



Innovative Approaches to Accelerate Community-Based Problem-Solving Skills

Ismat Zahra¹, Neo Mai¹ and Hew Soon Hin¹

¹ Multimedia University, Cyberjaya, Malaysia
ismatzahra57@gmail.com

Abstract: In today's world of teaching and learning, the primary objective of education is not only to provide academic knowledge to the students but guide them to foster their 21st-century skills, such as problem-solving, and collaboration. However, one of the significant challenges the higher education sector faces is the shift in traditional teaching and learning accelerated by COVID-19. This research has designed an engaging and motivated model named Game-Based Community of Practices (GBCoP) to incorporate the community of practices elements within a technology-backed learning environment where the class content was integrated with the latest digital tools and collaborative activities. A mixed-methods research design was utilised to comprehensively collect and analyse data regarding students' motivation, engagement, and 21st-century skills. To gather quantitative data, an online survey employing a 5-point Likert scale was administered as both a pre-test and post-test. Additionally, interviews were conducted to gain insights into students' perceptions of the game-based learning environment. The findings of the study revealed significant improvements in students' engagement and collaboration, as well as enhanced critical thinking and problem-solving skills as a result of the GBCoP learning environment. These outcomes strongly support the integration of these innovative learning strategies in the classrooms, fostering vibrant communities of practice and enriching student learning experiences.

Keywords: Community of Practices, Problem-Solving, Game Based Learning, Education 4.0

1 Introduction

Education must be adaptive and responsive to students' changing needs, especially in light of the present educational context [1]. Historically, education relied on physical presence, such as lecturers, students, classrooms, exams, and textbooks. The COVID-19 epidemic, on the other hand, disrupted this system, resulting in an abrupt halt in teaching and learning processes, and forcing the rapid transformation of approaches for effective classrooms while ensuring educational quality [2], [3]. The pandemic has hastened the digital revolution in education, especially higher education [4], [5], [6]. This transition not only provides learners with the flexibility to study at their leisure, but it also allows for the building of communities and the learning of meaningful knowledge. Such approaches to learning enable students to personalise their learning experiences, gaining control over how they study and engage in real-time problem-solving [4]. According to research, combining social engagement, peer cooperation, and community conversations increases students' thinking and analytical skills, assists in decision-making and problem-solving, develops leadership development, and improves time management. While social media is frequently connected with community-based learning, the structured application within the classroom environment is required to fulfil students' needs and prepare them for future challenges [6]. As a result, it is critical for teachers to give adequate opportunities for pupils to practise and prepare in the classroom. Collaboration in higher education through Community of Practice (CoP) has enormous potential for tackling the aforementioned issues. However, it is important to emphasise that these approaches are still underutilised and have not been thoroughly researched from the standpoint of

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teaching and learning [10]. As a result, the aim of this research is to answer the question, "What are the effects of a collaborative game-based learning environment on students' educational experiences?" Furthermore, it intends to present a collaborative framework called GBCoP for the teaching and learning with the integration of the GBL, which is intended to enhance community-based problem-solving skills and support the development of 21st century capabilities. Game Based Learning (GBL) engages individuals with the information and improves their intrinsic motivation to attain their objectives.

2 Literature Review

According to recent studies, online learning has difficulties in effectively engaging and inspiring students, resulting in a lack of motivation, restricted contact, and insufficient collaboration [6], [7]. To address these concerns, incorporating educational games into online learning settings with the assistance of Artificial Intelligence (AI) has been proposed as a way to improve student engagement and motivation. The following subsections investigate the uses and efficacy of CoP and GBL in educational settings. Furthermore, it investigates the incorporation of AI for gaming support, emphasising its potential to improve the learning process and enhance student outcomes.

