To what extent is AI game based and experiential learning by the company *EDUFIQ*, more effective in enhancing cognitive function than traditional rote memorisation methodologies?

By Yashraj Garg

Abstract

As education continues to transform after the pandemic and virtual platforms have replaced textbooks, advocacy towards online learning may spark curiosity regarding its benefits. Consequently, online Artificial Intelligence (AI) assisted game-based and experiential learning courses and programs are being developed by companies like *EDUFIQ*. Hence, the objective of the paper is to conduct a Literature Review to analyse and evaluate such courses through the lens of cognitive merits. Previous research demonstrates that game-based and experiential learning approaches to education help improve cognition function and development in students, particularly due to more improved life skills, and retained knowledge due to greater motivation to engage with course material. Such research has also resulted in criticism towards traditional educational methodologies, specifically how textbooks supporting 'rote memorisation' enable less cognitive processes and thus, reduce efficiency when learning content. Data also suggests that such programs help improve self-learning and make learning an independent process, rather than one dependent on the educator. Analogous to what has been assumed, such technology-based courses may prove to be more effective in educating students. The findings of this paper indicate that the improvement in cognitive function can be attributed to greater meta-cognitive, reflective, and problem solving requirements in game-based and experiential learning. Furthermore, application of Self-Determination Theory helps improve educational standards and informs institutions about the significance of transitioning to an educational model that prioritizes student motivation. Thus, demonstrating how the criteria ensuring success of such an education is unparalleled.

Keywords: Game Based Learning, Experiential Learning, Cognitive Function, Neurogenesis, Neuroplasticity, Self-determination theory, Visual stimuli, Information Retention, Memory, Perception

Introduction

With a growing demand for education across the world, come various challenges, which have become more convenient to address through the introduction of Artificial Intelligence (AI) based educational courses and programs. The utilisation of computer systems to simulate human intelligence not only has various applications in the educational industry, but has served as an indicator of greater cognitive function in children.

The company '*Edufiq*' has recently introduced a Virtual Game Based Learning Course, through which students can learn AI coding while playing the game called 'Minecraft.' Similarly, they have also developed a robust curriculum based on Experiential Learning, which utilises a 'Microbit', a device useful for enhancing coding and computer science skills through inputs, outputs, sensors, and radio communications. To further make this technology comprehensive, an 'Experiential Kit', consisting of a BBC Microbit, sensors of noise, temperature, and light, along with OLED screen, and 180 servo is now available to avail through their services. Therefore, the company's aim to make computer science and technology learning more elementary and intuitive for students, has been met with success due to the high-scale equipment used (Edufiq, 2022).

While there is a surge in such methodologies of teaching and learning, it ultimately leads to the question of why companies may choose to market newer ways of learning. Thus, delineating that older techniques of rote memorisation may prove to be insufficient in meeting the mounting educational needs of 21st century students. Various researchers have studied the liaison between AI led educational programs and cognitive function in students; however, it is still imperative to comprehend how certain features instilled in the human simulations may prove to be more effective. As a result of which, students may be met with higher achievement levels in life skills, a greater knowledge of course content, along with a greater enthusiasm for learning.

This paper aims to discuss and critically analyse literature to inform an understanding of the components involved in AI Game-based and Experiential Learning Programs, which set them apart from traditional text-book teaching. Through this, the objective is to examine the cognitive and behavioural benefits of such strategies, in an attempt to underscore the significance of prioritising psychological welfare for students. By utilising concepts of cognition such as memory, perception, thinking, and attention- AI and rote memorisation based teaching methodologies will be compared. The insights gained through the research process will help gather information necessary to make these AI learning platforms more accessible and prominent in the education sector; thereby, enhancing cognitive function of students.

Literature review

There has been considerable amount of literature analysing opportunities and limitations of the AI model of teaching. While results indicate that problem-solving along with self-examination are enhanced in game-based and experiential learning respectively, it is imperative to understand how such benefits are obtained. Moreover, traditional text-book based teaching has also been shown to be replaced, and the reasons behind it can be attributed to the rise in virtual learning platforms.

