Measuring Virtual Team Performance via Team-based Learning in Serious Games

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Abstract. In the academic and professional spheres of today, virtual teams have become a popular method of collaboration, necessitating an efficient evaluation of team performance in these digital contexts. This study examines the effectiveness of team-based learning in a sophisticated simulation game for virtual teams called ERPSim. This research, which crosses disciplinary boundaries, assesses the effect of ERPSim on the performance and skill development of virtual team members by adopting the constructivism paradigm. The study evaluates participants' capacity for strategic decision-making, teamwork abilities, and ERP system knowledge using a pre-post-game assessment approach and found that there have been considerable improvements in all three main aspects. Additionally, the qualitative response highlights the virtual team environment's transformative potential for facilitating interdisciplinary learning and enhancing problem-solving skills. This study demonstrates the transformative potential of constructivist-in- spired team-based learning in serious games to improve virtual team performance and prepare students for the difficulties of the rapidly changing virtual workplace. The findings highlight the crucial significance of serious games in encouraging dynamic and collaborative learning experiences and offer insightful information on gauging virtual team effectiveness. This study allows reviewers to delve into the developing field of virtual team assessment, paving the way for fresh ideas to promote productive teamwork and get students ready for success in a globally connected digital environment.

Keywords: Virtual teams, e-Learning, Gaming.

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1 Introduction

Virtual teams have become increasingly important in today's educational scene as a means of developing collaborative learning experiences. These teams work on projects and tasks together remotely utilizing digital communication technologies [1]. Virtual teams have two key dimensions: members rely on information and communication technology (ICT) for their interactions and are geographically separated and/or temporally separated [2].

The presence of certain structures and processes is required for virtual team effectiveness [3]. Team members must have the essential talents and be dedicated to the group's objectives. Furthermore, the essential processes of co- ordination and cooperation are critical for success [4][5]. Nonetheless, due to limited communication modalities and the lack of direct experience and observation, virtual teams confront challenges in these procedures. Virtual teams may require more time to create shared knowledge structures and coordination capabilities [6] [1]. As a result, good team evaluation is critical in virtual team situations, allowing students to understand their roles on the team and how the team performs as a cohesive unit despite physical separation [7].

Serious games, as opposed to entertainment-oriented games, are explicitly created for instructional rather than just entertaining objectives [8]. They are engaging tools that mix entertainment and educational purposes, allowing players to improve their knowledge and abilities by overcoming game difficulties [9]. Serious games, such as simulators, role-playing games, and educational games, can be employed in a range of situations, including corporations, healthcare facilities, and classrooms. Serious games should engage players in such a way that they achieve the necessary learning or behavior change while remaining enjoyable [10]. Serious games were first utilized in educational institutions to increase motivation and interest in studying. The lessons learnt should be useful in real- world workplace situations such as manufacturing, medical, and business [11]. Players' performances are reviewed and graded throughout the gaming experience. Successfully navigating obstacles yields prizes such as points, advancement, and enhanced capabilities. Educational aspects are smoothly interwoven into the gameplay, allowing players to learn knowledge and skills while playing the game.

Using the constructivism theory, this study intends to measure the performance of virtual teams through team-based learning using a serious game called ERPSim Maple game [12] [13]. Constructivism emphasizes active knowledge building by learners through interactions with their learning environment [14]. Constructivism is divided into two streams: individual cognitive constructivism, developed by Piaget [15], and sociocultural constructivism, developed by Vygotsky [16] based on sociocultural theories of cognitive development. These perspectives are similar in that they regard education as a process of assisting rather than spreading knowledge and learning as an active process of creating knowledge rather than just acquiring it [17]. Three instructional strategies were proposed to improve learning: modeling (via demonstration and articulation of reasoning), coaching (via motivational prompts, guidance, and reflection), and scaffolding (via task reorganization and adjustment [18]. Within the context of a virtual team, the ERPSim Maple game provides a simulated corporate environment in which participants manage an enterprise resource planning (ERP) system [12]. In collaborative learning,

When students work together on similar goals, they have the opportunity to exchange learning experience and update knowledge structures with peers which resembles a real-world workplace, allowing students to exchange learning experiences and update knowledge structures with peers through cognitive conflict [19]. Fur- thermore, serious games contribute to a number of learning outcomes. Students will be able to comprehend the business environment through reasoning and problem solving. In the process, they will also show significant improvements in critical thinking, creative thinking, knowledge acquisition and content understanding [14].

