Enhancing Digital Game-Based Learning Through Reflective Game Design (RGD)

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Abstract: Reflective learning is an acknowledged and effective mode of acquiring knowledge in every domain. Ongoing studies indicate that digital games possess reflective characteristics that offer experiential learning, creating an immersive and secure environment for stealth learning. Such games empower learners to autonomously identify, explore, fail, and retry, fostering a dynamic learning process. The fundamental game elements such as user interface (UI), head-up displays (HUDs), maps, prompt messages, and social interactions inherently embody reflective attributes. This inherent reflective nature within digital games contributes to the development of critical thinking, problem-solving skills, and motivation, seamlessly aligning with the fundamental principles of reflective learning. This research investigates the incorporation of Reflective Game Design (RGD) within digital game-based learning (GBL) and assesses its impact on learning outcomes. The primary objective of the study was to comprehensively examine and quantify the educational influence of RGD in achieving learning objectives, enhancing the overall learning experience, and improving retention rates, in comparison to non-RGD game design. Therefore, two digital prototypes were developed as part of this study: one featuring explicit integration of reflective learning, referred to as RGD design, and the other without RGD design, termed non-RGD. In order to assess the learning, a study was conducted that revealed substantial positive results through a comparative analysis of two groups: the experimental group (N=69), engaging in digital game design with reflective learning, and the control group (N=69), with non-RGD design. The findings demonstrate that Reflective Game Design effectively infuses reflective learning recommendations into the game-based learning environment. The incorporation of RGD not only provides immediate feedback to students, fostering self-directed learning but also elevates the immersive nature of digital games, thereby facilitating deeper learning experiences. This study contributes to the effectiveness of the game design by offering the RGD framework and valuable insights for researchers, educators, and game designers aiming to create impactful educational games.

Keywords: Reflective Learning, Game Design, Reflective Game Design, Learning Theories.

1. Introduction

In the field of education, the utilisation of games as a tool for learning has gained significant attention. In Game-Based Learning (GBL), theories such as behaviourism, constructivism, and cognitive theory provide foundational frameworks for optimising learning experiences. Over the past decade, there has been notable advancement within the GBL field, with a growing emphasis on integrating learning theories to better understand how games can effectively engage learners. Digital games in GBL provide interactive learning with authentic practice (Kapp, 2013) and high retention rates. Games immerse players in simulated environments, offering experiences that parallel real-life situations. Through gameplay, individuals encounter diverse scenarios, allowing them to apply theoretical knowledge in practical contexts (Gee, 2004). For instance, strategy games require players to make decisions about resource allocation, diplomacy, and warfare, encouraging them to reflect on the consequences of their actions within the game world.

Reflective learning involves revisiting and reassessing past actions to engage intentionally in the learning process. John Dewey emphasised reflection as integral to the learning process, influencing the skill development (Dewey, 1933). It progresses from unconscious learning or experience to mindful awareness, empowering individuals to absorb everyday experiences and make conscious choices. Reflective learning also involves the critical examination of experiences, allowing individuals to gain insights, develop new perspectives, and enhance their problem-solving abilities (Moon, 2013). Games offer an immersive and safe medium for stealth learning, allowing players to identify, explore, fail, and retry (Kapp, 2013). Games captivate players' interest and engagement through interactive gameplay and compelling narratives, raising intrinsic motivation for learning (Ryan et al., 2006). This high level of engagement sustains individuals' involvement in reflective activities, enhancing their commitment to self-improvement and learning. Therefore, they provide a structured environment where players encounter challenges, make decisions, and face consequences, thus facilitating the reflective process. Moreover, games offer immediate feedback on players' actions, enabling iterative learning cycles. Whether through in-game mechanics or narrative consequences, feedback prompts players to reflect on their strategies, adjust their approaches, and experiment with alternative solutions (Squire, 2008). Key game elements such as feedback in user interfaces (UI), heads-up displays (HUDs), maps, prompt messages, and social discourse are inherently reflective (Villareale et al., 2020a), making games effective tools for triggering and supporting reflective learning.