I. Cognitive benefits of AI game based learning

Game based learning has been described as the type of game play with specified learning outcomes. Various concepts such as motivation are important in the context of game based learning, as they relate to theoretical foundations with respect to cognitive, affective, motivational, and sociocultural factors (Plass et al., 2015). Play has various benefits, as it evolves with the different stages of cognitive development in children. As they mature through different developmental phases, the definition of play becomes more social, abstract, and symbolic. Therefore, allowing children to activate their *Schemas*, as a consequence of which they are able to hold multiple representations of the same object, which helps enhance perception and ability to symbolise (Piaget, 2013).

Incentive structures like badges, awards, honours, and other 'medals' in games have improved motivational factors which help create high situational interest in students during game based learning. Moreover, an end goal to achieve further helps give direction and context to the student's educational tasks; thereby, enhancing their engagement (Hidi & Renninger, 2006).

Neuroscience has long confirmed the benefits of visuals in engaging students through virtual learning platforms. Visuals do so, by helping expedite emotional reactions to information; thus, improving retention of information in students. Visual memory is encoded in the medial temporal lobe of the brain, which is where emotions are processed as well. To test this, Oei & Patterson (2013) conducted a study through which they found how the frequent practice and major demand to transition from temporally close stimuli through the course of the video game also helps reduce the attentional blinks by improving attention switching. Tracking multiple fast objects in parallel during game play, along with filtering out task-irrelevant stimuli help improve the skills of tracking multiple objects and cognitive control. Visual search and spatial working memory also have the potential to be enhanced due to game based learning, as attributed to the increased speed of response when exposed to visual stimuli. Thus, it can be analysed how the use of graphics, design, and interactive features in online games like *Minecraft* can help students engage more rigorously with subject matter of coding (Abdul, 2015).

Video games, which are solely built on the notion of repetition, failure, and accomplishing a certain goal also help students improve resilience and self-confidence. The technique of trial and error helps students acknowledge their own areas of improvement; thereby, enhancing their ability to perceive constructive criticism more positively. To meet individual and collective goals in the game, students possess the ability to collaborate with each other to comprehend the learning tools provided in the game learning platform. Similarly, by devising alternative strategies to meet a certain goal and adapting in times of adversity or 'loss'- students are able to critically evaluate certain circumstances and solutions, to follow the most suitable one. Thus, improving decision-making and critical thinking skills (Plass et al., 2015).

In order to confirm the conceived benefits of a game-based learning model, Prez et al. (2018) demonstrated how skills such as logical and naturalistic reasoning are inherently developed as by-products of this pedagogy. When students are more curious and seek further information on their video games, their enjoyment in the game activities linked to the subject increase drastically. Games like Minecraft further allow students to simulate and manipulate materials virtually, which is further linked to students' interests in terms of naturalistic exploration. The study also suggests how students tend to do better academically in questions where logic and mathematics are required, after being exposed to game-based learning. Mathematical missions in videogames and strategy based approaches may be attributed to this, as they enhance the ability to investigate patterns. This again coincides with psychological research, as a topic of interest is more likely to be stored in working memory for longer periods of time (Silvia, 2008).

