies, assuring

a consistent look and feel, and was deployed via Netlify. Backend services supported authentication (Firebase Authentication), progress synchronization (Firestore), and data collection and leaderboard rendering (Google Sheets). All participants used the same platform and training content, with the only difference being the type of leaderboard displayed (localized, global, or none), which is automatically updated after each gamified quiz. The platform was also designed to be accessed using desktops, tablets, and mobile phones.

The *scoring system* used to rank the participants was based on accuracy and efficiency in the three gamified quiz activities (Games 1 - 3). Points were earned based on the participant's ability to correctly answer phishing questions and the time spent on each quiz, using the formula: $\text{Score} = (\text{Correct Answers} \times 100) - \text{Time Taken}$ (in seconds), rewarding both accuracy and response efficiency. There was no limit on the number of attempts a participant could make for each quiz, and no penalty for multiple attempts.

Data anonymization was used to protect participants' privacy by assigning each participant a unique identifier rather than using their personally identifiable information (PII). The platform captured interactive logs highlighting behavioural metrics, including the number of attempts, coach, usage, and task completion time. No PII, including participants' roles in their organization, was stored in the database.

5. Results and Analysis

This section shows findings across three dimensions: (1) learning performance, measured through pre-and post-test scores; (2) behavioural engagement, captured through interaction metrics during training; and (3) motivation and user experience, assessed through validated self-report surveys.

5.1 Phishing Detection Performance

Measurement: To measure the effect of training, we included a pre-test and post-test, using 14 theoretical multiple-choice questions, with one correct answer per question. These questions were adopted verbatim from a recently published, peer-reviewed research that investigated phishing awareness and training effectiveness (Schöni et al., 2024). Questions were shown one at a time in a random manner (not necessarily going from first to last) to minimize order effects, reduce answer revision, and limit bias from differences in item difficulty. Positive changes recorded in the tests before and after the test were used to indicate learning outcomes. Comparisons of improvements across all experimental conditions were used to evaluate whether the design of leaderboards has implications for the effectiveness of phishing awareness training.

Results: To assess whether the exercise improved participants' phishing detection ability, pre-test and post-test scores were compared across all three groups. Table 3 summarises the performance improvement results.

Table 3: Performance Results

Condition	Pre-test Mean	Post-test Mean	Mean Improvement (SD)	Percentage Change
Localized leaderboard	9.50	11.75	+2.25 (1.58)	+23.7%
Global leaderboard	8.13	8.13	0.00 (2.27)	0%
No leaderboard	9.13	8.88	-0.25 (2.05)	-2.7%

The greatest improvement was observed in the localized leaderboard group, which increased by 23.7%, from 9.5 on the pre-test to 11.75 on the post-test. No differences were observed in the global leaderboard group, with the control group recording a small decrease in performance.

Analysis: A *contrast analysis* was conducted to determine whether the observed change in improvement scores (post-test minus pre-test) was statistically significant across the three conditions. All contrasts were evaluated using the pooled error term from a one-way ANOVA ($MSE=3.19$) with the degrees of freedom $df = N-K = 24-3 = 21$. As shown in Table 4 below, the localized leaderboard group showed statistically significant improvement over the combined average of the global leaderboard and control groups ($t(21) = 3.07$, $p=.006$) and independently over the global leaderboard ($t(21) = 2.52$, $p = .020$) and control group ($t(21) = 2.80$, $p = .011$), supporting H3. However, no significant difference was found between the global leaderboard and control group ($t(21) = 0.28$, $p = .782$).

Table 4: Statistical Analysis - Planned Contrast Analysis

Comparison	Coefficients (L, G, C)	Contrast Estimate (L)	SE	t	p-value
Localized vs Others	+2, -1, -1	4.75	1.55	3.07	.006
Localized vs. Global	+1, -1, 0	2.25	0.89	2.52	.020
Localized vs. Control	+1, 0, -1	2.50	0.89	2.80	.011
Global vs. Control	0, +1, -1	0.25	0.89	0.28	.782

Note. L = Localized leaderboard group, G = Global leaderboard group, C = Control group.

5.2 Behavioural Engagement

Measurement: Engagement was measured using three behavioural metrics derived from interaction logs: completion rate (proportion of training modules completed and quizzes); persistence (total number of quiz attempts per participant), and learning reinforcement (frequency of accessing hint support after each attempt). A higher level of interaction with the training tasks was inferred to indicate greater engagement with the training material.

Results: Differences in engagement were observed across the three conditions as summarized in Table 5. The localized leaderboard recorded a 100% completion rate, compared to 75% in both the global leaderboard and control group (as two participants dropped from each). Also, in the localized leaderboard, there were significantly more attempts and hint usage.

Table 5: Behavioural Engagement by Condition

Condition	Participants	Completion Rate	Average Attempts	Average Coach (hints) Usage
Localized Leaderboard	8	100%	8.13	1.50
Global Leaderboard	8	75%	3.25	0.25
No Leaderboard	8	75%	3.00	0.00

Analysis: A contrast analysis was conducted to determine whether quiz attempts and coaching usage differed significantly across the three groups, as presented in Table 6. Again, localized leaderboards showed statistically significant differences from global, control, and combined group for both average number of attempts and hint usage, supporting H1, while there was no statistical difference between global and control.

