Analysis of MDE Based Gamification Framework for Cognitive Evaluation

Mahbubul Islam[1], Swapnil Biswas[2], Md. Shakil Ahmed[1], Md. Jobayer Rahman[1], Ahmed Rafi Hasan[1], Al Amin[3], Md Saddam Hossain Mukta[4]

[1]Department of CSE, United International University (UIU), Dhaka 1212, Bangladesh
Email: {mislam201011@ms, mahmed192077@bs, mrahman192070@bs,ahasan191131@bs}cse.uiu.ac.bd
[2]Department of Electrical and Computer Engineering, Southern Illinois University Edwardsville, IL 62026, USA
Email: sbiswas@siue.edu
[3]Department of Information Systems, University of Maryland, Baltimore, 21250, Maryland, USA
Email: lisanalamin@gmail.com
[4]Department of Software Engineering, LUT University, 53850 Lappeenranta, Finland
Email: saddam.mukta@lut.fi

Abstract—Gamification is a promising approach, with expanding applications in academia and industry. Gamification techniques can increase psychological and behavioral engagement with a particular domain with the help of game elements. This study examines gamification within the MDE framework, focusing on its dynamics, mechanics, and emotional components, with a particular emphasis on its relation to cognitive evaluation. We conduct a comparative analysis of the MDE framework to align game elements with user segments that respond best to them. Additionally, we explore the cognitive outcomes of the MDE-based gamification framework, highlighting its relevance and impact. Here we compare the results of past research on various gamified platforms, tasks, and strategies, which analyzed their effects on user behavior and cognitive reactions, we identify the published correlations between game elements and cognitive outcomes. We synthesize these results into a model demonstrating which game elements can enhance user experience and performance, and outlining future research directions.

Index Terms—Gamification, Human behavior analysis, Cognitive assessment, MDE framework, Game elements

I. Introduction

In recent years, socio-cognitive evaluation has increasingly integrated with gamification, which involves using components of traditional games in non-gaming environments to increase motivation and engagement. As social media platforms have grown popular, they offer researchers insights into individuals' behavior through their online activity. This intersection of gamification and social media has significant implications for various fields, including recruitment, marketing, personalized recommendations, and credit scoring. Through the application of gamification and social media, researchers can enhance their comprehension of human behavior and formulate unique approaches to augment user engagement, elevate consumer experiences, and accelerate business results.

Gamification, first used in 2008 and popularized in 2010, enhances services by integrating game components like points, badges, and leaderboards to create engaging, game-like experiences [1]. It uses game design principles to increase engagement and enjoyment [2]. Standard game design techniques

integrate these features effectively [3]. Gamification elements divided into three categories by Robson et al. [4] and proposed a new gamification technique called MDE (mechanics, dynamics, and emotion). Figure 1 depicts key elements of the gamified MDE Framework. Standard game design techniques incorporate these features into the game [4]. Game design elements serve as the foundation of a gamification system. Standard design elements include points, badges, trophies, leaderboards, challenges, fellowship storylines, and avatars [5].
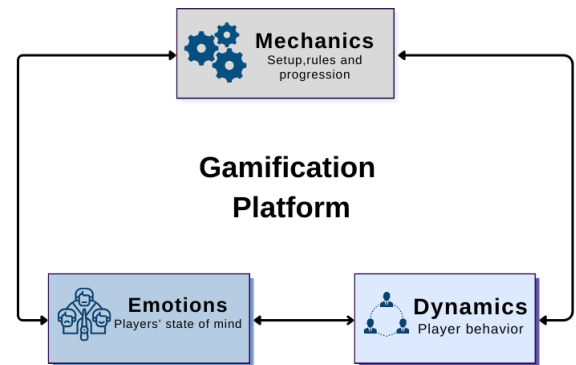