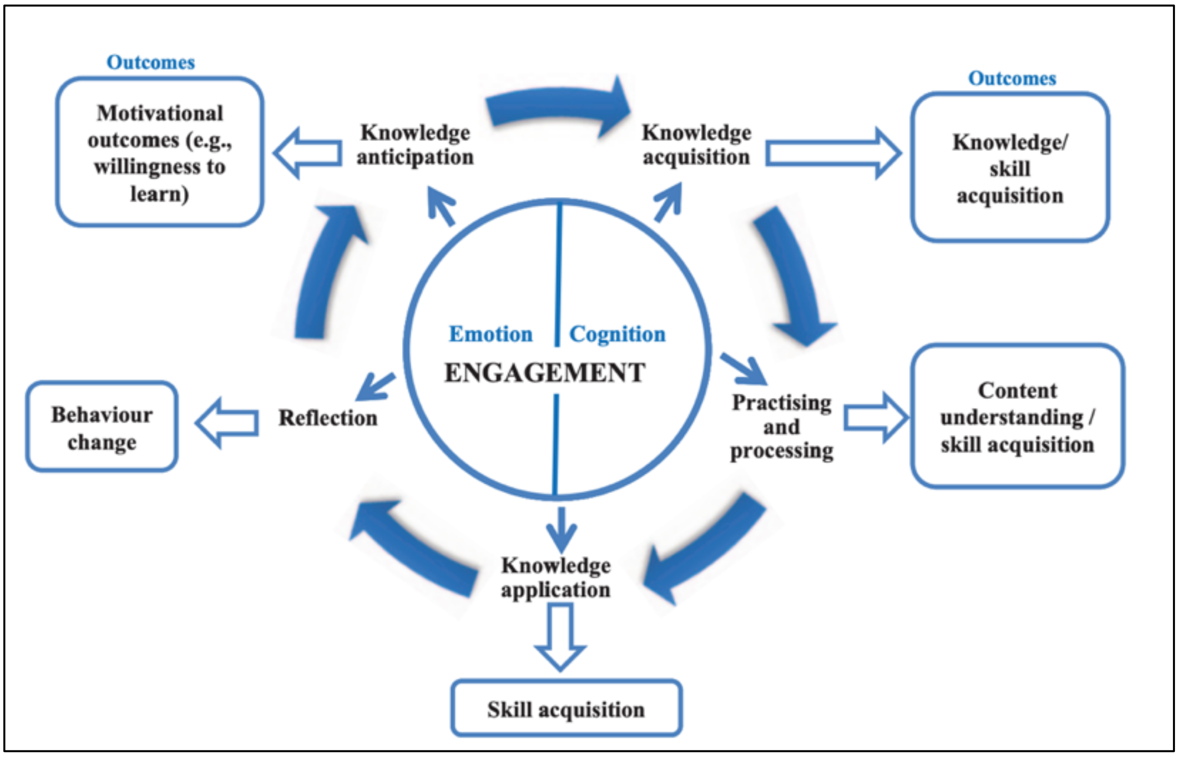

Figure 1: Adapted from Abdul Jabbar, A. I., & Felicia, P. (2015). Gameplay engagement and learning in game-based learning: A systematic review. *Review of educational research*, *85*(4), 740-779.

Not only this, but the way in which games are adaptable to the specific needs of the player also helps improve customisability; hence, engaging learners in a capacity which best reflects their personal circumstances (Fig. 1). While in a classroom, all children may be taught the same material at the same pace- AI game based learning helps measure self-regulation skills and prior knowledge according to which the complexity of problems and guidance are customised to meet the needs of the student. Therefore, making this model immensely valuable to cater to the individuality of each student which classrooms fail to do (Turkay et al., 2014). According to psychological researchers, prior knowledge helps facilitate the processing of new incoming information as it provides a structure for integration of the new information; thus, elaborating the memory trace (Brod et al., 2013). This not only enhances a student's self-esteem, but it further improves motivational outcomes by enhancing willingness to learn and an anticipation for knowledge. These greater levels of confidence further are all a consequence of the behaviour changes developed due to the cycle of applying knowledge in real life and reflecting on it. Not only does meta-cognition help students become more self-aware of their perspectives and ideas, but it improves affective learning (Abdul & Felicia, 2015). Thus, showcasing how students learning at their own pace will improve educational outcomes for institutions, as compared to the students undertaking the same journey of learning.

Hence, insights from Educational and Cognitive Psychology have helped inform the reasons why the GBL model is effective. Similarly, Experiential Learning can be analysed.

II. Cognitive benefits of AI experiential learning

Experiential learning has been defined as a type of engaged learning process where students actively 'learn by doing' and by reflecting on their experiences. Akin to game-based learning, experiential learning is an inductive learning process which utilises the "trial-and-error" concept. By applying concepts, theories, and ideas, to an interactive setting, this type of learning contains "real world" circumstances, also termed as applied experiential learning (Gentry, 1990). Various researchers have compared typical education to experiential learning, and stated that "experiential learning is when a personally responsible participant cognitively, affectively, and behaviourally processes knowledge, skills, and attitudes in a learning circumstance with a high level of active involvement (Hoover & Whitehead, 1975).

According to the 'Experiential Learning Theory', learning is a cyclic process of experiencing, reflecting, thinking, and acting which is a consequence of the combination of grasping and transforming experience. "Processing" and learning transfer occurring naturally or through leader facilitation are the primary emphasis of ELT (Kolb et al., 2014). The natural and unfamiliar environments are central to the experiential learning process, due to various reasons. When students are exposed to unfamiliar environments, their novel qualities help catalyse growth and mastery of subject material, while enhancing well-being, and awareness of themselves. Not only this, but students tend to overcome cognitive dissonances through mastery when in challenging contexts; thereby, spurring development. Danger, risk, and fear further help produce the optimal levels of anxiety, stress, and dis-equilibrium; hence, helping build "character" and improving psychological resilience in students (Ewert & Garvey, 2007). This "exploration" in experiential learning programs is also one that enables adventure in the students; therefore, improving risk-taking skills.