2.1 Community of Practice (CoP)

A CoP is defined as "a group of individuals who share a concern, set of difficulties, or passion for a topic and who continue to expand their knowledge and experience in the field through ongoing engagement" [10]. Through regular discussions, CoP members actively engage with one another to grow their expertise and gain significant experience in their profession. According to the source [10], CoP are forums where people with similar interests may join together to improve their understanding and proficiency in their respective fields. Members can not only learn and improve from their peers in this collaborative environment, but they can also encourage and facilitate the progress of others in the community. Furthermore, as indicated in [13], the concept of a game-driven community-based problem-solving learning environment inspired the development of this study. It is made up of three primary components that work together to create a community in the classroom where students communicate and collaborate to complete their assignments. The primary three aspects as mentioned previously are: Domain, Community with share their expertise, and Practice where students used a variety of tools to strategize their ideas based on the goal and also to work attain to their common objectives. A CoP literature provides persuasive evidence that this method can effectively stimulate knowledge exchange and knowledge development, hence increasing the effectiveness of current practises inside and across organisations [11]. CoP are widely recognised as excellent organisational structures that have been successfully applied in a variety of circumstances but are not properly used for teaching and learning environments. Furthermore, CoP have proven useful in enabling knowledge sharing, learning, and conversation among participants. They've also been crucial in attaining goals like border crossing, trust building, persistent involvement, and reciprocal learning. Furthermore, research shows that CoPs can be efficiently adapted to the redesign of learning environments. Researchers propose collaborative knowledge creation within task-focused environments as interactive learning tools advance [15].

2.2 Game-Based Learning (GBL)

There has been a significant increase in scholarly interest in game-based learning in recent years, notably in higher education. Extensive study has looked into the benefits of game-based learning and shown that it has a good impact on learner motivation, class participation, and overall learning performance and views. Educational games can make the learning process more fun for pupils by allowing them to feel at ease when confronted with various problems and empowering them to conquer these challenges via focused concentration, confidence, and patience. These characteristics are critical for developing lifelong learners in higher education [13]. Furthermore, evidence suggests that game-based learning increases engagement in a learning setting [9], [14]

outlines in the game-based learning aspects in Table 1. These thoughts can be divided into three categories; a. Empowered learners: Enabling students to take an active role in their learning process promotes active learner engagement, b. Problem-solving: Presenting well-designed challenges and exercises effectively improves problem-solving and critical thinking skills, c. Understanding: Encouraging children to think critically and make educated decisions about the best ways to address situations.

Table 1: Game-based learning aspects

No		“Principle”
1	“Empower Learners”	“1: Co-design” “2: Customize” “3: Identity” “4: Manipulation and Distributed Knowledge”
2	“Problem-Solving”	“5: Well-ordered Problems” “6: Pleasantly Frustrating” “7: Cycles of Expertise” “8: Information ‘On Demand’ and ‘Just in Time’” “9: Fish Tanks” “10: Sandboxes” “11: Skills as Strategies”
3	“Understanding”	“12: System Thinking” “13: Meaning as Action Image”

2.2.1 Competition in GBL

When there is competition in game-based learning, learners seek to surpass others in order to win the game. Numerous studies have found that competition has a favourable impact on learning performance, engagement, motivation, and persistence in learning activities created a competitive game-based learning system in the context of information literacy (IL) education, where learners can check scores and rankings via a leaderboard during the learning process. The results showed that pupils in the competitive mode outperformed those who did not take the post-test [11].

2.3 Game Assistance Using AI

AI-powered game assistance has transformed the way students interact with educational content. Game-based learning environments can provide personalised guidance and support by using the power of artificial intelligence, hence increasing student engagement and learning outcomes. AI algorithms monitor students' interactions, behaviours, and performance in the game, allowing the system to provide real-time feedback, hints, and assistance suited to each student's specific needs. This tailored strategy assists students in navigating problems, overcoming obstacles, and progressing at their own speed [16].

3. Methodology

3.1 Learning with Community Through Games

A collaborative game named “**EduBattle**” was developed and implemented in the classroom setting at Multimedia University as part of the project. This game was created for the design and development class to establish an environment favourable to community creation, teaching, and learning. The primary goals of “**EduBattle**” were to encourage students' problem-solving and critical thinking abilities. This game consists of two major components: The first part assesses the student's knowledge, and the second one allows practical scenario implementation. In “**EduBattle**” students need to create an account to enter the battle arena and select an avatar to use throughout the game. A few things need to be done before entering the battle arena. First, a room is created by students for two groups then the AI assistant will explain what needs to be done. Once entering the battle arena, students walk around the map with other team members to reach the destination. A few questions will pop up once you reach the pointed location. Additionally, each student has AI Assistant who guides them with the scenario, informs them of the situation, and motivates them to complete their tasks.

Furthermore, when students give the wrong answer, an alien attack them and their life decrease. Each level has been assigned a time to increase the urgency to complete the level with their group members. In this game, students will roleplay and do the tasks accordingly. Figure 1 displays a screenshot from the “EduBattle” game.