Fig. 1. MDE based Gamification Framework

As the gamification based application continues to grow in industry as well as academia, it becomes increasingly important to understand the various approaches used in game design and their effects on psychological outcomes. The main objective of this study is to present a comprehensive exploration of gamification elements (mechanics, dynamics, and emotions), reviewing the latest research and developments in this field. We focus on various game-based techniques and tools that have been developed to measure individual cognitive traits and investigate how game design elements can be integrated to enhance user cognitive output (psychological and behavioral). Through a comparative analysis of existing methods, we aim to establish correlations between game-based elements and cognitive traits, providing valuable insights into

their relationship. The major contribution of this paper is as follows:

- Conducting a comparative analysis of the MDE framework enhances gamification by aligning game elements (mechanics, dynamics, and emotions) with the user segments that respond best to them.
- Delving into the cognitive outcomes of the MDE-based gamification framework underscores the relevance and impact of our research.
- Conducting a rigorous correlation analysis, we examined the intricate relationship between game elements and cognitive outcomes.

The rest of this paper is organized as follows: Section II presents related works. Section III describes the approach of the gamification design framework. Section IV covers various types of cognitive evaluations. Section V discusses our in-depth analysis. We finally come to a conclusion in Section VI.

II. RELATED WORK

In this section, we conduct a summary of gameful experience and cognitive evaluation based study. Several studies have contributed to the understanding and application of gamification in cognitive domains. The way you are in real life is related to how you play games, and different cognitive features have distinct motives and objectives in a game environment [6]. According to research, interacting with 'Fallout 3' is a video game that can provide knowledge similar to taking a personality test [7]. Also, research showed how players behaved in "Neverwinter Nights" a game like environment, and discovered a correlation between every player's psychological profile and their behavior while playing the game [8, 9]. In his literature evaluation, Boot et al. [10] examined how video games can be used to study cognitive processes. Comparatively, other research by Gray et al. [11] proposed that research on game data might provide insight into ideas of human performance and how players advance from beginner to expert. He proves the value of applying game data to improve social, behavioral, or cognitive theories. Additionally, Khaleghi et al. [12] present a framework for gamifying cognitive tasks, developed through a design science research approach and expert evaluation. The study proposed a seven-phase gamification framework and highlighted the need for tailored game element selection to optimize cognitive task engagement. Finally, the "Lean Gamification Canvas" merges business and gamification design for smoother development, deeper user engagement, and successful commercialization [13].

Unlike previous works, this paper proposes a comparative analysis of game design-based frameworks, game elements (game mechanics, dynamics, emotion) psychological outcomes, and possible application domains. Also based on a synthesis of previous work, we depict a correlation between game design with game elements and cognitive features. We also present a common challenge for future research scope to improve the domain.

III. GAMIFICATION DESIGN FRAMEWORK

In gamification, many parameters are employed to create game-like surroundings, such as the baseline technique and game element (mechanics, dynamics and emotion) illustrates in Figure 2 based on MDE principle [4]. Using the platform and features, users can obtain psychological outcomes such as motivation, interest, attractiveness, and improved performance. We have discussed the baseline approach, and game element (mechanics, dynamics, and emotion) from various studies. Table I summaries a comprehensive comparative analysis of game design, game elements, cognitive outcome, and use cases.

A. Game Mechanics

Platforms, task, and progression that are employed in non-gaming contexts to provide emotion and engagement to a game like environment are known as game mechanics [20]. Game platform, Game task, progression and some other significant components are major building blocks for game mechanics.
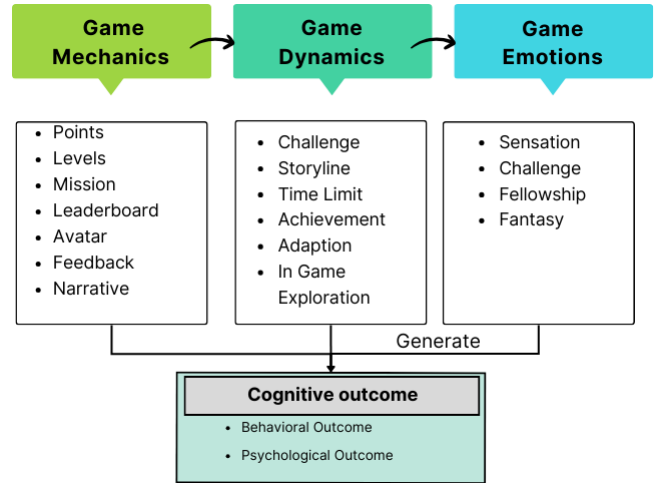

