SERIOUS GAME APPLICATIONS REPORT – HARI TANMAI GANDI, G01300M

INTRODUCTION:

Debriefing in healthcare, is a practice which aims to reduce negative clinical outcomes by learning through reflection and analysis of performance. Debriefing has been proven to improve clinical outcomes by learning through reflection of events of a performed clinical practice (Evans, et al., 2023). Research suggests that there is a lack of accessibility to research material, transparency, and standardization of practices which may aid and positively impact the wellbeing of healthcare workers' debriefs (Evans, et al., 2023). Existing research studies encourage the development of empirical works which offer alternative approaches for medical teaching process (Xu et al., 2023) and greater likelihood of informing best practices or guidelines for clinical practices (Richins, 2020). They also conclude that 'Basic Life Support' (BLS) knowledge is noticeably insufficient among the population despite being essential, even to non-medical people, in order for them to take action in emergency events (Shaheen et al., 2023). Furthermore, the epidemic of COVID-19 has reshaped public awareness and posed challenges for education. In this context, it is necessary to develop innovative approaches such serious games for medical teaching, in order to popularize and explore their potential (Xu et al., 2023).

A study sampling Swiss citizen, discovered that both medical and non-medical groups of people, did not know more than a third of the "minimum medical knowledge (MMK)" (Bachman, 2007). MMK defines the knowledge about typical signs or symptoms and risk factors of fatal clinical conditions. Further analysis revealed that people regardless of their university degrees or clinical experiences only had slightly higher MMK knowledge than those without, suggesting a dramatic lack of knowledge in public regarding these risk factors (Bachman, 2007). Another study concludes that public awareness of first aid needs to be increased along with appropriate guidelines as they are currently insufficient (Dolenc et al., 2022). Although these two studies evaluated knowledge in terms of fatal conditions and first aid, it is safe to assume that there isn't enough exposure to less fatal conditions or other medical aspects based on these findings. Which is why it is important to create means to create awareness about various aspects of medicine.

The target audience includes the healthcare workers who require methods to debrief, and the general population since multiple surveys (Shaheen et al., 2023) suggest there is lack of basic medical knowledge among large sections of the population (Albadi et al., 2020).
Statistics have also seen an increase in bystander CPR rates, following a hands-only CPR campaign. This led to increase in survival rates for out-of-hospital cardiac arrests (OHCA) from 3.7% to 9.8% (Shaheen et al., 2023). Bystanders are found to have difficulty performing CPR due to inadequate knowledge, training, lack of skill, or confidence (Mori et al., 2013). So, the minimum of hands-only CPR knowledge should be adequate for individuals to deliver lifesaving measures as studies stated that students were less hesitant to perform CPR to a stranger if needed (Albadi et al., 2020).

So, this project acts as an interactive pedagogical framework that constitutes a balance between learning activity and gamification, to create basic awareness on certain aspects of medicine, including CPR, as well as assisting the well-being of healthcare workers when used. This is done by simulating a gamified version of few basic clinical practices that are worth creating awareness about, such as administering appropriate medicine to patients with different diseases, transfusion of blood, and replicating the action of CPR, which may also serve as a debriefing tool. These mechanics are designed with elements of game design and learning theories in mind, to create player engagement, satisfaction, and improve information retention through the gameplay. The next sections will discuss what methodologies were used, to what extent, and where.

RESEARCH & IMPLEMENTATION:

Self-Determination Theory (SDT) & Flow Theory:
SDT which originates from research on intrinsic and extrinsic motivations (Ryan and Deci, 2000) is one of the most frequently applied frameworks in serious game design followed by Flow Theory (Yang, Li, 2025). SDT proposes that human intrinsic motivation can be satisfied by fulfilling three basic psychological needs – Autonomy, Competence, and Relatedness. Autonomy refers to the initiative in action that is supported by personal interest while not being influenced by external factors such as rewards or punishments (Deterding, 2016). In this project, autonomy is hinted through the largely self-directed decision making within the available tasks. The player mostly retains control over the order of actions, which may seem like an autonomous choice.
Flow Theory discusses various factors responsible for inducing the flow state. The most important aspect is the balance between skill and challenge. The project's gameloop is what's most responsible for attempting to induce flow. Gameplay elements such as multiple concurrent patients of different types, a limited timed CPR patient who needs immediate attention, medicine dosages, shelf order randomization, and possibility of