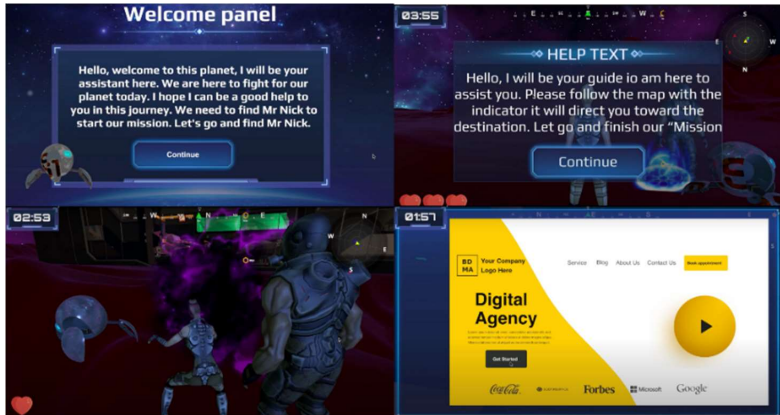


Figure 1: EduBattle - Screenshots from the Game

3.2 Methodology

A course at the design faculty was completely revamped as part of this research. The goal was to incorporate game-based learning elements [14] to structure and leverage a CoP learning methodology [15] in order to establish a collaborative atmosphere to enhance real-time and problem-solving. The course, titled "Mobile Application Design and Development," was presented entirely in person, allowing for direct interaction between professors and students. Several features were added to the course to connect it with Wenger's community of practice paradigm. These aspects were created to encourage students' knowledge-sharing, active involvement, and collaborative problem-solving. By implementing game-based learning strategies, the overall aim of the study was to increase student engagement and motivation by harnessing the inherent features of competition, interactivity, and rewards typically present in games. Furthermore, the incorporation of CoP principles in the learning environment aimed to create a helpful and engaged learning environment. Students were encouraged to work together, share their skills and talents, and handle real-world design difficulties as group activities. The goal was to establish a sense of belonging and ownership among students in the learning community, where they could learn from one another and actively contribute to the overall learning experience. Table 2 and 3 gives a full mapping of the course components to the aspects of the CoP model with game-based learning and provides a more extensive summary of how the course was linked with Wenger's community of practice framework.

Table 2: Community of practices class implementation

“Community of Practices (CoP)”	“Game-Based Learning”
“Domain”	“A group project was assigned to the students.”
“Community”	“(1) Students will form groups” “(2) A short activity was assigned where they need to pick a topic to solve a design problem.” “(3) share their knowledge to achieve one goal.”

"Practice"	"(1) Used Design and Development Tools." "(2) Students were provided with multiple tasks for practice for each class."
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Table 3: Game-based learning implementation.

"Game-Based Learning"	"Class Implementation"
"Learner Empowerment"	"(1) Students form groups." "(2) Students were provided with different activities and assignments." "(3) Students were allowed to pick their roles to complete the task."
"Problem-Solving"	"(1) Lecturer gave small problems as to solve." "(2) A flexible role-playing environment was provided for interaction among the groups/teams."
"Understanding"	"(1) A group/team project was assigned." "(2) Each activity and problem were designed to engage, motivate and foster student's critical thinking, problem-solving and decision-making skills."

The purpose of this study was to investigate students' acceptance and impressions of the use of a multiplayer game as a framework for constructing communities within the educational setting.

3.3 Data Collection Method

The study used a mixed-method research design with a convenient sampling of 81 students for the pre-and post-test and 57 students from the course for the survey. The participants were given a consent form to sign and were informed that the study was entirely voluntary. The link to the game was only given to individuals who agreed to participate. The game began with a 10-15-minute briefing for the students who would be playing. After all, participants understood the purpose of the data collection, they were given a pre-test to assess their prior knowledge of the subject. Following the pre-test, students were provided with a link to the game in order to evaluate their team performance and improve their problem-solving, critical thinking, and collaboration skills. After finishing the game, students were given a post-test and an open-ended survey to complete. This study employed a mixed-method research design and a sampling methodology. 81 students completed the pre-and post-tests, while 57 students completed the course survey. Participants were given a consent form and told that their participation was entirely optional before they began the data collection process. Only individuals who accepted to take part were given access to the game through a URL and survey. A briefing session of around 10-15 minutes was held at the start of the class to explain to each group the game to guarantee clarity on the objectives of data collecting.