Fig. 2. Detailed gamification design framework and cognitive outcome

1) Game platform: There are various game platforms used for different criteria. Designers can select the platform upon environment, goal, and user pattern. Problem-solving games (PSG) are designed to engage players in critical thinking, logical reasoning, and decision-making, which is most popular in the research domain. A problem-solving games platform with avatars, animation, challenges, timers, and a scoring system to explore the impact of these elements on enjoyment, attention, and attractiveness [14, 18]. Another favoured platform is Role-playing game (RPG) which involves players assuming fictional characters and embarking on adventures within a structured game world. Pietter Haizela et al. [15] developed a simple RPG platform with avatars, animation, challenges, timers, and a scoring system to foster engagement and interest among users. Another form of game platform is text-based game (TBG) which relies on text-based narratives and user input to create an interactive storytelling experience. Numerous research [16, 17] developed a text-based (TB) adventure game

TABLE I
COMPARATIVE ANALYSIS OF MDE FRAMEWORK AND COGNITIVE EVALUATION

Ref	Platform	Mechanics	Dynamics	Emotion	Cognitive Evaluation
[14]	PSG	Avatar, animation, points	Time limit, exploration, achievement	Challenge, fantasy, sensation	Enjoyment
[15]	RPG	Avatar, animation, points	Time limit, exploration, achievement	Challenge, fantasy, sensation	Engagement, enjoyment
[16]	TBG	Narrative, points, levels	Storyline, exploration, achievement	Challenge, fantasy, sensation, fellowship	Enjoyment, motivation
[17]	TBG	Narrative, points, levels, avatar	Storyline, exploration, achievement	Challenge, fantasy, sensation	Engagement, motivation, enjoyment
[18]	PSG	Avatar, animation	Time limit, exploration, achievement	Challenge, fantasy, sensation	Engagement, enjoyment
[19]	GBA	Leaderboard, narrative , levels	Time limit, exploration, achievement,	Challenge, fantasy, sensation, fellowship	Engagement, motivation, enjoyment

Note: Problem-solving games (PSG), Role-playing game (RPG), Text-based game (TBG), Game based assessment(GBA)

platform incorporating narrative, graphics, points, and levels, focusing on enjoyment, motivation, and preference.

2) Game Task: Apart from the basic platform discussed above, there are also some game tasks that involve the user to the play. Various missions depict quests, optional assignments, selection, collection objects, and decision-making [21]. Sometimes minigames are added to change the monotonous environment. Minigames refer to a collection of diverse mini-games within a single gaming platform. Leandro Navarro [22] investigated multiple mini-games incorporating challenges, context, storytelling, and rewards-based quizzes, and puzzles.

3) Progression: In a game, the gathering of points, levels, and a leaderboard will create a rivalry amongst players to determine who is the most prominent in a particular environment. Developers may develop dynamics by combining and matching those mechanics [23]. A scoring scheme is used to measure achievement or performance. These points are able to be utilized as advantages, as an expenditure to advance the goals, or to indicate one's current position [24, 25]. The awareness of progression in the game is given to players via the usage of the levels system in a variety of game styles. Initial levels typically require less effort and take less time to achieve, whereas advanced levels require greater effort and abilities [26]. The objective of leaderboards is to encourage users to keep using them and to move their names up in regard of their efforts. Leaderboards are often utilized to encourage rivalry among participants. The top scorers' overall scores and current standings are shown on a leaderboard. In order to prevent demotivation, lower ranks are not shown on the leaderboard. Leaderboards are the most effective in motivating students [27]. Avatar, feedback, and narrative also exist as additional components for game mechanics. For generating dynamics, designers can combine and match those mechanics. Avatar is the virtual representation of the player [28]. An avatar depicts a user or player within a gaming environment. Feedback that is prompt, intense, and consistently improves learner engagement [29, 30]. Therefore, the more often and shortly feedback is given, the higher the learner engagement and