For the last few decades, reflective learning has been considered as one of the acceptable means of learning in traditional learning. However, despite its potential to enhance teaching and learning experiences, dedicated work on reflective design in GBL remains limited. Various studies have integrated reflective practices into learning environments to improve learning outcomes, yet these practices vary across domains and produce differing results. While current game design comprises all features that facilitate reflection "as a whole set" (Garris et al., 2002, Hughes et al., 2016, Yusoff et al., 2009), it misses individual reflection differences. However, getting maximum usage of the reflective nature of games with authentic learning content while maintaining the fun criteria can be challenging. Therefore, further exploration and study are required in this context (Khaled, 2018, Mekler et al., 2018). Villareale et al. (2020b) surveyed programming games to find out the reflection in GBL and encouraged researchers to extend their work to a larger sample and investigate other genres of educational games. As Khaled (2018) quoted, "Games are reflection machines. Hence, a sound design methodology and guidelines are needed to assist the game designer in aiding effective learning with reflective practices.

1.1 Reflective Game Design (RGD) Framework

Sengers et al. (2005) coined "Reflective Design" to incorporate reflective practices into technology. This concept includes broad principles that assist technology designers in reimagining metaphors to enhance skilled user engagement. Educational games hold immense potential for fostering reflective learning due to their inherent alignment with experiential learning principles. The literature identified game features promoting reflective feedback. These features, when incorporated into educational games, can encourage deeper reflection in players, leading to improved learning outcomes and even behavioural changes (Villareale et al., 2020b, Shaheen et al., 2021). Digital games, with traits like freedom (Klopfer et al., 2009) and elements of fantasy, promote stealth reflective learning, overcoming disengagement and fostering authentic practice (Malone, 1980, Kapp, 2013). A survey by Shaheen and Fotaris (2023) showed strong support (86.5%) for reflection through digital games, highlighting practical elements like Heads-Up Displays (HUDs) and social collaboration. The interview phase emphasised the consequences' role, stating that games' losses mimic real-life learning from mistakes, reinforcing reflective behaviour.

It is well-established that games offer a platform for authentic experiences, making them particularly conducive to learning. In this context, Kolb's Learning Model (Kolb, 1984), often referred to as the *experiential learning cycle*, proves to be highly relevant to the goals of GBL. This model is adapted to formulate the Reflective Game Design (RGD) framework (Shaheen et al., 2022).

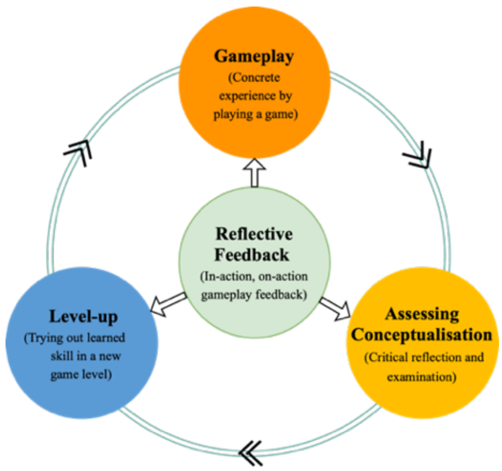


Figure 1: The RGD Framework (Shaheen et al., 2022), the arrow pointing away from the reflective feedback signifies the integration of reflective learning at every stage of the framework.

