Asia-Pacific Journal of Information Technology and Multimedia 15(1) 2026: 282 – 294
https://doi.org/10.17576/apjitm-2026-1501-17

Design and Validation Study for a Conceptual Framework in Multiplayer Educational Games as an Agent for Social Learning and Critical Thinking

Kajian Reka Bentuk dan Penentusahan bagi Rangka Konseptual dalam Permainan Pendidikan Berbilang Pemain sebagai Agen Pembelajaran Sosial dan Pemikiran Kritis

*Nuraziera Mohd Hatta[1], Ibrahim Ahmad[*1], Laili Farhana Md Ibharim[2], Norsiah Bahari[3], Heru Astikasari Setya Murti[4]*

[1]Universiti Teknikal Malaysia Melaka, Malaysia
[2] Universiti Pendidikan Sultan Idris (UPSI), Tanjung Malim, Perak, Malaysia
[3] Institut Pendidikan Guru Perempuan Melayu, Melaka, Malaysia
[4]Universitas Kristen Satya Wacana Salatiga, Central Java, Indonesia

[*]Corresponding author: ibrahim@utem.edu.my

Received 8 September 2025
Accepted 17 March 2026, Available online 30 June 2026

ABSTRACT

The opportunities of games to become active environment that facilitates Social Learning (SL) and Critical Thinking (CT) are opened by the integration of multiplayer educational games into educational process. This research seeks to confirm a conceptual framework to explicate how multiplayer educational games can be used to facilitate pedagogy by providing adaptive, interactive, and collaborative learning experiences. The framework was created through the incorporation of the ideas of Social Learning Theory, Community of Inquiry Framework, Constructivist Learning Theory, and well-known models of critical thinking. With the Design and Development Research (DDR) approach, the research adopted an expert validation approach to test the framework with respect to content validity, theoretical consistency, clarity and practicality. The framework was tested by six professionals in the field of educational technology, instructional design, and game-based learning using rubrics and qualitative evaluation. The results show that there is a high level of agreement on all dimensions of validation (mean = 4.65), which implies that the framework has a high level of theoretical consistency and a clear conceptual framework. The framework suggests two main constructs, SL and CT, which are manifested by multiplayer game activities such as collaboration, feedback, problem solving, and reflective interaction. Essentially, the framework introduces multiplayer educational games as learning systems that promote understanding, interaction, and critical thinking by sharing experiences and engaging in social interaction. Simply, games are created in such a way that encourages socialization and critical thinking.

Keywords: Conceptual Framework, Multiplayer Educational Games, Social Learning, Critical Thinking, Design and Development Research, Expert Validation.

ABSTRAK

Integrasi permainan pendidikan berbilang pemain dalam persekitaran pembelajaran menawarkan peluang unik untuk meletakkan permainan sebagai agen aktif yang memudah cara pembelajaran sosial dan pemikiran kritis. Kajian ini membentangkan reka bentuk dan penentusahan bagi satu rangka konseptual yang mentakrifkan bagaimana permainan pendidikan berbilang pemain dapat berfungsi sebagai pemangkin pedagogi melalui mekanisme adaptif, interaktif dan kolaboratif. Rangka tersebut dibangunkan melalui sintesis prinsip daripada Social Learning Theory, the Community of Inquiry framework, Constructivist Learning Theory, serta model Pemikiran Kritis yang telah mapan. Dengan menggunakan pendekatan Penyelidikan Reka Bentuk dan Pembangunan (DDR), kajian ini melibatkan penilaian pakar untuk meneliti kesesuaian kandungan, penjajaran teori, kejelasan, dan kebolehgunaan praktikal rangka yang dibangunkan. Seramai enam orang pakar dalam bidang teknologi pendidikan, reka bentuk pengajaran dan pembelajaran berasaskan permainan telah menilai rangka tersebut menggunakan rubrik berstruktur serta maklum balas kualitatif. Hasil penilaian menunjukkan tahap persetujuan yang tinggi (min = 4.65) bagi semua dimensi penentusahan, sekali gus mengesahkan ketekalan teori dan kejelasan reka bentuk rangka yang dibangunkan. Rangka yang telah disahkan ini mengenal pasti dua konstruk utama iaitu Pembelajaran Sosial dan Pemikiran Kritis, serta hubungan operasinya dengan ciri permainan berbilang pemain seperti kolaborasi, maklum balas, penyelesaian masalah, dan interaksi reflektif. Dengan memposisikan permainan pendidikan sebagai sistem perantara dan bukannya alat pasif, rangka ini menyerlahkan peranan permainan digital sebagai agen yang merangsang perkongsian kefahaman, inkuiri, dan penaakulan dalam konteks pembelajaran digital. Kajian ini menyumbang kepada pembangunan teori pembelajaran berasaskan permainan dengan menyediakan asas yang telah disahkan untuk pembangunan prototaip serta penilaian empirikal pada masa hadapan