Through their AI experiential learning program, *EDUFIQ* aims to engage students in the world of coding, which is set in unfamiliar and challenging contexts testing the mettle of students. Hence, the challenging nature not only stimulates further cognitive exploration, but helps enhance various skills.

Seligman (2012) explicated the *theory of wellbeing* in which the pillars of positive emotions such as engagement or *flow*, relationships, purpose, and accomplishment help enhance quality of lives of individuals. This is in tandem with the objectives of the experiential learning model, as students are able to engage and inquire into material as they please, build relationships with peers through collaboration, and have a defined aim to accomplish (AEE, 2013). Not only does it help improve wellbeing for students, but the "golden ratio" has various implications to improve learning experiences for children, according to which leveraging participant strengths can help them master personally meaningful and self-determined challenges while working in a team (Fredrickson & Losada, 2005).

Pursuing extrinsic goals such as wealth and popularity has a negative impact of student wellbeing and learning, resulting in a poor self-esteem, and interfering with need-satisfying behaviours. However, affiliation and self-acceptance help improve ones' wellbeing, self-concept, and ultimately learning because they are intrinsically motivating and satisfying rather than based on external validation. They also satisfy basic psychological necessities such as autonomy, competence, and connection. Moreover, the focus on 'personal growth' also helps improve performance and enhance learning as delineated in the study by Vansteenkiste et al. (2004).

Reliance on educator's instructors in controlling environments of schools undermine intrinsic motivation and inhibit abstract learning which requires deep information processing. On the contrary, autonomy-supportive environments like those in experiential learning spaces help facilitate student-led learning, evaluate performance, and fine-tuning (Black & Deci, 2000). Hence, further underscoring how rote memorisation is instructor-led whereas experiential learning is instructor-encouraged, but student-driven. This helps evaluate the need for more experiential learning courses in schools, to enhance student wellbeing and alleviate the current stress levels.

Neuropsychology has helped understand how different parts of the brain are involved in experiential learning. Concrete experiences arrive through the sensory cortex, while reflective observation utilises the integrative cortex towards the back, and new abstract concepts occur in the frontal integrative cortex. Moreover, active testing involves the motor brain, which further validates how the claims by experiential educators citing the effects on learning as a consequence of experiential learning (Zull, 2002). In response to typical multisensory adventure environments, the brain grows through neurogenesis and rewires through neuroplasticity; thereby, promoting resilience, learning transfer, and interpersonal relationships (Allan et al., 2012). Not only this, but neuropsychological processes are associated with high executive functions in the experiential learning framework. Funahashi (2020) argued that executive function, is the by-product of the coordinated operation of various processes to accomplish a goal in a flexible manner. The mechanism responsible for this coordinated operation is termed "executive control", which is mediated by the prefrontal cortex. Research showcased how prefrontal cortex is essential to decision-making, judgement, and planning skills as well, which would all be impacted in its absence. Various executive processes occur in experiential learning, such as self-regulation, control of cognition, temporal organization of response to immediate stimuli, planning behaviour, and attention control. Thus, enhancing cognitive function.