productivity. Thus, feedback plays a vital part in determining engagement and performance. Narrative is also an important feature for game elements, it can increase the attention of the player from the beginning and can keep excitement from progression from one level to another [27].

B. Game Dynamics

The fundamental ideas of game design that produce and facilitate aesthetic experiences are known as game dynamics. These are the main components that propel the gamer forward [31]. According to previous research, rewards are the most popular type of dynamic in gamification [29, 32]. Rewarding users for their achievements boosts motivation, encouraging them to repeat and improve their performance. Other popular dynamics include challenges, storylines, and adaptation [29]. Users can choose tasks of varying difficulty and receive rewards accordingly. Any action that requires the user to exert effort to achieve and deal with a range of scenarios or figure things out [33] is called challenge. Challenges can be used to generate interest in overcoming them and moving on to the next level [34]. The term "storyline" refers to the game's plot, which helps maintain motivation throughout the gamification process by creating an optimal interest curve, with peaks at the beginning and end of the learning process. A compelling plot provides context for learning and problem-solving, demonstrating real-life applications of concepts [27].

A time limit imposes a specific constraint, requiring users to complete an activity within a set period [34, 35]. Achievements reward users with the best scores through badges, achievements, or redeemable rewards to boost motivation. Players explore the virtual world of the game by traveling around it. Adaptation systems modify gameplay either directly or indirectly by taking into account user data and actions.

C. Game Emotion

Since gamification is an interactive learning approach that is more engaging than traditional methods, all gamification frameworks incorporate aesthetics, also known as emotion [36]. User can experience emotions like challenges, sensations, and fantasy through game platform. Challenges and

progression in gamified environments motivate users to persist and think critically, keeping them engaged [36]. Overcoming obstacles provides a sense of accomplishment. Gamification models offer Sensation by being more interactive than passive learning methods. Challenges motivate users to keep trying and learning, providing satisfaction upon completion. For example, Lyttel Inventors 35 [37] involves missions, minigames, and RPG mechanics, challenging players and offering a sense of accomplishment. Fellowship emerges when players communicate within the gamified environment. Fantasy involves role-playing within the game world, where user progress depends upon engaging their imagination and problem-solving skills [38].

IV. COGNITIVE EVALUATION

Game features (mechanics, dynamics, and emotions) increased motivational affordances in gamified systems result in psychological (e.g., motivation, enjoyment) and behavioral (e.g., engagement, performance) outcomes [39]. Research indicates that gamified systems can lead to positive psychological consequences [40], including improved user experience [41] and motivation [42]. Beneficial behavioral outcomes include increased participation and engagement. Figure 3 depicts the relation between the gamification framework and motivational affordances.

A. Psychological outcome

1) Motivation: Performance assessment features such as points, levels, and badges are feedback methods that have been found to generate extrinsic motivation. It is thought that framing questions as part of a narrative increases attention and motivation, reducing thoughtless responses. Game features can improve intrinsic and extrinsic motivation by addressing one of these essential psychological demands of competence, autonomy, and relatedness [43]. Utomo and Santoso's [35] study was carried out in an online learning environment which has some game elements to examine the impact on students' motivation and behavior towards learning. Based on the student responses, the authors found that personalized real-time feedback increased learners' motivation "toward active learning behavior".