Reflective Game Design (RGD) framework (Shaheen et al., 2022) as illustrated in Figure 1 is an iterative model, where each cycle enhances learning through reflective feedback. Reflective feedback, both in-action (during gameplay) and on-action (after gameplay) is an integral component within this framework, offering reflective insights across all stages of the design process. The foundational building blocks within each stage include reflective learning principles and game-reflective features. Here's a brief explanation of each stage:

i. **Gameplay:** The first stage in the framework is to design gameplay, which can be a small game activity or a complete level. Gameplay enables learners to engage with a game using various elements such as game rules, mechanics, challenges, stories, feedback, and levels. This interaction provides authentic practice, offering concrete experiences related to the learning objectives.
ii. **Assessing Conceptualisation:** After authentic gameplay experience, the next stage is to use in-game mechanics to assess the learner's understanding. Ensuring learning and critical reflection, this stage involves incorporating ongoing reflective feedback and asking players to assess their skills during gameplay. It involves grasping complex ideas, while reflective assessment entails critically examining experiences, fostering a deeper comprehension.
iii. **Level Up:** A level-up represents the active experimentation of a learned skill in a fresh environment or situation. In game design, level design plays a pivotal role, as each level-up, coupled with the integration of previously acquired skills, enhances authentic practice and learning. Therefore, the RGD framework's third stage is to design a level-up with previous experience to engage learners in active participation.
iv. **Reflective Feedback:** In the RGD framework, reflective feedback is a central stage, which suggests providing reflective feedback after creating each digital during and post-game activity, i.e., gameplay, assessment, level and so on.

1.2 Research Question

This ongoing research seeks to engage the target audience to validate and assess the learning outcomes of reflective game design. A crucial aspect of this study involves evaluating the effectiveness of learning facilitated by RGD, Therefore, the objectives of the study are as follows:

- Conduct a comparative study to evaluate the educational impact of Reflective Game Design (RGD) in comparison to game design that does not incorporate explicit reflective practices (non-RGD).
- Measure and quantify the effectiveness of RGD in achieving learning objectives.
- Evaluate the extent to which RGD enhances the overall learning experience.
- Analyse the impact of RGD on improving retention rates among participants.

2. Methodology

2.1 Research Design

The study adopted a pre-test-post-test control-experimental group design, where participants were selected from two existing classes. The experimental group underwent a specific treatment, while the control group did not receive any intervention (Sauro and Lewis, 2016). The evaluation of interest occurred at two-time points: before the intervention (pre-test) and after the intervention (post-test).

This design comprised three key components:

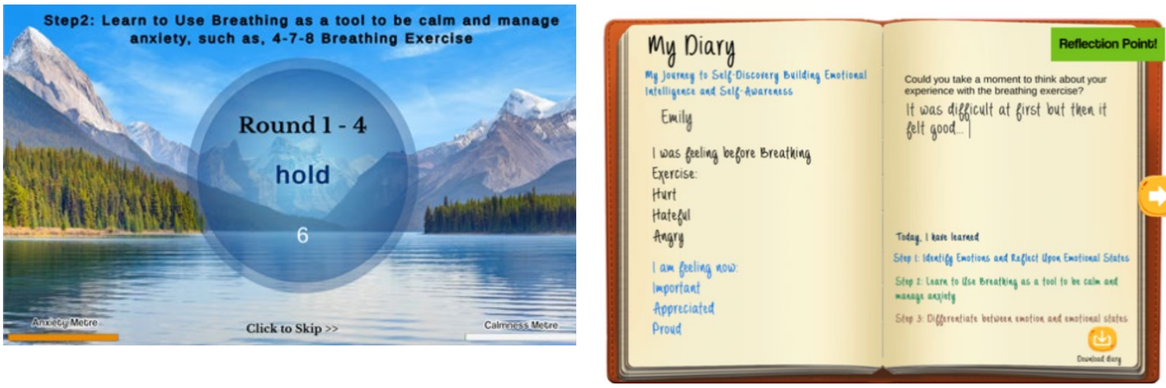
- Participants were purposefully assigned to either the experimental or control group, ensuring that each participant belonged exclusively to one group and not both.
- Both groups experienced identical conditions, differing only in the presence of the intervention. The experimental group received the specified RGD digital prototype, whereas the control group received a non-RGD digital prototype.
- Measurement of outcomes for both groups simultaneously at the pre-test and post-test stages