This study investigates how the virtual team environment in the ERPSim Maple game improves participants' understanding of ERP systems and supports knowledge production through social interactions and active engagement. This study adds to our understanding of how virtual team-based learning experiences provided by ERPSim Maple game align with constructivism principles by incorporating constructivism theory into the study design and assessment framework. The following research questions are addressed:

i. How effective is a serious game like ERPSim Maple in improving virtual team performance?
ii. To what extent is a serious game like ERPSim Maple able to facilitate constructivist-inspired team-based learning?

The following sections provide a full description of the study methodology, explain the findings and their implications on virtual team performance using team-based learning for serious games.

2 Materials and Methods

2.1 Participants

This study employs purposive sampling where the participants were 62 registered students who enrolled in the 14-weeks Enterprise Resource Planning course. Students were introduced to roles and concepts, as well as business procedures linked to Enterprise Resource Planning (ERP) systems, at the start of the course. Following that, stu- dents were asked to work in virtual fictitious organizations of four individuals with specified roles including inventory manager, sales manager, report manager and finance manager. They were engaged in team-based learning and urged to strategize and com- municate well to complete the necessary transactions. Game material and adequate time were given for them to comprehend the business history of their organization and products, as well as the simulation game's objectives. Google Meet conferencing was selected as a dependable communication medium for students and educators in a virtual environment [20].

2.2 Procedure

For three rounds of practice sessions, an asynchronous approach was adopted, in which students played the game on their own while the simulation was not yet started or was suspended. These practice games help students prepare for the gameplay. The interval

between rounds of the simulation is 24 hours, and the instructor will perform the scenario for three days in a row, each day at 12 p.m. for five minutes. Students are advised not to make any modifications or transactions during this time.

During the simulation game, students had to buy and sell maple products. Each company imported four various grades and two different sizes of bottled maple syrup from Canada and marketed them in Germany's North, West, and South markets. In the first round of the game, each company started with an initial inventory of 1500 units and will only focus on selling their products. Starting with round 2, the teams will over- see planning and purchasing, as well as making orders for commodities and restocking inventory in response to market demand. They will sell products to supermarkets throughout the rounds. Each company competes with the other maple product importers to meet client demand while making the most profit. After round 1, the instructors announce the results and rankings to the students and provide them with a 24-hour window to re-strategize and prepare for the next round on day 2. This format was maintained for round 3 to better prepare students for gameplay. Fig 1 depicts the game's components.

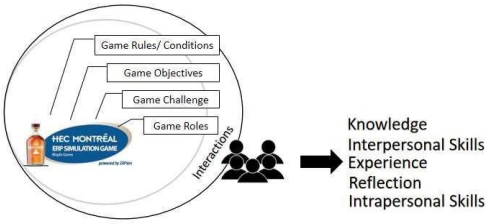

Fig. 1. Game components.

2.3 Pre-Game Assessment

A pre-game examination was undertaken to provide a baseline understanding of participants' strategic decision-making ability, teamwork skills, and ERP system expertise. This assessment included self-reported questionnaire items, in keeping with constructivist ideas of active involvement and individual knowledge production as well as team collaboration, social engagement and technology-supported tools. The 5-point Likert scale is employed where 1 indicates totally disagree, 2-disagree, 3- neither agree or disagree, 4-agree and 5-totally agree as listed in Table 1.

2.4 ERPSim Maple Gameplay

ERPSim is a business simulation game for SAP ERP and SAP S/4HANA in which participants run their virtual firm in a competitive market using a real ERP system. Participants will be able to observe and analyze the results of their decisions, which is quite like what they would encounter in the workplace. The game facilitates learning by establishing a dynamic environment with continues-accelerated time simulation, automated administrative activities, and simulated business engagements. They would

also need to acquire technical system skills, understand the business processes, collaborate and work in teams, and learn to use company live data. The ERPSim Maple game is a replacement for the earlier Distribution game, offered by HEC Montreal.

Participants were immersed in the ERPSim Maple game, participating in team- based learning activities within the virtual team environment where they actively con- struct knowledge by making strategic decisions, communicating with team members, and addressing real-world business difficulties in the simulation game. These interactions were created to foster knowledge building, critical thinking, and interdisciplinary learning, in accordance with constructivist ideas. The synchronous approach was used, in which all teams played the simulation game at the same time for about 2.5 hours. The simulation game was reloaded to give students a new start and to give equal opportunities to all teams. Teams played the game in a single session during this time. The simulator was programmed to allow 15 minutes per round for a total of 5 rounds. Within the constructivist framework, a 10-minute break was granted between rounds to re-strategize and enable collaborative decision-making, problem-solving, and knowledge acquisition. The students were obliged to complete the post-game assessment following the final game.