2) Enjoyment: A key feature of GBP (Game based platform) that enables some possible benefits, such as the game element of the story, is expected to promote intrinsic interest, engagement, and enjoyment while facilitating stealth evaluation. Furthermore, this study is the first to evaluate participants' reactions to GBP, demonstrating that GBP outperforms typical personality inventories in perceived enjoyment, easiness, and effort [15]. The study found that people enjoy taking gamified surveys and pay closer attention to them. Additionally, the effect of gamification-related attention and enjoyment is moderated by particular personality factors, and gamification-related enjoyment improves the attractiveness [16].
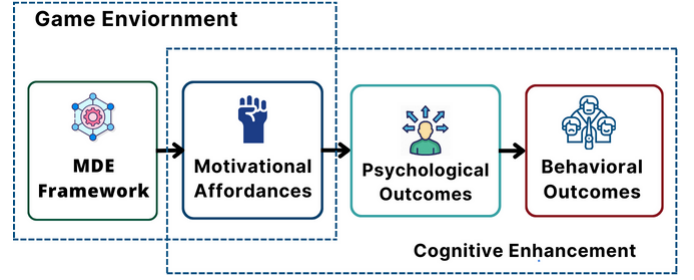

Fig. 3. Relation between the Gamification element with motivation affordance

B. Behavioral outcome

1) Engagement: Game progressions like badges, stories, and levels influenced learners' engagement on a peer assessment platform. Gamification encouraged players to utilize the platform more frequently, increasing engagement [44]. Image-based puzzle and challenge systems, which boost satisfaction and elicit more definitive answers than questionnaire-based evaluations, may increase engagement and, thus, applicant perception [6].
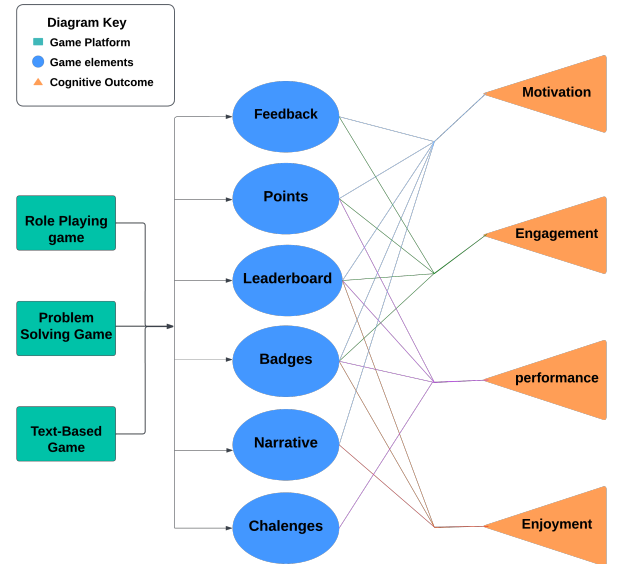

Fig. 4. Game elements and their correlated psychological outcome and game platform [45, 46, 47]

2) Performance: Several studies [48, 49] have evaluated the effects of gamification on user performance by incorporating various game features. Dominguez et al. [44] used challenges, leaderboards, trophies, and medals in an e-learning platform and discovered that the gamified group performed better than the control group in most activities and assignments. Similarly, Tsay et al. [43] implemented rapid feedback, badges, a scoreboard, and time constraints, discovering that the gamified group had higher scores and greater engagement than the control group.