Kata kunci: Permainan Pendidikan Dalam Talian Berbilang Pemain Secara Besar-besaran, Pemikiran Kritis, Pembelajaran Sosial, Reka Bentuk Permainan Pendidikan.

INTRODUCTION

In recent times, multiplayer educational games have emerged as one of the most effective learning tools that merge the elements of gameplay and pedagogically informed activities. In addition to providing engaging gaming experiences, they can help learners develop cognitive and social skills and engage in active learning processes. By interacting with each other and solving problems collaboratively, participants will be able to jointly build up their knowledge base and learn the material (Coleman & Money, 2019; Hamari et al., 2016; Arnab et al., 2014). Multimedia elements, including visuals, sounds, and other stimuli, are likely to enhance learner engagement through motivation and attention increase. Nonetheless, current educational game designs are largely focused on superficial interaction and/or static adjustments of difficulty levels but do not offer adaptive learning experiences (Zhang et al., 2024; Othlinghaus-Wulhorst & Hoppe, 2020). As a result, there is a lack of evidence about integrating pedagogical constructs, such as critical thinking (CT) and social learning (SL), into the game design principles (Clark & Mayer, 2016; Mayer, 2014).

The emergence of adaptive learning systems that utilize computational design principles to adapt to the learner demonstrates the potential of the technology (Aleven et al., 2021; Shute & Ventura, 2020). However, when it comes to multiplayer educational game design, there is no framework that could help link theoretical aspects with the design to transform the environment

itself into an agent of learning. It means that educators and developers are lacking a tool that would allow designing systems encouraging higher-order thinking, collaboration, and reflection in the context of multiparty digital environments.

The proposed study aims to fill in this gap by designing and validating a multiplayer educational games' conceptual framework. The conceptual model will include learning theories and models as well as design features that will enable the development of multiplayer educational games as intelligent environments that facilitate social learning and CT. For this purpose, the present project will use the following theoretical frameworks: Social Learning Theory by Bandura (1977), the Community of Inquiry Framework (COI) by Garrison et al. (2000), Constructivist Learning Theory (Piaget, 1973; Vygotsky, 1978) and CT models suggested by Facione (1990), Paul and Elder (2014), Bloom (1956), and Kolb (1984). All these theories highlight the importance of reflection, social interaction, and experience for higher-level cognitive development. Using the Design-Deliver-Revalidate (DDR) method, the research will be carried out in two phases: (1) design (i.e., conceptual design of the relationships between the aspects of design, pedagogy, and cognition) and (2) validation (i.e., expert analysis of the theoretical foundation). Expert reviews by specialists in education and educational technology design will be used as a primary evaluation method to assess the relevance, clarity, theory-groundedness, and usability of the design (Richey & Klein, 2014; Wang & Hannafin, 2005).

METHODOLOGY

The main method applied in this study was the Design and Development Research (DDR). DDR was selected since the study was to develop and test a conceptual framework on the basis of known learning theories. DDR is typical of the educational research that aims at developing practical and theory-based solutions via repeated evaluation (Richey and Klein, 2014; Wang and Hannafin, 2005; Sahrir et al., 2012; Karunamoorthy and Mazalan, 2024).

In order to ensure that the framework was well-grounded in theory as well as valid, the study was based on two primary stages: developing the conceptual framework and getting a review of experts. In the first phase, the focus was on finding and combining key ideas about Social Learning (SL) and Critical Thinking (CT) in multiplayer educational games. During the second phase, the framework was reviewed by experts to ensure that it was clear, aligned with theory, and practical. All the phases were well planned to ensure that the teaching concepts, the features of the game design, and the learning objectives were aligned with one another.