2.5 Post-Game Assessment

Following the gameplay session, participants completed a post-game evaluation to measure the impact of team-based learning within the constructivist framework. The post-game evaluation, like the pre-game assessment, includes objective measures and self-report questionnaires to track changes in participants' strategic decision-making ability, teamwork skills, and ERP system knowledge. This enabled an examination of the learning outcomes and skill development as a result of the constructivist virtual team learning experience. Table 1 also lists the post-game assessment which was also based on the 5-point Likert scale i.e., 1-totally disagree, 2-disagree, 3- neither agree or disagree, 4-agree and 5-totally agree. Table 1 lists the pre- and post-game assessment.

Table 1. Pre and Post Game Assessment.

Constructivism Theory	Pre-Game	Post-Game
Emphasizes knowledge production by virtual team members.	I expect that participating in the gameplay will enhance my under- standing in enterprise business pro- cesses and integration.	I feel that participating in the gameplay enhanced my under- standing in enterprise business processes and integration.
Emphasizes collaborative learning and social engagement among virtual team members.	I anticipate that the gameplay will encourage effective collaboration among team members in virtual organization settings.	The gameplay provided opportunities for effective collaboration among team members in virtual organization settings.
Emphasizes virtual team members' active engagement in knowledge construc- tion.	I believe that participating in the gameplay will improve my problem-solving skills in response to business challenges.	Participating in the gameplay improved my problem-solving skills in response to business challenges.

Emphasizes virtual team members' communication and dia- logue in knowledge development.	I expect that the gameplay will encourage effective communication among team members to exchange business information.	The gameplay encouraged effec- tive communication among team members to exchange business information.
Emphasizes strategic decision making in solving problems.	I anticipate that participating in the ERPSim Maple game will improve my ability to make strategic deci- sions based on realistic business scenarios.	The gameplay improved my abil- ity to make strategic decisions based on realistic business sce- narios.
Emphasizes active engagement and participation among virtual team members.	I expect that the gameplay will pro- mote active engagement and partic- ipation from all team members through assigned roles and respon- sibilities.	ERPSim Maplestory promotes active engagement and participa- tion from all team members through assigned roles and responsibilities.
Emphasizes critical thinking skills of learners.	I believe that participating in the ERPSim Maple game will enhance my critical thinking skills in response to business challenges.	The gameplay enhanced my criti- cal thinking skills in response to business challenges.
Demonstrates active collaboration among virtual team members	I anticipate that participating in the ERPSim Maple game will be an effective platform to demonstrate active collaboration among team members.	ERPSim Maple game is an effective platform to demonstrate active collaboration among team members.
Emphasizes authentic learning experiences for virtual team members	I expect that the gameplay will pro- vide a realistic representation of business operations and expose my- self to real-world business operations.	ERPSim Maple game provided a realistic representation of busi- ness operations which allows me to improve my ability to make strategic decisions based on real- istic business scenarios.
Emphasizes use of technology-supported tools for active collaboration	I anticipate that participating in the gameplay will improve my adaptability to technology used in virtual teams' environments.	ERPSim Maple game allows me to demonstrate adaptability to re- mote collaboration tools and technology as a virtual team member.

3 Results and Analysis

Overall, the findings show that team-based learning in the serious game ERPSim, influenced by constructivism theory, improves participants' strategic decision-making abilities, teamwork skills, and ERP system knowledge. According to the findings, the immersive virtual team environment encourages interdisciplinary learning, problem-solving, and critical thinking, which contributes to the development of skills required for success in the virtual work environment.

Moreover, Fig 2 illustrates the comparison of the pre- and post-game mean scores for each questionnaire item. These findings provide the overview of self-assessment from all participants before and after the gameplay. The average mean of all items is 3.8525 with standard deviation of 0.8566. This denotes that before the gameplay, the

Participants had varying expectations regarding playing the serious game. However, the average mean is 4.2407 with a standard deviation of 0.6164. The higher average mean suggests that after playing the serious game, participants' expectations on average rose. Additionally, the participants' expectations got more consistent or aligned. The findings add to the increasing body of research on constructivist virtual team learning experiences and offer insights for educators and practitioners looking to improve virtual team learning settings.