V. DISCUSSION

In this research, we describe an MDE-based gamification framework and conduct a comparative analysis of the game

elements (mechanics, dynamics, and aesthetics). Additionally, we obtain a relation with cognitive outcomes (psychological and behavioral). Different game elements affect users differently, which is why cognitive state impacts heavily. We utilize some notable previous work to draw a significant correlation between these two factors shown in Figure 4. According to previous research [45, 46, 47], we mapped a correlation between the game baseline method, game elements (mechanics, dynamics, and aesthetics), and psychological outcome. Our analysis found some key points (1) underlying popular game platforms like RPG, PSG, and TBG including game elements like badges, levels, points, and leaderboards greatly influence cognitive outcomes like motivation, engagement, performance, and enjoyment, (2) while game elements points influence motivation, engagement, and performance through lack of enjoyment. Besides that, (3) the end feedback system and background narrative increase motivation, engagement, and enjoyment but lack improved performance in this type of game element to the user. While a (4) challenging environment in gamification only improves the performance of the user but absent motivation, engagement, and enjoyment. Figure4 summaries the correlation between the baseline method, game elements, and psychological outcome. Our work contributes to better modeling approaches for the designer when designing a personalized gamified system. The comparative analysis of game elements and cognitive outcomes from corresponding elements' describe in this paper increases the designer's proposition to develop a gamification platform. As well as the correlation between game elements and cognitive outcome helps to select appropriate game elements for conventional application.

VI. Conclusion

Gamification is important as it enhances engagement, provides a comprehensive understanding of traits, promotes self-awareness and personal development, and allows for personalized evaluations. Our study has explored various approaches and tools developed for measuring individual traits, highlighting the potential of gamification to boost user engagement and motivation during the assessment process. Through our comparative analysis, we have synthesized correlations between game design elements and personality traits, offering valuable insights into the effectiveness of gamified assessments. However, there is still ample room for future work in this field. Further research should focus on refining and validating the gamification techniques used for trait evaluation, exploring the long-term impact of gamified assessments on behavior and self-awareness, and investigating the potential of personalized gamification approaches.

References

[1] Z. H. Morford, B. N. Witts, K. J. Killingsworth, and M. P. Alavosius, "Gamification: The intersection between behavior analysis and game design technologies," *The Behavior Analyst*, vol. 37, pp. 25–40, 2014.

[2] J. Hamari, J. Koivisto, and H. Sarsa, "Does gamification work?–a literature review of empirical studies on gamification," in *2014 47th Hawaii international conference on system sciences*, pp. 3025–3034, Ieee, 2014.

[3] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining" gamification"," in *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*, pp. 9–15, 2011.

[4] K. Robson, K. Plangger, J. H. Kietzmann, I. McCarthy, and L. Pitt, "Is it all a game? understanding the principles of gamification," *Business horizons*, vol. 58, no. 4, pp. 411–420, 2015.

[5] M. Sailer, J. U. Hense, S. K. Mayr, and H. Mandl, "How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction," *Computers in human behavior*, vol. 69, pp. 371–380, 2017.

[6] B. Fatehi, *Gamifying psychological testing: Insights from Gamifying the TAT*. PhD thesis, Northeastern University Boston, 2017.

[7] A. Canossa, J. B. Badler, M. S. El-Nasr, S. Tignor, and R. C. Colvin, "In your face (t) impact of personality and context on gameplay behavior.," in *FDG*, 2015.

[8] Q. Li, Y. Song, Z. Hou, and B. Zhu, "Lect. notes comput. sci.(including subser. lect. notes artif. intell. lect. notes bioinformatics)," 2011.

[9] G. Van Lankveld, P. Spronck, J. Van den Herik, and A. Arntz, "Games as personality profiling tools," in *2011 IEEE Conference on Computational Intelligence and Games (CIG'11)*, pp. 197–202, IEEE, 2011.

[10] W. R. Boot, "Video games as tools to achieve insight into cognitive processes," 2015.

[11] W. D. Gray, "Game-xp: Action games as experimental paradigms for cognitive science," 2017.

[12] A. Khaleghi, Z. Aghaei, and M. A. Mahdavi, "A gamification framework for cognitive assessment and cognitive training: qualitative study," *JMIR serious games*, vol. 9, no. 2, p. e21900, 2021.

[13] B. H. Yousefi and H. Mirkhezri, "Lean gamification canvas: A new tool for innovative gamification design process," in *2020 International Serious Games Symposium (ISGS)*, pp. 1–9, IEEE, 2020.