Table 6: Planned Contrast Analysis – Quiz Attempts and Coaching Usage

Comparison	Coefficients (L,G,C)	Contrast Estimate (L)	SE	t	p
Quiz Attempts					
Localized vs Others	+2, -1, -1	10.00	1.74	5.76	<.001
Localized vs. Global	+1, -1, 0	4.88	1.00	4.86	<.001
Localized vs. Control	+1, 0, -1	5.13	1.00	5.11	<.001
Global vs. Control	0, +1, -1	0.25	1.00	0.25	.805
Coaching Usage					
Localized vs Others	+2, -1, -1	2.75	0.52	5.31	<.001
Localized vs. Global	+1, -1, 0	1.25	0.30	4.18	<.001
Localized vs. Control	+1, 0, -1	1.50	0.30	5.02	<.001
Global vs. Control	0, +1, -1	0.25	0.30	0.84	.412

Note. L = Localized leaderboard group, G = Global leaderboard group, C = Control group.

5.3 Motivation and User Experience

Measurement: Post-experiment survey data were collected from all participants using two validated instruments: the Intrinsic Motivation Inventory (IMI) and the User Engagement Scale (UES). The IMI is a multidimensional instrument that assesses participants' subjective experiences (Ostrow & Heffernan, 2018) focused on three scales: 'Interest/Enjoyment', 'Perceived Competence', and 'Effort/Importance', measured on a 7-point Likert scale. The UES (O'Brien et al., 2018) is a validated tool that assesses user engagement in human-computer interaction contexts, containing 30 items with the focus on (1) focused attention, (2) perceived usability, (3) aesthetic appeal, and (4) reward factor. Responses were recorded on a 5-point Likert interval scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). Internal consistency was acceptable across all subscales (Cronbach's $\alpha = .71-.89$ for the IMI and $.74-.91$ for the UES-LF), exceeding recommended thresholds ($\alpha > .70$).

Results: The localized leaderboard group reported the highest levels of interest and enjoyment ($M = 6.84$, $SD = 0.27$ vs. $M=6.34$ for global and $M=6.25$ for control), perceived competence ($M = 6.77$, $SD = 0.31$ vs. $M=6.00$ for global and $M=5.40$ for control), and effort/importance ($M = 6.88$, $SD = 0.21$ vs. $M=5.93$ for global and $M=5.00$ for control). UES results followed a similar pattern, with the localized leaderboard group showing the highest scores across focused attention ($M = 4.16$, $SD = 0.51$ vs. $M=3.88$ for global and $M=4.14$ for control), perceived usability ($M = 4.73$, $SD = 0.33$ vs. $M=4.36$ for global and $M=4.45$ for control), aesthetic elements ($M = 4.98$, $SD = 0.07$ vs. $M=4.45$ for global and $M=4.83$ for control), and reward factor ($M = 4.90$, $SD = 0.16$ vs. $M=4.35$ for global and $M=4.24$ for control).

Analysis: A contrast analysis was carried out to determine if survey results differed statistically across the three conditions. The contrast coefficients were defined as [+2, -1, -1], comparison of the localized leaderboard group against the combined average of the other two groups and presented for IMI in Table 7 and for UES in Table 8. There were statistically significant differences in perceived competence ($p=0.007$), effort/importance ($p<0.001$), and reward factor ($p=0.022$).

Table 7: IMI Results – Planned Contrast Analysis (Localized vs. Others [+2, -1, -1])

Subscale	Contrast Value (L)	SE	t	p
Interest/Enjoyment	1.09	0.88	1.23	.231
Perceived Competence	2.15	0.72	2.99	.007
Effort/Importance	2.83	0.67	4.19	< .001

Table 8: UES Results – Planned Contrast Analysis (Localized vs. Others [+2, -1, -1])

Subscale	Contrast Value (L)	SE	t	p
Focused Attention	0.30	0.61	0.50	.622
Perceived Usability	0.66	0.50	1.31	.203
Aesthetic Elements	0.68	0.54	1.24	.229
Reward Factor	1.21	0.49	2.48	.022

6. Limitations, Conclusion and Future Research

In conclusion, this preliminary experiment clearly shows the potential of localized leaderboards to improve motivation, engagement, and knowledge and skill acquisition during phishing awareness training (23% improvement from pre-test to post-test, with no improvement in the other two groups). The main limitations of this research are the small number of participants (24), the lack of a long-term retention test, a predefined strategy for the local leaderboard implementation, and the participants' belonging to a single organization. Also, there were no incentives offered for participation and the platform was developed without external funding. Future research should consider large-scale experiments with diverse participant groups from different organizations; longitudinal studies to observe whether improvements in learning and engagement are sustained over time; the effect on different types of participants; different types of localized leaderboards (e.g., showing only neighbours, or multi-level) and the addition of other gamification elements or games.

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Ethics Declaration: This research applied established ethical guidelines for research involving humans, approved by the Institutional Review Board (IRB) at George Mason University (Protocol No STUDY00000890), including informed consent and the right to withdraw from the research at any time or for any reason, with all data deleted.

AI Declaration: The authors declare that all intellectual content, analysis, interpretation, and conclusions are the authors' own. AI-based tools were used during the preparation of this manuscript for grammar checking purposes only and for translating survey text from Arabic to English.

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