RESEARCH DESIGN

The research strategy was a qualitative, design-based one to aid in the formulation and testing of the proposed framework. The research involved combining theories and receiving expert feedback instead of involving learners as participants. The principal aim was to create a computation model of multiplayer educational games that facilitates SL and CT.efinement (Asadzadeh and Shahrokhi, 2024; Okudan et al., 2009). This cyclic approach enabled the study to repeatedly test the correlation between pedagogical principles and game design features in the process of framework development. The phases of the DDR adapted to the present study are shown in Figure 1.

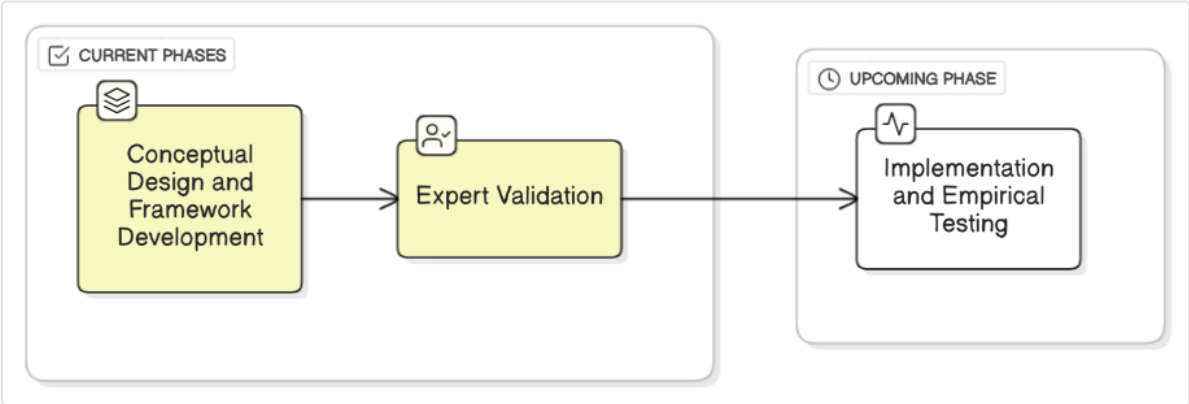

FIGURE 1. Overview of the DDR Phases Highlighting the Current Study

DATA SOURCES AND SCOPE

Data for the design phase were drawn from an extensive literature synthesis encompassing Learning theories (Social Learning Theory, Constructivist Learning Theory, Cognitive Load Theory, Experiential Learning Theory, and the Community of Inquiry Framework). CT frameworks (Facione, 1990; Paul & Elder, 2014; Bloom, 1956; Kolb, 1984). Computational design models related to adaptive systems and educational games were also considered (Ariya et al., 2019; Akkaya & Akpinar, 2022). These sources were analyzed to identify essential constructs and design principles that would inform the structure of the proposed framework. For the validation phase, five experts were purposively selected from the fields of educational technology, game-based learning, and instructional design. Their role was to review the framework's theoretical consistency, content relevance, and clarity.

CONCEPTUAL FRAMEWORK DEVELOPMENT: PROCEDURE

The concept development was an outcome of a well-structured and systematic process which comprised four distinct phases (Table 1). Below are the contributions made by each of the phases while designing the structure of the multiplayer games from theoretical foundation:

TABLE 1. Procedure for Conceptual Framework Development

Phase	**Description**	**Output / Focus**
1. Identification of Core Constructs	Literature was reviewed to extract key theoretical constructs relevant to CT and SL.	Defined constructs and relevant learning theories.
2. Theoretical Integration and Abstraction	Synthesized relationships among constructs to determine their computational representation in adaptive game design.	Derived adaptive design principles.
3. Framework Structuring	Organized constructs into three interrelated layers: Cognitive, Social, and Multimedia Adaptivity. Structured using an Input–Process–Output (I–P–O) logic.	Initial framework model.
4. Design Verification and Logical Alignment	Reviewed for theoretical consistency and logical flow across components before expert validation.	Final conceptual framework ready for validation.

To provide a clearer overview, the stages are illustrated in Figure 2, showing the iterative nature of the development process.