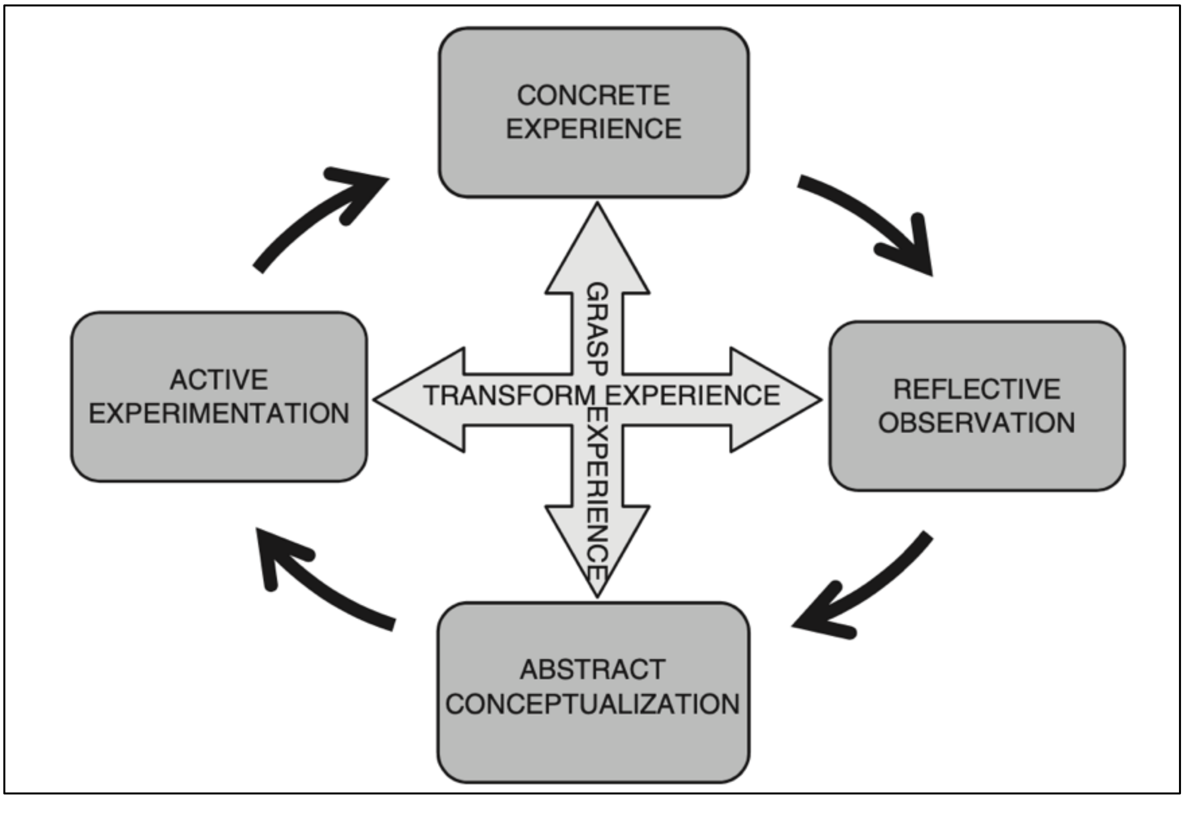

Figure 2: Adapted from Kolb, A. Y., & Kolb, D. A. (2009). The learning way: Meta-cognitive aspects of experiential learning. Simulation & gaming, 40(3), 297-327.

Moreover, Fig. 2 by Kolb (2009) demonstrates how meta-cognitive abilities are enhanced through experiential learning, specifically when learners critique their own learning and progress. Questioning the content the student has learned holistically, and evaluating whether it is plausible to the prior knowledge and expectations trigger meta-cognitive experiences. Selecting cognitive strategies and seeking knowledge from other students and teachers is what offsets the journey to this path of meta-cognition once the complexity of the task has been acknowledged by the student. Knowledge of a student's own variables, task variables, and strategy variables further helps create an 'action plan' which students are able to follow conveniently. While knowledge variable is the general knowledge of how humans process and learn information along with the individual knowledge of the learning process, task variables refer to the nature and requirements of the task. Furthermore, strategy variables knowledge about techniques to enhance learning and conditional knowledge about the pertinence of the context to apply the strategy in. Thus, this entire experience of evaluating a course of actions to reach an outcome is instigated through experiential learning.

While experiential and game-based learning offer various benefits, it is crucial to evaluate current circumstances of rote-memorisation and its prevalence.

III. Cognitive limitations of rote memorisation based learning methodologies

Rote learning is a technique aimed at using repetition to memorise course material, which has been viewed as the norm in various educational institutions across the world. This method preaches that recall of repeated material becomes faster as one repeats it more frequently.