2.2 Game Design

Based on the systematic review and initial user research (Shaheen et al., 2021, Shaheen and Fotaris, 2023), preliminary game design decisions were made. It was decided to develop a serious game aimed at enhancing self-awareness to validate learning in RGDs. To incorporate learning effectively into the game designs, Learning Objectives (LO) were formulated with the assistance of content matter experts. Low-fidelity and high-fidelity prototypes were then developed in co-design sessions with selected participants, utilising the RGD framework. The digital game titled "The Mend", a house renovation puzzle game was designed and developed. In this game, the player's self-awareness is symbolised by a house that has been damaged by uncertainties and a lack of self-awareness. The player's objective is to solve puzzles with mindful activities to repair the house, thereby gaining insights into self-awareness throughout the gameplay.

In the game, reflective game design features (Lin et al., 1999) were utilised to promote reflection-in-action and on-action, which are briefly explained below in the context of digital games.

a. **Reflective Process Displays and Prompts:** The UI/HUD visual aids make implicit learning processes explicit, allowing learners to assess their progress and reflect on ongoing actions. For example, process displays and prompts, i.e., Figure 2 (a) illustrates the breathing exercise with visual aids, including an activity description and a timer indicating the seconds to breathe in and out.
b. **Process Models:** These are benchmarks or standard solutions that present standardised process steps, enabling learners to compare and relate to their progress. The process model example in Figure 2 (b)) depicts the diary, which displays reflections on feelings before and after the breathing exercise for comparison.



(a) Breathing exercise – Mindful Activity. (b) A diary to record self-journal.

Figure 2: Illustration of game activities

Moreover, Shaheen and Fotaris (2024), briefly explained the process with learning objectives, game design, game narrative and game mechanics with user testing. As the RGD framework process is iterative, an initial non-RGD prototype was created. Subsequent iterations integrated reflective feedback, resulting in two prototypes: one without RGD, termed non-RGD, and one with RGD.

2.3 Learning Measurement Instruments

It's widely acknowledged that using a standardised test on the intervention's subject matter is preferable to developing a study-specific test. To measure learning in the game aimed at enhancing self-awareness, this study identified several standardised tools for measuring self-awareness, including the "Construction of the Self-Awareness Outcomes Questionnaire" (Sutton, 2016), "Emotional Self-Awareness Questionnaire" (Killian, 2012), "Self-Reflection and Insight Scale" (Grant et al., 2002), and "Self-Awareness Questionnaire" (Wong and Law, 2017). However, these tools primarily measure aspects like emotional and personal awareness, which didn't fully align with the specific learning objectives outlined. Therefore, in collaboration with subject matter experts, initial questionnaires were developed and tested with a small sample. Feedback from this testing phase refined the questionnaire, resulting in a final instrument with six items to evaluate learning, administered both before and after gameplay to assess learning outcomes.

2.4 Research Intervention

2.4.1 Recruitment

The study recruited young adults aged 18-24, primarily targeting undergraduate students at the University of Brighton, social forums, and online gaming communities. Ethical approval was obtained, ensuring proper handling of human subjects. Participants with gaming experience were selected to avoid diversity, and identified through a screening question in the recruitment survey.

2.4.2 Data Collection

This research followed strict anonymisation procedures during data collection. Interviews and group sessions avoided personal or confidential inquiries. Participants were given a consent form with an information sheet to read and sign. The digital prototypes (RGD and non-RGD) were hosted on a website using the Google Firebase service for seamless distribution to the target audience. User surveys, integrated with questionnaires, were created using JISC Online Surveys to ensure a streamlined experience. A mechanism was implemented to redirect participants between the survey and the game for smooth navigation. The web URL guided users through:

- **Pre-test**: Participants completed six multiple-choice questions (MCQs) to gauge baseline knowledge.
- **Gameplay:** Participants engaged with web-based high-fidelity prototypes.
- **Post-test:** Participants completed another set of six MCQs to assess knowledge retention post-gameplay.
- Participants were categorised into the following two groups,
- **Control Group:** The pre-test survey gathered 73 responses, with 69 in the post-test. Responses lacking a corresponding post-test were excluded.
- **Experimental Group:** The pre-test survey collected 86 responses, with 76 in the post-test. Responses without a corresponding post-test were excluded.