To examine their perspectives of the redesigned framework and the collaborative experience supported by the customised game named "EduBattle" during their learning process, a survey was administered to the students based on available literature. The survey sought to investigate four important features, which fell under the following constructs: improving problem-solving ability, developing critical thinking abilities, increasing motivation, participation and teamwork. A 5-point Likert scale questionnaire was used in the survey, with responses from 5 (Strongly Agree to) 1 (Strongly Disagree).

4. Results and Discussion

4.1 Students' performance of pre-test and post-test

The test's goal was to assess the student's current level of comprehension of the topic. Participants were given an explanation of the pre-test/post-test and its purpose before the data-collecting process began. Following that, the students were directed to complete the pre-test, which functioned as the study's initial assessment tool.

The pre-test consisted of 26 multiple-choice questions, six of which were linked to the student's demographic information (such as consent, age, gender, nationality, race, and level of study) and 20 of which were general in nature. The participants were given 20 - 30 minutes to complete the test. The data gathered during this phase was recorded in the actual classroom using a Google form. Later, the data analysis was conducted using SPSS software, specifically version 27. To assess any significant changes in the student's performance, a paired sample t-test was carried out. This statistical test aimed to determine whether there were statistically significant differences between the student's scores in the pre-test and post-test. The results obtained from the collected data are presented in the table below.

Table 4: Paired Sample T-test with Sig(2-tailed) Analysis

		m= Mean	n= Number of Participants	Std. Deviation	Std. Error Mean
Pair1	Post-Test Results	13.38	81	2.517	0.280
	Pre-Test Results	9.40	81	2.853	0.317

		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the difference		t	df	Sig (2-tailed)
					Lower	Upper			
Pair1	Post-Test Pre-Test Results	4.06744	3.58616	0.39846	3.27447	4.86040	10.208	80	<0.001

Table 4 offers a detailed breakdown of the summary statistics for the paired sample pre-test and post-test outcomes. The mean score for the post-test is m=13.38, whereas the mean score for the pre-test is m=9.40. Table 5's statistical analysis shows a significant difference (p.001) between the two sets of tests. The T-Test results indicate that students' performance increases considerably after engaging in collaborative and competitive game-based activities. This result demonstrates the efficacy of implementing an online game-based learning environment since it improves students' understanding and grasp of the subject matter.

4.2 Students' Responses to the Survey Questionnaire

After the pre and post-test, a survey questionnaire was then given to the individual participant after taking their consent. To examine their perspectives of the redesigned framework and the collaborative experience supported by the customised game named "EduBattle" during their learning process, a survey was administered to the students based on available literature.

4.2.1 Enhance Problem-Solving Capabilities

Table 5 shows that participants had a good attitude towards a game-based community of practice teaching and learning environment, considering them pleasant and effective for improving their problem-solving abilities. Furthermore, the results show that students have a strong preference for group work as a method of obtaining new information (Item=1, m=4.32, p=77.1) and majority of students, particularly 78.9%, have learned how to effectively combine and organise disparate concepts and facts in order to handle complex problems (Item=2, m=3.98, p=78.9). Furthermore, the majority of students stated that engaging in collaborative problem-solving with their classmates improves their cognitive abilities and adds to the growth of their thinking process (Item=3, m=4.18, p=54.2). Furthermore, 68.7% of students reported effectively

adhering to plans and allocating responsibilities within group projects (Item=4, m=3.77, p=68.7), and 77.1% stated that the information gained via these joint endeavours will help them in the future (Item=5, m=4.02, p=77.1).

4.2.2 Foster Critical Thinking

The findings regarding the fostering of critical thinking skills showed that the students responded positively, with a majority acknowledging the beneficial impact of using games with AI support and collaboration with your team in the classroom. Specifically, a significant percentage of students (62.5%) expressed that the collaborative game utilised in the study helped them to better grasp and comprehend the subject matter (Item=14, m=3.71, p=62.5). Additionally, 60% of students reported that this type of collaborative game facilitated the development of their critical thinking abilities (Item=15, m=3.77, p=60). Moreover, a considerable proportion of students 64.6% stated that engaging in group work contributed to their enhanced understanding of the subject (Item=6, m=3.75, p=64.6). This suggests that collaborative activities within the game-based learning environment had a positive influence on their critical thinking skills and comprehension of the topic at hand.