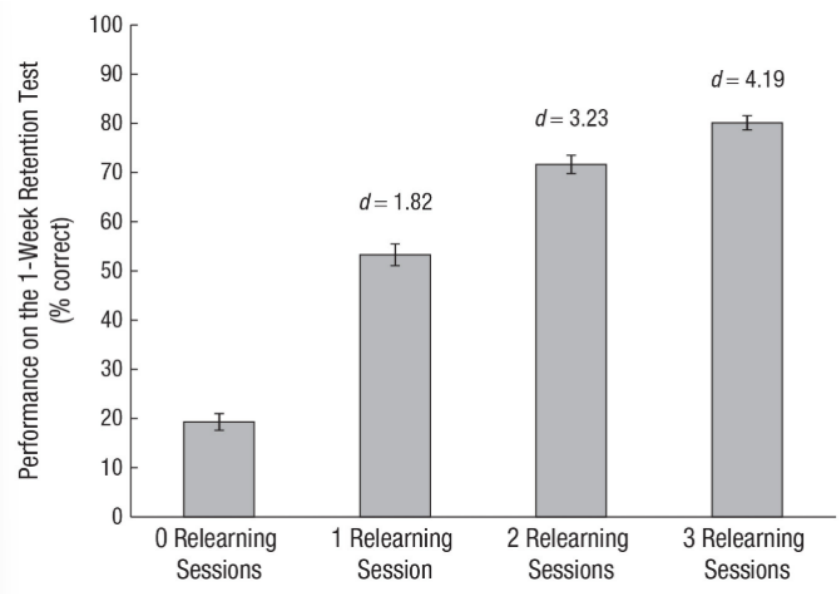
patient death upon incorrect blood transfusion are implemented in attempts to introduce a sense of difficulty.

Constructivism:
The constructivist theory refers to the method of learning which allows learners to "construct" their knowledge and skills through various possible interactions. This enables learners to develop their own understanding through experience, reflection, and repetition rather than simply memorizing facts from external source (ELM Learning, 2024). Constructivist environments are proven to help improve the attractiveness of learning environment while encouraging participant reflection (Farhad, Hoda, 2023). This project includes the element of constructivism by following a few principles of constructivism (ELM Learning, 2024):
- Learning is an active process where users are allowed to experiment with the given mechanics.
- Knowledge is applicable to real-world contexts, stressing that the education is meant to assist the learner.
- Allowing enough time for the player to reflect which enables them to assess their current level of knowledge.
- Allowing users to make mistakes, which is an important aspect of learning in a error safe environment.

Retrieval practice & Memory Palace:
This is a simple approach that has important implications for its application to educational practices, where focusing on getting information out is stressed (Roediger et al., 2011). Through this act of calling information to mind which often produces large gains in long-term memory for that information (Agrawal et al., 2020). Retrieval practice is often effective even without feedback and can be integrated naturally if there is knowledge to be acquired (Roediger et al., 2011). However, feedback and other additional cues such as spatial positioning, awareness, or situational experience may aid this process as they create additional associations to the learning event, further enhancing memory retrieval of that information. These aspects slightly align with the *Method of Loci* (memory palace) which is widely known as a practice where information is deliberately encoded to specific locations for easier retrieval. (Krokos et al., 2018). These two aspects can be seen integrated into the shelf system. Each shelf holds one type of medicine and the order of shelves is randomized every session. This requires the player to actively remember the name of the shelves along with their positions.

Successive Relearning:
Successive relearning is defined by practicing a task until it is performed correctly and repeating this process after spaced intervals (Rawson et al., 2022). This suggests the

structure of learning to be conducted through multiple sessions, in which time on task is tailored for learners and allows them to meaningfully learn, rather than doing it through a single session. The impact of successive relearning has been proven through boosts in learner's retention that occurred after each relearning session, which grew proportionally with the relearning session count. In this project, the player is repeatedly presented with three types of patients whose conditions are randomized and require accurate administration by the player.