To ensure equal sample sizes, data from the last participants in each group were excluded, resulting in a total sample size of 69 for both groups. All data was stored on the JISC database for analysis.

2.5 Data Analysis and Results

Since the participants in both the pre-test and post-test questionnaires were the same, the data falls within the area of the dependent variable. This involves before-and-after observations on the same subjects, such as students' diagnostic test results before and after a specific module or course. Since the number of samples was bigger than 20 (which is a general guideline), a standard T-paired test was decided to use. The paired t-test, alternatively recognised as the Student's t-test for paired samples, was introduced by William Sealy Gosset (Gosset, 1908). A paired t-test is used to compare two population means of two samples in which observations in one sample can be paired with observations in the other sample (Shier, 2004). The results are shown in Table 1.

- The control group received the non-RGD design, and the test comprised six content-specific questions, each scored one point, yielding a total score of six.

To calculate Student's t-test for score difference, the null hypothesis (Ho) in this case was the true mean difference is zero ($\mu_0 = 0$),

$$Ho > 0 : \ Improvement, Ho \le 0: no\ improvement$$

The paired T-Test analysis, reveals that the hypothetical mean is 0.00, while the actual mean is 0.8696, indicating a difference of 0.8696. The calculated T value is 5.53449461, which exceeds the critical value of 1.667 from the Consequently, with a T value of 5.53449461 greater than 1.667, the mean of the dataset significantly differs from the hypothesised mean, $\mu_0 = 0$, with $p < .001$. Therefore, the null hypothesis is rejected, providing evidence of learning among participants who engaged with the non-RGD digital game prototype.

As the experimental group received the RGD digital game prototype, and the test comprised six content-specific questions, each scored one point, yielding a total score of six.

Similarly, to calculate Student's t-test for paired samples, null hypothesis (Ho) in this case was the true mean difference is zero ($\mu_0 = 0$.),

$$Ho > 0 : \ Improvement, Ho \le 0: no\ improvement$$

Table 1: The paired T-test results (N=69) with alpha 0.05 and $\mu_0 = 0$.

Parameters	Control Group	Experimental Group
Mean of $\bar{d}$	0.8696	2.53623188
Standard Deviation of $\bar{d}$	1.3051	2.26598706
Variance of $\bar{d}$	1.1424	1.5021
standard error of difference $SE(\bar{d})$	0.15711737	0.27279279
T value	5.53449461	9.29728358
Critical value	1.667	1.667
Confidence interval of this difference	95%	95%

The paired T-Test analysis, reveals that the hypothetical mean is 0.00, while the actual mean is 2.53623188, indicating a difference of 2.53623188. The calculated T value is 9.29728358, which exceeds the critical value of 1.667 from the Consequently, with a T value of 9.29728358 greater than 1.667, the mean of the dataset significantly differs from the hypothesised mean, $\mu_0 = 0$, with p < .001. Therefore, the null hypothesis is rejected, providing evidence of learning among participants who engaged with the RGD digital game prototype.

2.5.1 Comparative Results

After the intervention the descriptive static analysis (refer to Table 2) shows that the pre-test mean scores for both groups were recorded as 2.83 and 2.44, indicating a relatively similar level of knowledge among students in both groups before the intervention. Subsequently, the post-test mean scores showed a slight increase, with mean scores of 3.42 and 4.98 compared to the pre-test mean scores of 2.83 and 2.44, respectively. This suggests that participants in both groups experienced some level of learning as a result of their engagement with the GBL prototypes. Remarkably, the experimental group exhibited a higher mean post-test score of 4.98 compared to the control group's mean score of 3.42. This significant difference in post-test scores indicates a substantial improvement in participants' knowledge levels resulting from their interaction with the experimental intervention of the RGD prototype.