'Massed practice' or colloquially known as *cramming* is a rote memorisation technique which reduces recall score in percent, as compared to other more 'active' forms of learning which engage more cognitive functions. Various studies have also showcased how students who used spaced learning techniques have outperformed those who utilise massed practice for assessments in the long run. This is particularly because massed practice eliminates the retrieval process where information is viewed as ‘unnecessary’ to retrieve as the same had recently been presented. (Kang, 2016). While experiential and game based learning allow for complex connections between previous and new knowledge, rote memorisation is focused on memorising bare facts without diving deeper and developing cross-connections between subject disciplines. Therefore, negatively impacting the ability of students to critically analyse and engage with their course material (Evans et al., 2003).

IV. Alternate learning strategies

In the recent years, there has been criticism towards rote memorisation based methodologies dependent on memorising and regurgitating sheer amounts of information on examinations. An example of such a methodology known as ‘*Active Recall’* has been popularised by mainstream media. While such techniques may achieve the goal through different methods, all of these ‘effective strategies’ essentially aim to achieve the primary goal of improving retention of information. Moreover, experiential learning and active recall may even be more inter-connected than earlier perceived. Both these types of learning advise against passive learning and underscore how being ‘actively engaged’ in the learning process is essential to improving retention of information. However, experiential learning extends this further to apply the principles of authentic real-life circumstances in the context of teaching (Ward & Walker, 2008).

Discussion

Various depths of cognition and neuroscience have been explored with respect to game-based and experiential learning strategies; however, there are various limitations and possibilities of the study as well.

Firstly, gathering data on the experiential learning was possible, but specific data regarding AI assisted experiential learning was limited. Thus, demonstrating that the scope of

Artificial Intelligence in the field of experiential learning requires further research to fully comment on. This is crucial, because adventurous and physical forms of experiential learning in outdoor settings is not comparable to technological learning through experience. Hence, more insight pertaining to the role of coding in enhancing cognitive function through experiential techniques, is required.

Moreover, another essential factor to consider is that *Minecraft* game-based learning was much more wide-ranging and possessed a greater amount of literature exploring the field. Hence, providing more specific feedback in terms of the design and function of Minecraft and how it engages learners; thus, improving cognition through neuroplasticity. Therefore, the results for the benefits of game-based learning are more reliable and supported by empirical evidence to a greater extent than experiential learning. However, more research is needed on how the phenomenon of game-based learning is supported directly by neuroscience, as the links were not extremely pertinent to the field of neurobiology. On the contrary, experiential learning proved to possess an extremely detailed neuroscientific profile validating its benefits. Thus, showcasing how more information can benefit the study further.

In addition, it is vital to note that the researchers' findings may have been contextualised to a certain area and demographic; therefore, the results are not entirely generalisable to the situation of EDUFIQ in particular. This is because the demographic of Indian students of grades 5^{th} to 10^{th} grades was not studied exclusively in the literature reviewed. Thus, reducing the validity of the results in the context of Indian students, as many sociocultural factors such as cultural background, family environment, and type of school can impact the cognitive impact of game-based and experiential learning on students. Most of the data, while exploring more factors beyond cognitive benefits, was accurate because it was supported by the conclusions of the researchers. Various studies emphasising on how the design and function of games can impact the visual transmission of information also informed how impact of memory retention on visual memory can vary from game to game. Thus, shortlisting studies based exclusively on Minecraft helped provide a more specific analysis of visual elements and their relationship to cognitive function.

While *Minecraft* has been shown to enrich the learning experience of children with learning disabilities, there are various factors to consider regarding its contextual application. One important aspect of the AI assisted Minecraft game based learning model of teaching is that financial investments, hardware requirements, technological knowledge, and board regulations may make this less accessible to underprivileged students (Petrov, 2014). However, the necessary mediations to this can be achieved through communication with educational boards and policy makers to ensure that the student families would be in a financial circumstance to be able to pay for this model of teaching, in addition to the school fees.

Not only this, but another concern is the increased screen time due to game based learning, which can further have a negative impact on the eyesight of students; thereby, harming their physiological health. Thus, a limit to the hours that students will spend with the games should be stipulated in order to maximise learning while minimising consequences (Greipel et al., 2020). Furthermore, it is crucial to undergo various rounds of expert evaluation as the game-based learning transactions may not always be aligned to teaching or learning goal. Hence, to mitigate this- *Edufiq* has released a syllabus pertaining to the educational requirements of each grade and therefore, the game-based and experiential learning courses are suited to the requirements and capabilities of the grade being taught.