Performance of learners based on the relearning session counts.

However, research evidence indicates that successive relearning did not yield benefit when performed multiple times without spacing (Rawson et al., 2022). Only a fourth of the learners retained the knowledge of what they correctly recalled multiple times in a single session whereas most of the learners remembered the knowledge that they correctly recalled over three sessions (Rawson et al., 2018). This suggests that learning through a single session is not efficient despite its immediate results in terms of retention and that *Successive Relearning* combined ensures better retention only when combined with spaced practice (Vaughn et al., 2016).

- This aspect can be easily seen in this project where one of the patient types in this project who requires to be administer an appropriate medicine.

Spaced repetition:

Spaced repetition is a practice which is an important aspect of *Successive* Relearning theory (Rawson et al., 2022), is defined by providing sufficient processing time to the learner along with the opportunities to review, before they are presented with new unknown tasks. It has shown to be effective enough to be used for STEM education with foreign language and vocabulary acquisitions (Yeh et al., 2016). Various research studies have also observed that knowledge and skills decrease over time (Srivilaithon,

2020), and that spacing between learning sessions has a positive impact on learning and memorizing new materials. Medical field contains many foreign vocabularies and guidelines for which spaced repetition may serve as an effective learning strategy (Yeh et al., 2016).

VAK Learning Styles:

VAK refers to a multi-sensory learning style that involves the elements of sight, sound, and movement (Engage Education, 2023). These three aspects serve as ways to absorb information. These aspects are incorporated throughout the gameplay experience of this project through particle effects, UI, sound cues, and interaction mechanics.

Gamification in Game Based Learning (GBL):

Game based learning is typically referred as “serious games” or “gamification”. The formal definition of serious games is an interactive computer application that has challenging goals and incorporates some scoring mechanism, therefore providing users with practical knowledge and skills (Xu et al., 2023). Gamification is a strategy that involves game mechanics to engage users to solve problems. This involves the integration of game design elements such as levels, progress bars, animations and points system for increasing user engagement. Research argues that the potential of gamification has been overlooked in information retrieval (Medlar, et al., 2021), despite being extensively studied and proven to improve learner’s engagement, motivation and performance by promoting gameful experiences (Yeh et al., 2016).

Principle	From
Move cards from “acquisition” to “maintenance” based on a fixed ratio in real time	Spacing
Resume from where the learner left from the previous training session	Spacing
Notify learners for reviewing “maintenance” cards	Spacing
Allow users to set when the “maintenance” card notificaiton appears	Spacing
Reward learners with achievement badges	Gamification
Provide points	Gamification
Present a leaderboard ranking based on learner activity	Gamification
Show training progress to enable self-awareness	Gamification
Start from easier cards then progess to more difficult cards	Gamification

List of principles derived from spacing and gamification theories.

Despite the discussed benefits of gamification, research indicates that some weaknesses remain. GBL by itself cannot yield significant results in short or long-term retention sometimes. It needs to be accompanied by other methodologies which may assist serious game learning. Through feedback, experimentation, attempts to improve immersion, and spaced repetition with active participation and autonomy (Xu et al., 2023). This project implements various feedback loops in attempts to engage the

audience along with a time pressure CPR patients that brings a separate CPR mini-rhythm-game upon interaction.

Kirkpatrick Model:
This is a widely recognized evaluation system that is categorized into four levels (Xu et al., 2023):
- How participants are reacting to the program.
- What they can learn from the program.
- How the program effects their behavior.
- Influence of program on the results.

Although this may be an evaluation model rather than a design methodology, it still can be used to derive a few pointers from the stated factors that determine better outcomes. For example, the reaction aspect of *Kirkpatrick* evaluation encourages the application of satisfactory elements to the game to get better results in evaluation. This aspect could also lead to better results in the behavioral aspect of *Kirkpatrick* model since satisfactory elements lead to elevated motivation levels which allows better learning.

ARCS + G Model:
ARCS + G is a motivational design model based on ARCS which utilizes gamification of learning to sustain learner motivation using systematic problem-solving approaches (Hamzah et al., 2014). The gamification elements are based on game mechanics such as reward, status, competition, achievement, self-expression, and altruism.