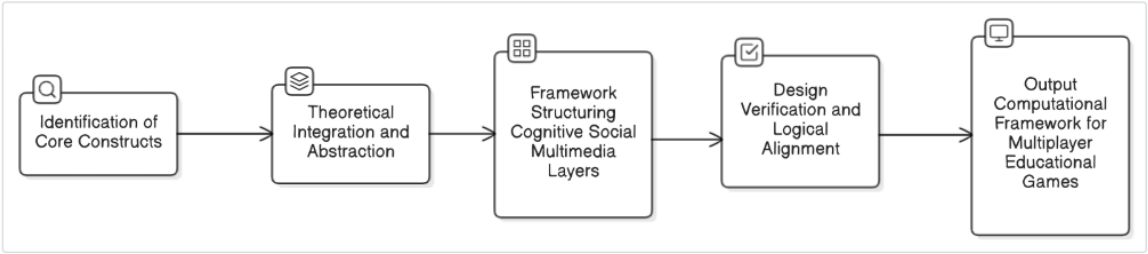

FIGURE 2. Conceptual Framework Development Process

EXPERT VALIDATION PROCESS

After the conceptual framework was developed, the study proceeded with an expert validation process to evaluate whether the framework was theoretically reliable, clearly structured, and practically suitable for multiplayer educational game development (Asadzadeh & Shahrokhi, 2024; Okudan et al., 2009). The main objective of this stage was to confirm that the framework was grounded in established learning theories while also being applicable within adaptive game-based learning environments.

The validation process involved collecting feedback from five experts in educational game design, instructional technology, and digital learning systems. These experts were intentionally selected because they could provide both technical and pedagogical insights. To qualify for participation, each expert was required to have at least five years of professional experience in related fields, involvement in research or publications connected to educational technology or serious games, and familiarity with learning theories and assessment frameworks.

To facilitate the evaluation process, the study has developed a validation rubric on four main aspects; content relevance, clarity, theoretical alignment, and practical applicability. These were the criteria to assess whether the framework was suitable to reflect the intended SL and CT constructs and be applicable to developing a multiplayer educational game.

All the experts judged the framework on a 5-point Likert scale (1-Strongly Disagree to 5-Strongly Agree). Open-ended questions were also provided to enable more comments and recommendations to improve them. The answers were categorised descriptively to find the general degree of consensus and to interpret qualitative feedback to make the framework better. This procedure gave greater strength to the content validity and face validity of the intended conceptual framework.

METHODOLOGICAL PROCESS: OUTPUT

As a result of the DDR process, a tested conceptual framework was generated that deems multiplayer educational games as a tool to help SL and CT (Bandura, 1977; Garrison et al., 2000; Piaget, 1973; Vygotsky, 1978; Facione, 1990; Paul and Elder, 2014; Bloom, 1956; Kolb, 1984). Theoretical constructs were matched with practical design foundational parts within the conceptual framework (Ariya et al., 2019; Akkaya & Akpinar, 2022; Dallaqua et al., 2023). It has been noted that SL is presented in four fundamental aspects that are collaboration, communication, feedback and reflection, and social interaction. Meanwhile, CT involves analysis, evaluation, inference, explanation, interpretation, and self-regulation. The conceptual framework makes these ideas conceptually linked with particular game design foundational elements, including real-time communication tools, collaborative missions, feedback and

tracking systems, and problem-solving situations that promote collaborative reasoning and reflective inquiry since the conceptual framework facilitates the learning process.

Expert validation provided evidence that the coceptual framework exhibits profound theoretical cohesion and practical correspondence to the game based-learning design. Theorists assert that the conceptual framework is very clear when the conceptual framework depicts the relationships between constructs. The conceptual framework that was validated offered a strong theoretical and structural basis that would be used in the further development of the prototype and its empirical testing in the context of the multiplayer educational game. The conceptual framework enlightens the educational professionals and software developers who may be interested in developing digital learning experiences, which are adaptive, collaborative, and cognitively engaging because the conceptual framework acts as a guide in the development.

RESULTS AND DISCUSSION

OVERVIEW OF RESULTS

Following the DDR approach, this section shares findings from both the framework development and expert validation phases. The results are organized into four sections: conceptual framework design, integration of SL and CT with game design, expert validation findings, and discussion based on learning theories.

The first phase focused on creating a conceptual framework that brings together Social Learning (SL) and Critical Thinking (CT) in a multiplayer educational game. In this phase, key theoretical ideas were identified and turned into practical game design elements to support collaborative and reflective learning.