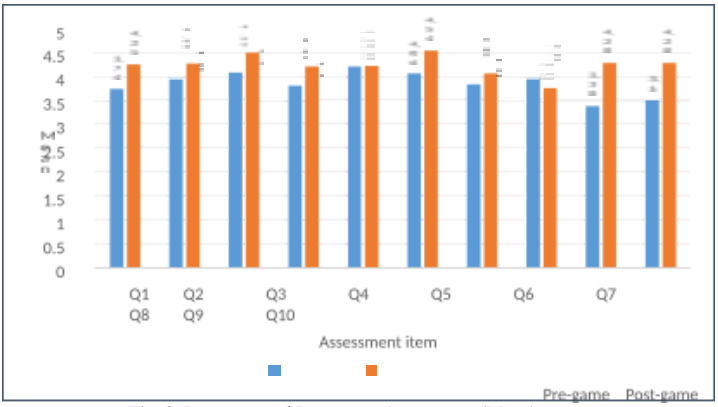

Fig. 2. Pre-game and Post-game Assessment (Mean)

Furthermore, a comparison of pre-game and post-game scores was computed using paired t-test to reveal the usefulness of the virtual team environment in facilitating knowledge creation, collaborative learning, active engagement or participation as well as critical thinking and problem-solving capacities among participants in this serious game. The results are shown in Table 3.

Table 3. Result of Paired T-Test based on the Questionnaire Item

	Serious Game	T-stat	*p*-value
Q1	Participants discovered that the gameplay provides an interactive and engaging environment for actively creating knowledge about enterprise business processes and ERP system integration.	-4.26	7.58E-05
Q2	Participants discovered that the gameplay encourages virtual team members to collaborate, allowing for effective teamwork and knowledge sharing.	-2.89	5.48E-03
Q3	Participants discovered that the gameplay requires them to use problem-solving strategies in a virtual team con- text, hence improving their problem-solving skills.	-3.72	4.52E-04

Q4	Participants discovered that the gameplay inspires team members to use communication tools and channels for effective collaboration and information exchange.	-3.29	1.71E-03
Q5	Participants discovered that the gameplay improves their capacity to make strategic judgments inside the simu- lated business settings, encouraging active participation.	-0.15	8.80E-01
Q6	Participants discovered that the gameplay stimulates active participation and engagement from all virtual team members through the game's given roles and duties.	-3.26	1.89E-03
Q7	Participants discovered that the gameplay challenges them to think critically and analyze complicated business problems, hence improving their critical thinking skills.	-1.46	1.50E-01
Q8	Participants discovered that the gameplay fosters collab- oration among participants from various backgrounds, al- lowing them to use their knowledge in a more integrated manner.	1.50	1.39E-01
Q9	Participants found that the gameplay imitates real-world business processes, exposing them to authentic difficul- ties and circumstances.	-6.60	1.37E-08
Q10	Participants found that the gameplay improves their capacity to adapt to remote collaboration tools and technology utilized in virtual team contexts.	-6.71	8.82E-09

Our analysis of the pre- and post-game participant comments indicates that there is inadequate statistical support to claim that the gameplay greatly improved the participants' critical thinking abilities and their capacity to assimilate knowledge. The predetermined roles of the players at the outset of the game may be the cause for this where the participants were too focused on their own roles. It was discovered that the p-values for questions Q5, Q7, and Q8 exceeded the significance level of 0.05. However, our study does offer statistically significant evidence, at the significance level of 0.05, to draw the conclusion that the participants did in fact discover the following advantages from engaging in the serious game, ERPSim Maple: improved problem-solving skills, improved comprehension of enterprise business processes and ERP systems, active participation through teamwork and knowledge sharing, encouragement of engagement from all virtual team members and support for active collaborative in solving problems. These results all support constructivism theory and highlight the power of team-based learning in serious games to improve virtual team performance and prepare students for the challenges of the virtual work environment.

4 Conclusions

The Malaysia Education Blueprint 2013-2025 emphasizes providing students with 21st-century skills and preparing them for employment [21] [22]. It values experiential learning, collaborative problem-solving, a technology-enabled pedagogies. The incorporation of serious games such as ERPSim corresponds with the blueprint's goals by offering students interactive learning experiences that stimulate critical thinking, creativity, and teamwork.

This study provides persuasive evidence that team-based learning in serious games like the ERPSim Maple game improves virtual team performance and facilitates learning within a constructivist framework. This study sheds light on the potential of constructivist learning approaches in virtual team environments, emphasizing their importance in preparing students for the demands of the modern virtual work landscape. The ERPSim Maple game improves students' grasp of difficult concepts linked to ERP systems, their capacity to make strategic decisions, and their competence in remote collaboration tools by actively engaging them in team-based learning—skills that are critical for employability in the digital era.

Our study shows that using serious games in teaching and learning activities can establish a student-centered learning environment that prepares students for the de- mands of the modern workforce. ERPSim and other serious games integrated into the curriculum provide students with the requisite skills and competencies, improves virtual team performance, encourages learning, and develops critical abilities that prepares students with the skills they need to survive in the digital age and contribute to the nation's development by adopting creative ways and exploiting the potential of serious games.

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