Model / Technique	Arcs Categories			
	Attention	**Relevance**	**Confidence**	**Satisfaction**
ARCS	-Perceptual Arousal -Inquiry Arousal -Variability	-Goal Orientation -Motive Matching -Familiarity	-Learning Requirements -Success Opportunities -Personal Responsibility	-Intrinsic Reinforcement -Extrinsic Rewards -Equity
Gamification	-	-	-Reward -Status -Competition	-Achievement -Self-expression -Altruism

However, due to the scope of this project, not all elements are included. This project derives few aspects from this model. Confidence, relevance and satisfaction in this project are promoted by many visual and auditory clues along with the point/money system that acts as a direct reference of player performance.

REFERENCES:

Ryan, R.M. and Deci, E.L. (2000). *Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being*. [online] ResearchGate. Available at: https://www.researchgate.net/publication/11946306_Self-Determination_Theory_and_the_Facilitation_of_Intrinsic_Motivation_Social_Development_and_Well-Being.

Bachmann, L.M., Gutzwiller, F.S., Puhan, M.A., Steurer, J., Steurer-Stey, C. and Gigerenzer, G. (2007). Do citizens have minimum medical knowledge? A survey. *BMC Medicine*, 5(1). doi:https://doi.org/10.1186/1741-7015-5-14.

Roediger, H.L. and Butler, A.C. (2011). The critical role of retrieval practice in long-term retention. *Trends in Cognitive Sciences*, 15(1), pp.20–27. doi:https://doi.org/10.1016/j.tics.2010.09.003.

Mori, S., Whitaker, I.Y. and Marin, H. de F. (2013). Avaliação do website educacional em Primeiros Socorros. *Revista da Escola de Enfermagem da USP*, 47(4), pp.950–957. doi:https://doi.org/10.1590/s0080-623420130000400025.

Landers, R.N., Bauer, K.N., Callan, R.C. and Armstrong, M.B. (2014). Psychological Theory and the Gamification of Learning. *Gamification in Education and Business*, pp.165–186. doi:https://doi.org/10.1007/978-3-319-10208-5_9.

Hamzah, W.M.A.F.W., Ali, N.H., Mohd Saman, Md.Y., Yusoff, M.H. and Yacob, A. (2014). Enhancement of the ARCS model for gamification of learning. *2014 3rd International Conference on User Science and Engineering (i-USEr)*. doi:https://doi.org/10.1109/iuser.2014.7002718.

Yeh, M., Toshtzar, A., Guertin, L. and Yan, Y. (2016). Using spaced repetition and gamification to enhance K-12 student science literacy with on-demand mobile short reads. *2016 IEEE Frontiers in Education Conference (FIE)*. [online] doi:https://doi.org/10.1109/FIE.2016.7757361.

Vaughn, K.E., Dunlosky, J. and Rawson, K.A. (2016). Effects of successive relearning on recall: Does relearning override the effects of initial learning criterion? *Memory & Cognition*, 44(6), pp.897–909. doi:https://doi.org/10.3758/s13421-016-0606-y.

Deterding, S. (2016). Contextual Autonomy Support in Video Game Play. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. doi:https://doi.org/10.1145/2858036.2858395.

Rawson, K.A., Vaughn, K.E., Walsh, M. and Dunlosky, J. (2018). Investigating and explaining the effects of successive relearning on long-term retention. *Journal of Experimental Psychology: Applied*, 24(1), pp.57–71. doi:https://doi.org/10.1037/xap0000146.

Krokos, E., Plaisant, C. and Varshney, A. (2018). Virtual memory palaces: immersion aids recall. *Virtual Reality*, [online] 23(1), pp.1–15. doi:https://doi.org/10.1007/s10055-018-0346-3.

Albadi, S., Al-Hadi, H. and Nadar, S.K. (2020). Knowledge and Attitudes toward Basic Life Support among Medical Students in Oman. *Indian Journal of Critical Care Medicine : Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine*, [online] 24(7), pp.599–600. doi:https://doi.org/10.5005/jp-journals-10071-23475.