Table 2: The average, variance, and standard deviation values of participants' scores, with a total score of 6.

	Group	Mean	Standard deviation	Variance
Pre-test	Control	2.83	1.72	2.96
	Experimental	2.44	1.52	2.33
Post-test	Control	3.42	1.42	2.01
	Experimental	4.98	1.89	1.37

The paired T-test was conducted to assess the effectiveness of learning between the RGD prototype and the non-RGD prototype. The null hypothesis (Ho) stated that "the means of the non-RGD and RGD prototypes will be equal", represented as:

$$Ho: \mu_1 = \mu_r$$

Results (Table 3) indicated that participants using the RGD prototype (N = 69, M = 2.54, SD = 2.27) reported significantly higher learning outcomes compared to participants using the non-RGD prototype (N = 69, M = 0.87, SD = 1.31), with a significant difference observed (t (69) = 5.2943, p < .01). Since the means are not equal the p-value is less than the alpha level (i.e., 0.01 < 0.05), the null hypothesis (Ho) is rejected.

Table 3: The paired T-test results comparing the learning rates of the non-RGD prototype (N=69) and the RGD prototype (N=69) with Alpha (α) 0.05.

Parameters	Values
Mean	non-RGD = 0.87; RGD = 2.54.
Standard Deviation	non-RGD = 1.31; RGD = 2.27.
Standard error of difference $SE(\bar{d})$	0.315
T value	5.2943
Degrees of Freedom (d.o.f)	136
Critical value	1.658
Confidence interval of this difference	95%

The boxplot (refer to Figure 3) visually represents the median and range of accuracy scores for each prototype group. The median accuracy score for the RGD prototype appears higher than that of the non-RGD prototype, indicating that, on average, participants in the RGD group achieved higher levels of accuracy in learning compared to those in the non-RGD group. This suggests that the RGD prototype had a greater impact on the learning rate of participants than the non-RGD prototype. This suggests that the RGD prototype was more effective in facilitating learning compared to the non-RGD prototype. The result shows that within the experimental group, participants who engaged with the RGD game displayed significantly higher scores compared to those in the control group who engaged with a non-RGD game. Consequently, it can be inferred that the implementation of RGD principles positively impacted participants' learning outcomes.

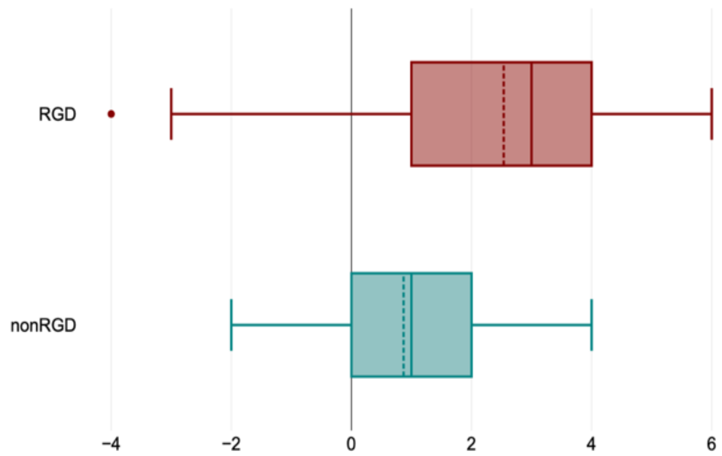


Figure 3: visual representation of comparative analysis of control group and the experimental group.