The second phase involved experts reviewing the proposed framework to check its validity. They looked at its theoretical consistency, clarity, relevance, and how well it fits multiplayer educational game design. The results show that the framework has a strong foundation and good potential to support SL and CT in digital game-based learning.

CONCEPTUAL FRAMEWORK DESIGN RESULTS

The theoretical framework was to merge the SL and CT constructs into one framework that would enable collaborative, reflective and adaptive learning in learning in multi-player education games. This was led by the DDR approach which put emphasis on how the theoretical concepts can be translated into practical design features which are pedagogically based. To promote systematic underpinning, the framework evolution was based on a tiered conceptual procedure that relates theories to game design aspects and anticipated learning results. This linear structure provided theoretical consistency, but also allowed one to easily follow the relationships between the pedagogical concepts and the way they were applied to the game. Figure 3 shows the overall design process.

FIGURE 3. Framework Design Flow from Theories to Learning Outcomes.

Constructs in SL and CT were selected according to the existing learning theories. The SL dimension was based on the SL Theory (1977) of Bandura, Community of Inquiry (Garrison et al., 2000) and Constructivist Learning Theory (Piaget, 1973; Vygotsky, 1978). These models emphasize on cooperation, social interaction and reflective feedback as sources of learning through collective experience. In the meantime, the CT dimension was based on the CT Framework by Facione (1990), the Model by Paul and Elder (2014), the Taxonomy of Bloom (1956) and the Experiential Learning Theory by Kolb (1984), which identify reasoning process, evaluation, interpretation, and self-regulated inquiry as essential cognitive processes. The theoretical alignment of SL and CT constructs is summarized in Tables 2 and 3.

TABLE 2. Theoretical Derivation of SL Core Elements

Model / Theory	Collaboration	Communication	Observation	Modeling	Feedback & Reflection	Social Interaction	Constructivist Learning
SL Theory (Bandura)	✓	✓	✓	✓	✓	✓	—
Community of Inquiry	✓	✓	—	—	✓	✓	—
Constructivist Learning Theory	✓	✓	—	—	✓	✓	✓

✓indicates theoretical support for the construct within each model. The synthesis confirms four SL core elements collaboration, communication, feedback and reflection, and social interaction as foundational to the framework.

TABLE 3. Theoretical Derivation of CT Core Elements

Model / Theory	Remembering	Understanding	Applying	Analysing	Evaluating	Creating	Interpretation	Inference	Explanation	Self-Regulation
Facione's CTFramework	—	—	—	✓	✓	—	✓	✓	✓	✓
Bloom's Taxonomy Model	✓	✓	✓	✓	✓	✓	—	—	—	—
Paul–Elder CTFramework	—	—	—	✓	✓	—	—	✓	✓	—
Kolb's Experiential Learning Theory	—	—	—	—	—	—	—	—	—	✓

✓indicates theoretical emphasis for the construct within each model. The synthesis identifies six recurring CT elements: analysis, evaluation, inference, interpretation, explanation, and self-regulation was used in the framework design.

TABLE 4. Mapping of SL and CT Elements to Game Features and Mechanics

SL & CT Theory	Characteristics of SL and CT	Game Elements		References
		Game Features	Game Mechanics	
SL Theory: 1. SL Theory (Bandura) 2. Community of Inquiry (CoI) 3. Constructivist Learning Theory (CLT)	• Collaboration • Communication • Feedback & Reflections • Social Interaction	• Communication Tools • Collaboration Tools • Social Interaction Tools • Feedback & Tracking system • Reward System	• Chatbox/Realtime chat • Team-Based Missions • Role-Based Team Gameplay • Multiplayer Interactions, • Virtual Social Spaces • Real-Time Feedback • Point, Badges, Leaderboard	Garris, Ahlers, & Driskell (2002); Prensky (2001) Gee (2007); Rama et al. (2012) Kolb (1984); Ng & Raghbir (2021) Bandura (1977); Gee (2007)
CT Theory: 1. Facione's Framework 2. Paul-Elder Framework 3. Kolb's Experiential Learning Cycle 4. Bloom Taxanomy	• Analysis • Evaluation • Inference • Integration • Explanation • Self-Regulation	• Collaboration Tools • Feedback & Tracking system • Reward System • Problem Solving Tools • Analytics & Interpretation Tools • Dynamic & Adaption Tools	• Team-Based Missions • Role-Based Team Gameplay • Real-Time Feedback • Problem-Solving Tasks • Scenario Challenges • Clue-Based Tasks • Narrative-Driven Quests • Interpreting Symbols • Maps and Environmental Clues • Adaptive Difficulty	Rama, Black, van Es, & Warschauer (2012) Ng & Raghbir (2021) Gong, Ren, Wu, & Fang (2019) Oksanen & Hämäläinen (2013) Sailer, Hense, Mayr, & Mandl (2020)