4.2.3 Increase Motivation

The results pertaining to increased motivation demonstrated that a significant majority of students (more than 68%) reported feeling highly motivated while engaging in their group projects (Item=7, m=3.88, p=68.8). This indicates that the collaborative and competitive elements of the game-based learning environment inspired a sense of enthusiasm and drive among the students, fostering their commitment and dedication towards the tasks at hand. Furthermore, the findings revealed that 66.7% of students expressed satisfaction in sharing their knowledge and insights with their team members, which proved instrumental in generating creative ideas (Item=8, m=3.94, p=66.7). This suggests that the collaborative nature of the learning environment, facilitated by the game-based approach, encouraged open communication, knowledge exchange, and collaboration among students. Such interactions not only enhanced their understanding of the subject matter but also stimulated their creativity, as they were able to draw upon diverse perspectives and collectively generate innovative solutions. Overall, these findings indicate that the integration of game-based learning with the community of practice in the classroom not only heightened students' motivation levels but also fostered a collaborative and supportive atmosphere, where sharing knowledge and ideas were valued. This, in turn, contributed to a dynamic and engaging learning experience that nurtured students' intrinsic motivation and facilitated the development of their creative thinking abilities.

4.2.4 Improve Engagement

66.7% of the participants expressed their enjoyment of team interaction (Item= 9, m= 3.94, 66.7), and a majority of them found the meeting discussions enjoyable (Item= 10, m= 3.92, p=66.7). Additionally, 66.7% of the students reported being engaged with the game's content (Item= 11, m= 3.91, p=66.7), and they expressed high satisfaction with the game design and content (Item= 12, m= 3.85, p=66.7). Furthermore, 71.7% of the students mentioned that they had fun and felt deeply involved in the tasks (Item= 13, m= 3.77, p=71.7).

Table 5: Survey Results of the Learning Environment

A Survey Questions			
Survey Item (online game-based learning) N = 57	Mean	Std Deviation	%
"1. Working as a group gives us an opportunity to explore and implement new ideas."	4.10	0.831	77.1
"2. I am now capable of blending and organising different ideas and information to solve complex problems"	3.98	0.641	78.9
"3. I feel collaborative problem-solving help me to improve my thinking skills."	4.18	0.944	54.2
"4. I prefer to work in a group so I can learn new things"	3.71	0.841	68.7
"5. I believe the knowledge acquired during the group activities will benefit me in future."	4.02	0.863	77.1

“6. The group activates helped me to understand the subject better.”	3.75	0.863	64.6
“7. I was highly motivated to do the group activities.”	3.88	0.890	68.8
“8. I am happy that I was able to share my creative ideas and managed to implement them in our group.”	3.94	0.836	66.7
“9. I enjoyed my interaction with my teammates.”	3.94	0.783	66.7
“10. I enjoyed coming to our group meetings.”	3.92	0.821	66.7
“11. This game keeps me engaged with the content.”	3.91	0.785	66.7
“12. I feel highly satisfied with the game design and content?”	3.85	0.945	66.7
“13. I was having fun and was deeply involved in the task?”	3.77	1.016	71.7
“14. I feel this game help me to understand the concept better”	3.71	1.071	62.5
“15. In my opinion, games foster critical thinking.”	3.77	0.72	60.5
Cronbach’s Alpha = 0.975			

To further strengthen the survey results, students were encouraged to provide comments regarding their engagement, motivation, and collaboration. Some of the comments are presented in Table 6. For example, one student mentioned their motivation to achieve a high GPA and unleash their full potential in the course. Others highlighted that working together to solve problems made the process easier and more enjoyable. Students also noted that collaborative work allowed them to get to know each other better. They expressed that it was the best and fastest way to achieve success in project building. Overall, the feedback received from the students was overwhelmingly positive, indicating their enthusiasm for incorporating games into education in the future.