[14] T. Triantoro, R. Gopal, R. Benbunan-Fich, and G. Lang, "Personality and games: enhancing online surveys through gamification," *Information Technology and Management*, vol. 21, pp. 169–178, 2020.

[15] P. Haizel, G. Vernanda, K. A. Wawolangi, and N. Hanafiah, "Personality assessment video game based on the five-factor model," *Procedia Computer Science*, vol. 179, pp. 566–573, 2021.

[16] J. L. Harman and K. D. Brown, "Illustrating a narrative: A test of game elements in game-like personality assessment," *International Journal of Selection and Assessment*, vol. 30, no. 1, pp. 157–166, 2022.

[17] J.-L. McCord, J. L. Harman, and J. Purl, "Game-like personality testing: An emerging mode of personality assessment," *Personality and Individual Differences*, vol. 143, pp. 95–102, 2019.

[18] G. Liapis, K. Zacharia, K. Rrasa, A. Liapi, and I. Vlahavas, "Modelling core personality traits behaviours in a gamified escape room environment," in *European Conference on Games Based Learning*, vol. 16, pp. 723–731, 2022.

[19] F. Y. Wu, E. Mulfinger, L. Alexander III, A. L. Sinclair, R. A. McCloy, and F. L. Oswald, "Individual differences at play: An investigation into measuring big five personality facets with game-based assessments," *International Journal of Selection and Assessment*, vol. 30, no. 1, pp. 62–81, 2022.

[20] L. A. Gil-Aciron, "The gamer psychology: a psychological perspective on game design and gamification," *Interactive Learning Environments*, vol. 32, no. 1, pp. 183–207, 2024.

[21] A. Bernik, D. Radošević, and G. Bubaš, "Introducing gamification into e-learning university courses," in *2017 40th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO)*, pp. 711–716, IEEE, 2017.

[22] H. L. Navarro, "Entia: design of a digital game for personality assessment through the five-factor model sub title author navarro, hundzinski leandro (okawa, keiko) , publisher ," 2017.

[23] T. Fulcini, R. Coppola, L. Ardito, and M. Torchiano, "A review on tools, mechanics, benefits, and challenges of gamified software testing," *ACM Computing Surveys*, vol. 55, no. 14s, pp. 1–37, 2023.

[24] B. Kumar and P. Khurana, "Gamification in education-learn computer programming with fun," *International Journal of Computers and Distributed Systems*, vol. 2, no. 1, pp. 46–53, 2012.

[25] M. Islam, *Contextual Gamification Platform based Big5 Personality Trait and Preference Selection for User Recommendation*. PhD thesis, UIU, 2024.

[26] G. Goehle, "Gamification and web-based homework," *Primus*, vol. 23, no. 3, pp. 234–246, 2013.

[27] F. F.-H. Nah, Q. Zeng, V. R. Telaprolu, A. P. Ayyappa, and B. Eschenbrenner, "Gamification of education: a review of literature," in *HCI in Business: First International Conference, HCIB 2014, Held as Part of HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014. Proceedings 1*, pp. 401–409, Springer, 2014.

[28] L. De-Marcos, E. Garcia-Lopez, and A. Garcia-Cabot, "On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking," *Computers & Education*, vol. 95, pp. 99–113, 2016.

[29] R. Raymer, "Gamification: Using game mechanics to enhance elearning," *ELearn*, vol. 2011, no. 9, 2011.

[30] K. Kapp, "Games, gamification, and the quest for learner engagement train," *Dev*, vol. 66, no. 6, p. 64, 2012.

[31] S. Watini and W. Setyowati, "Using gamification to increase e-learning engagement," *International Transactions on Education Technology*, vol. 1, no. 2, pp. 84–94, 2023.

[32] R. Brewer, L. Anthony, Q. Brown, G. Irwin, J. Nias, and B. Tate, "Using gamification to motivate children to complete empirical studies in lab environments," in *Proceedings of the 12th international conference on interaction design and children*, pp. 388–391, 2013.