2.5.2 Qualitative Data

The qualitative data was collected from the open-ended questions in the survey questionnaire administered to the experimental group (N = 69) following their interaction with the RGD game. The data collected was analysed by categorising responses into themes or topics related to different elements of the program. Each theme corresponds to a specific aspect of the intervention, such as game activities, assessments, reflection points and game narrative. Participants Specific responses include:

Table 4: Open-ended responses (N=69).

Topics	Responses
• Game activities	• Participants appreciated various aspects of breathing exercises, such as techniques and simple activities like inhaling and exhaling. • The benefits include stress reduction, relaxation, and a calming effect on both the body and mind. • Specific responses include: • "*The breathing exercise made me feel less stressed".* • *"I like the breathing exercise; it was really joyful and a relaxing activity".* • *"Breathing exercises help me relax and reduce my stress".* • *"The breathing exercise really helped me relax".* • *"I expected hard puzzles, I would have liked them more of they were harder".*
• Diary	• The use of a diary or journal was highlighted as a preferred activity for emotional expression and self-reflection. • Participants find value in describing their emotions, indicating that the process aids in self-awareness. One response was: • *"I like journaling the most because it helps in describing my emotions"*
• Game narrative	• While some participants found joy and relaxation in the game, others expressed some improvements can be made in games to make it more engaging. Suggestions for improvement include incorporating more captivating elements, such as escaping horror rooms and introducing self-aware journeys within the game. • Specific responses include: • *"I like the game idea".* • *"The puzzle one and inhale exhale".* • *"The character because make the game looked unique, and also breathing exercise because it make me cool down and make other cool down when you are in a bad mood".* • *"OK, so firstly I liked the way the proper info of society is depicted in the initial story, but unfortunately, the game was not that much captivating".*

The analysis involves understanding participant responses in relation to specific elements of the program. It provides insights into what aspects of the intervention were well-received, areas that participants found engaging, and suggestions for improvement. The emphasis on a holistic experience, combining engaging game elements with relaxation activities like breathing exercises, is notable in the participants' feedback.

3. Discussion

The comprehensive approach to assessing the impact of learning involved the implementation of digital RGD and non-RGD prototype interventions via the website platform. This intervention was preceded by administering pre-tests and post-tests comprising six sets of questions aligned with the learning objectives. The subsequent detailed comparative statistical analysis yielded significant and insightful results, which are elaborated upon below:

Game-based learning generally demonstrates a positive effect on the rate of learning. This indicates that engaging with educational content through game mechanics enhances the learning process, making it more effective and enjoyable for participants. Game elements such as challenges, rewards, and interactivity contribute to increased engagement and knowledge retention.

Reflective game design prototypes yield higher mean scores compared to traditional game design prototypes. This suggests that incorporating reflective elements into game-based learning experiences enhances their effectiveness in facilitating learning outcomes. Reflective game design encourages players to actively reflect on their experiences within the game, leading to a deeper understanding and retention of the educational content.

Quantitative responses yielded valuable insights and suggestions for improvement that will be used in the reflective game design recommendations.

Quantitative and qualitative data revealed a positive reception of the RGD approach and offered suggestions for improvement, affirming the efficacy of the reflective design in GBL experiences. These findings serve as a foundation for further refinement and development of reflective game design, aiming to optimise their efficacy in facilitating educational objectives. Therefore, it can be seen that the integration of reflective elements significantly enhanced the learning experience and outcomes.

4. Conclusion and Future Work

In conclusion, the comprehensive study examining the impact of reflective game design on learning outcomes reveals several key insights. Initially, marginal differences were observed between the control and experimental groups in pre-test results, indicating similar knowledge levels among participants. However, post-intervention, both groups showed significant improvements in mean scores, with the experimental group outperforming the control group in the post-test. A detailed statistical analysis further confirmed the substantial difference between the two groups, providing robust evidence for the effectiveness of the RGD prototype in enhancing learning outcomes.

In the future, these findings will serve as the groundwork for establishing recommendations for Reflective Game Design, offering valuable insights for researchers, educators, and game designers striving to develop impactful educational games.

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