Furthermore, games and technology have been shown to have a negative impact on mental wellbeing of students which can further harm cognitive functions. Studies show that antisocial behaviour, isolation, and a short attention span may arise due to a game-based learning program (Huen et al., 2016). However, Edufiq already has strategized and developed collaborative forums and platforms to encourage socialisation, collaboration, and cognitive enrichment as a product.

Moreover, there are various factors to consider for a successful implementation of experiential learning as explored by Roberts (2018). Firstly, it requires immense patience and guidance by the teacher or leading instructor of the course. Therefore, identifying whether such a resource is practical for institutions should be ensured prior to the teaching journey. Additionally, a patient teacher is essential in this type of a learning framework, because the excessive focus on student-focused learning can be hampered if lesson instructions are unclear. Not only this, but this step can also help alleviate stress, anxiety, and any confusions experienced by the children. Hence, building more positive interpersonal relationships between the student and teacher. Moreover, Snydner et al. (2003) outlined how a good teacher must also be enthusiastic to improve cognitive abilities of students by encouraging participation. Thereby, making this an essential factor to consider. Experiential learning is also a framework which is highly subjective as its based primarily on ‘meta-cognition’ and ‘student perspectives’; therefore, the focus can shift from objectivity to ‘no one right answer.’ While this is great to expand the students’ intellectual and creative curiosity, it can hamper the flow of learning content by making the learning process highly subjective; therefore, impeding the progression of subject syllabi. However, assigning a particular lesson or period on student working days, like Edufiq has done, is a great strategy to ensure academic rigour and progression.

While various other factors are essential to consider, research consistently demonstrates the application of the Self-determination Theory in the context of these types of learning. The adaptability of Game Based Learning to the player's skillset makes it essential to help students realise their effectiveness and mastery over subject material. By achieving small yet viable goals in games, students feel more competent, which leads to greater feelings of motivation. Similarly, the aspect of relatedness in this theory describes how students can often feel a sense of connectedness and belonging when interacting with other students through experiential and game-based learning. Therefore, this collaboration unveils a common medium for students to learn, grow, and prosper, regardless of their differences. Moreover, the feeling of choice in the aspect of autonomy, helps describe how the customisation of each game to the student's strengths is again, linked to a greater motivation (Reeve, 2002). This is particularly because endorsing and positively re-enforcing the students' behaviour in a constructive manner to "level-up" or progress from one stage to the other in a game helps enhance a sense of autonomy. Therefore, all the three factors of autonomy, relatedness, and competence in the context of Self-Determination Theory help comprehend how Game-based and Experiential learning frameworks emphasize how students are motivated to grow and change through intrinsic inspiration. This "inspiration" is a product of receiving the three innate and universal psychological needs. Therefore, giving rise to self-determined learners as a result of the needs being fulfilled (Deci & Ryan, 2012).

Conclusion

Overall, it has been analysed that AI game-based and experiential learning by the company *EDUFIQ*, are more effective in enhancing cognitive function than traditional rote memorisation methodologies. Cognitive abilities or skills are brain-based aptitudes essential for acquiring languages, knowledge, manipulating information, and reasoning with data, all of which are central to an effective computer science education with a focus on cognitive proficiency of students. Not only do cognitive skills occupy a vital role in a student's overall development, but it improves their skills in the real-world, as thinking, reading, retaining information, learning, and staying attentive help improve problem-solving, decision-making, and remembering important tasks. As digital platforms have replaced textbooks after the pandemic, there is a valid reason as to why rote memorisation should take a backseat; specifically, due to its inability to help retain memory in the long-term. Various researchers have compared how active recall and high engagement levels with subject material supersede the repetitive massed practice, for it does not enable students to become cognizant. By measuring data on how game-based and experiential learning have impacted the education industry, educational psychologists are encouraging more and more curricula to adapt to the ever-volatile needs of the students' education in the modern day. In this regard, it is possible that the inaccessibility and negative impacts of the learning frameworks can be mitigated through psychological and technical advancements aimed at spreading awareness about a balanced use of these approaches to learning. As with anything, it is crucial that students utilise these platforms in a diligent manner and minimise their time in front of the screen to prevent physiological damage to the eyesight. Therefore, taking necessary precautions and encouraging meta-cognition in students can help create an education relevant to today's time, where companies like *EDUFIQ* are transforming the narrative around the ultimate intellectual experience.

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