[33] C. Butler, "A framework for evaluating the effectiveness of gamification techniques by personality type," in *HCI in Business: First International Conference, HCIB 2014, Held as Part of HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014. Proceedings 1*, pp. 381–389, Springer, 2014.

[34] A. C. T. Klock, I. Gasparini, M. S. Pimenta, and J. Hamari, "Tailored gamification: A review of literature," *International Journal of Human-Computer Studies*, vol. 144, p. 102495, 2020.

[35] A. Y. Utomo and H. B. Santoso, "Development of gamification-enriched pedagogical agent for e-learning system based on community of inquiry," in *Proceedings of the International HCI and UX Conference in Indonesia*, pp. 1–9, 2015.

[36] A. Tanouri, A.-M. Kennedy, and E. Veer, "A conceptual framework for transformative gamification services," *Journal of Services Marketing*, vol. 36, no. 2, pp. 185–200, 2022.

[37] T. Mailula, "Applying gamification in education to drive participation and engagement: A case study on grade 5 science learners at lyttelton primary school.," *Johannesburg: University of Johannesburg*, 2016.

[38] G. P. Kusuma, E. K. Wigati, Y. Utomo, and L. K. P. Suryapranata, "Analysis of gamification models in education using mda framework," *Procedia Computer Science*, vol. 135, pp. 385–392, 2018.

[39] E. S. Rivera and C. L. P. Garden, "Gamification for student engagement: a framework," *Journal of further and higher education*, vol. 45, no. 7, pp. 999–1012, 2021.

[40] P. Bitrián, I. Buil, and S. Catalán, "Enhancing user engagement: The role of gamification in mobile apps," *Journal of Business Research*, vol. 132, pp. 170–185, 2021.

[41] M. Li, P. Y. Chau, and L. Ge, "Meaningful gamification for psychological empowerment: exploring user affective experience mirroring in a psychological self-help system," *Internet Research*, vol. 31, no. 1, pp. 11–58, 2021.

[42] J. Kim and D. M. Castelli, "Effects of gamification on behavioral change in education: A meta-analysis," *International Journal of Environmental Research and Public Health*, vol. 18, no. 7, p. 3550, 2021.

[43] M. B. Armstrong and R. N. Landers, "An evaluation of gamified training: Using narrative to improve reactions and learning," *Simulation & Gaming*, vol. 48, no. 4,

pp. 513–538, 2017.

[44] A. Domínguez, J. Saenz-de Navarrete, L. De-Marcos, L. Fernández-Sanz, C. Pagés, and J.-J. Martínez-Herráiz, "Gamifying learning experiences: Practical implications and outcomes," *Computers & education*, vol. 63, pp. 380–392, 2013.

[45] I. Caponetto, J. Earp, and M. Ott, "Gamification and education: A literature review," in *European Conference on Games Based Learning*, vol. 1, p. 50, Academic Conferences International Limited, 2014.

[46] W. Bleidorn and C. J. Hopwood, "Using machine learning to advance personality assessment and theory," *Personality and Social Psychology Review*, vol. 23, no. 2, pp. 190–203, 2019.

[47] A. G. Wright, K. M. Gates, C. Arizmendi, S. T. Lane, W. C. Woods, and E. A. Edershile, "Focusing personality assessment on the person: Modeling general, shared, and person specific processes in personality and psychopathology.," *Psychological assessment*, vol. 31, no. 4, p. 502, 2019.

[48] R. N. Landers and A. K. Landers, "An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance," *Simulation & Gaming*, vol. 45, no. 6, pp. 769–785, 2014.

[49] C. H.-H. Tsay, A. Kofinas, and J. Luo, "Enhancing student learning experience with technology-mediated gamification: An empirical study," *Computers & Education*, vol. 121, pp. 1–17, 2018.