Richins, M.T., Gauntlett, L., Tehrani, N., Hesketh, I., Weston, D., Carter, H. and Amlôt, R. (2020). Early Post-trauma Interventions in Organizations: a Scoping Review. *Frontiers in Psychology*, 11(1). doi:https://doi.org/10.3389/fpsyg.2020.01176.

Srivilaithon, W., Amnuaypatanapon, K., Limjindapron, C., Diskumpon, N., Dasanadeba, I. and Daorattanachai, K. (2020). Retention of Basic-Life-Support Knowledge and Skills in Second-Year Medical Students. *Open Access Emergency Medicine*, Volume 12, pp.211–217. doi:https://doi.org/10.2147/oaem.s241598.

Agarwal, P., Roediger, H., McDaniel, M. and Mcdermott, K. (2020). *How to use retrieval practice to improve learning: Retrieval guide*. [online] Available at: https://pdf.retrievalpractice.org/RetrievalPracticeGuide.pdf.

Medlar, A. and Głowacka, D. (2021). Game over? *ACM SIGIR Forum*, 55(2), pp.1–18. doi:https://doi.org/10.1145/3527546.3527551.

Dolenc Šparovec, E., Slabe, D., Eržen, I. and Kovačič, U. (2022). The importance of elderly people knowing basic first-aid measures. *BMC Emergency Medicine*, 22(1). doi:https://doi.org/10.1186/s12873-022-00675-9.

Rawson, K.A. and Dunlosky, J. (2022). Successive Relearning: An Underexplored but Potent Technique for Obtaining and Maintaining Knowledge. *Current Directions in Psychological Science*, 31(4), p.096372142211004. doi:https://doi.org/10.1177/09637214221100484.

Evans, T.R., Burns, C., Essex, R., Finnerty, G., Hatton, E., Clements, A.J., Breau, G.,

Quinn, F., Elliott, H., Smith, L.D., Matthews, B., Jennings, K., Crossman, J., Williams, G., Miller, D., Harold, B., Gurnett, P., Jagodzinski, L., Smith, J. and Milligan, W. (2023). A Systematic Scoping Review on the Evidence behind Debriefing Practices for the Wellbeing/emotional Outcomes of Healthcare Workers. *Frontiers in Psychiatry*, [online] 14(1). doi:https://doi.org/10.3389/fpsyt.2023.1078797.

Farhad Seraji and Hoda olsadat Musavi (2023). Does Applying the Principles of Constructivism Learning Add to the Popularity of Serious Games? A Systematic Mixed Studies Review. 47, pp.100585–100585. doi:https://doi.org/10.1016/j.entcom.2023.100585.

Engage Education (2023). *VAK learning styles: what are they and what do they mean? Engage Education* |. [online] Engage Education. Available at: https://engage-education.com/blog/vak-learning-styles-what-are-they-and-what-do-they-mean-engage-education/.

Shaheen, N., Shaheen, A., Rehab Adel Diab, Abdelrahman Mohmmed, Ramadan, A., Swed, S., Muhannad Wael, Kundu, M., Soliman, S., Mohamed Ashraf Elmasry and Sheikh Shoib (2023). Basic Life Support (BLS) Knowledge Among General Population; a Multinational Study in Nine Arab Countries. *PubMed*, 11(1), pp.e47–e47. doi:https://doi.org/10.22037/aaem.v11i1.1975.

Xu, M., Luo, Y., Zhang, Y., Xia, R., Qian, H. and Zou, X. (2023). Game-based learning in medical education. *Frontiers in Public Health*, 11(11). doi:https://doi.org/10.3389/fpubh.2023.1113682.

ELM Learning (2024). *Constructivist Learning Theory*. [online] ELM Learning. Available at: https://elmlearning.com/hub/learning-theories/constructivism/.

Dernat, S., Grillot, M., Andreotti, F. and Martel, G. (2025). A sustainable game changer? Systematic review of serious games used for agriculture and research agenda. *Agricultural Systems*, 222, p.104178. doi:https://doi.org/10.1016/j.agsy.2024.104178.

Yang, J. and Li, R. (2025). The art and science of serious game design: a quasi-experimental study based on self-determination theory in traditional Chinese culture education. *Frontiers in Psychology*, 16. doi:https://doi.org/10.3389/fpsyg.2025.1536513.