Table 6: Student comments

<p>Comments:</p> <ol style="list-style-type: none"> 1. “Solving problems together will certainly make it easier, as well as more fun.” 2. “It’s good because different skill assets can be used while doing the group project, and we can help each other to improve.” 3. “It is fun to work together and we can know each other more than we know” 4. “I feel that we can gain a lot of knowledge together” 5. Solving problems as a group allows more solutions being conjured up and more opinions from each member. Therefore, the possibility to solve a problem would vary and whichever one is chosen, i would respect it. 6. my motivation in this trimester is to get 4.0 in my GPA and to unleash my full potential in this course. 7. I feel great about it and felt wow when they share their knowledge to me as well.
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The focus of this research was to explore how collaborative game-based learning can enhance problem-solving skills among students. The comprehensive analysis of various data sources, including pre-tests, post-tests, student questionnaires, and class activities, yielded valuable insights into the success of the study. The findings reveal that students actively participated in group discussions, generating diverse solutions and demonstrating a high level of enjoyment throughout the learning process. The following key insights were derived from the study:

- a. The collaborative game effectively engaged students with the learning content, creating an immersive experience where they worked as a team to overcome challenges. The results demonstrated that this approach significantly improved students' problem-solving effectiveness and facilitated deep understanding and critical thinking of the subject matter. This heightened motivation sparked a high level of involvement and enabled students to strategize and devise effective solutions.
- b. The data analysis indicated that the collaborative game successfully captured students' attention and fostered deep engagement with the learning content,

- resulting in notable enhancements in their problem-solving skills. The interactive and stimulating nature of the game environment motivated students to actively participate and apply critical thinking strategies to overcome obstacles and allow them to build communities inside the class to gain knowledge from their peers.
- c. The survey responses and comments from students further supported the positive impact of GBCoP learning process. The gamified approach effectively motivated students and fostered collaboration among them, enabling them to effectively work together to solve common problems. This collaborative aspect of the game-based learning experience nurtured a sense of shared responsibility and collective effort among students.
 - d. Moreover, the study revealed that within the collaborative game environment, students took the initiative to engage in discussions aimed at problem-solving. This active involvement contributed to a deeper understanding of the subject matter and facilitated knowledge and idea-sharing among students. Collaborative problem-solving scenarios provided students with opportunities to exchange perspectives, strategize collectively, and plan for future challenges.
 - e. Additionally, the findings highlighted the significant improvement in students' knowledge and the development of their problem-solving and critical thinking skills when engaged in project-based group work. The opportunity for communication and cooperation within the group setting allowed students to effectively apply their knowledge, share insights, and collectively tackle complex problems.

5 Conclusion

The primary objective of this study was to examine the impact of introducing a GBCoP approach in the classrooms, with a focus on fostering 21st-century skills such as collaboration, motivation, and engagement. To achieve this, a custom-designed game was created and implemented in the classroom setting. The results of the study provided compelling evidence in support of the redesigned framework for the classrooms. The collaborative and challenging activities incorporated into the game proved to be effective in improving students' problem-solving and critical-thinking abilities. Through the game, students were actively involved in tackling complex problems, analysing information, and developing innovative solutions. This hands-on and interactive approach not only enhanced their cognitive abilities but also promoted collaborative teamwork and communication skills. Moreover, the study findings emphasised the importance of student engagement in the learning process. The GBCoP learning environment captured students' interest and motivated them to actively participate and immerse themselves in the learning scenario.

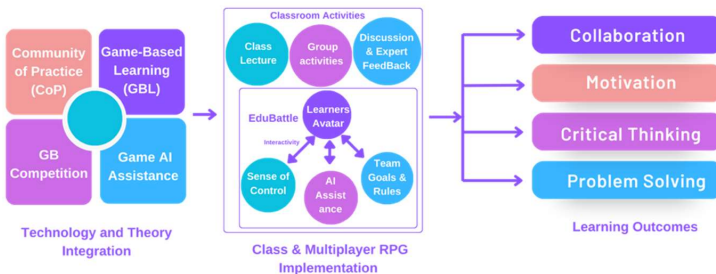


Figure 2: GBCoP Framework

The challenging nature of the game stimulated their curiosity, encouraging them to explore and delve deeper into the subject matter. As a result, students became more deeply engaged in their learning experiences, leading to enhanced knowledge acquisition and skill development. In conclusion, the study demonstrated the positive

impact of GBCoP learning framework in the classrooms. It showcased the potential of collaborative and challenging activities to improve students' community problem-solving and critical thinking skills, as well as their level of engagement in the learning process. These findings provide valuable insights for educators seeking to leverage CoP with game-based learning approaches to create effective and engaging learning environments that promote 21st-century skills.

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