The Conceptual Framework of Multiplayer Educational Games as an Agent of SL and CT in Figure 4 was based on the mapping in Table 4. This unified framework defines the theoretical-to-design relationship, which is a way in which core constructs, game features, and mechanics interact to create collaborative and reflective learning experiences in multiplayer settings.

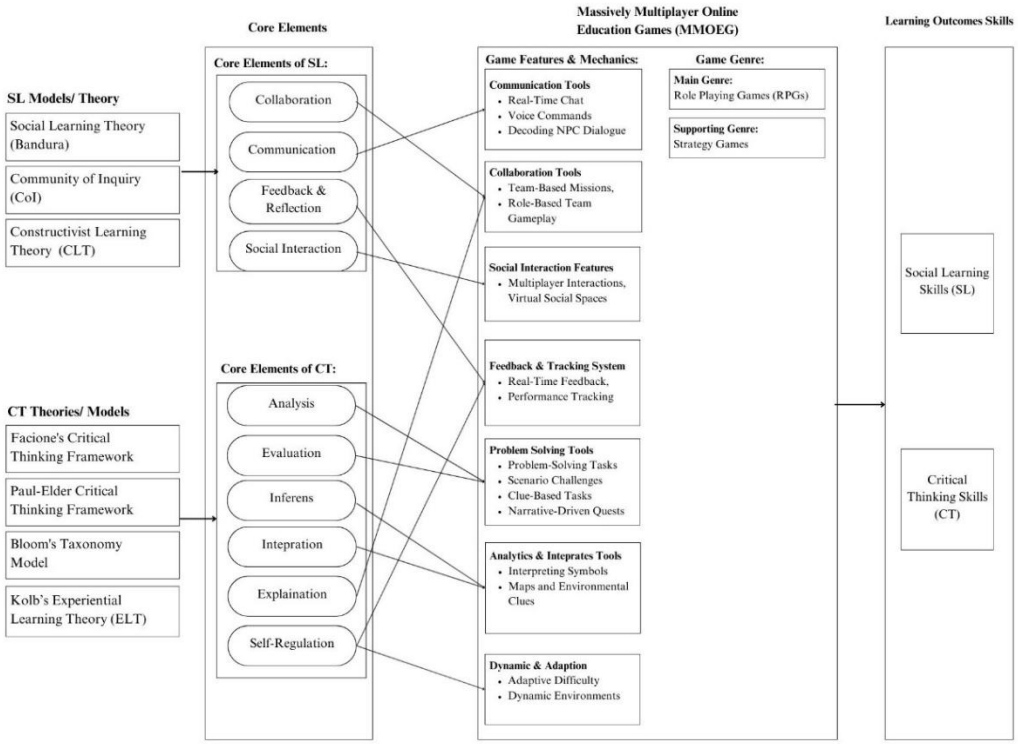

FIGURE 4. Conceptual Framework for Multiplayer Educational Games as an Agent for SL and Critical Thinking

EXPERT RESULTS AND INTERPRETATION OF RESULTS

The professional validation stage was to test the developed Conceptual framework on the background of its content relevancy, presentation clarity, theoretical consistency, and applicability. The expert review is a suggested process in the Design and DDR method to validate theoretical consistency and design practicability prior to empirical execution (Richey and Klein, 2014; Wang and Hannafin, 2005; Kholid and Supriyadi, 2023).

This phase involved six domain experts who have various academic and professional backgrounds and they represented the areas of educational technology, instructional design, computer science and game-based learning. The validation strategy chosen was expert judgment because it is known to provide content and face validity of educational design frameworks (Lawshe, 1975; Shaheen and Fotaris, 2024; Ratnawati et al., 2020). The framework diagram, theoretical summary and evaluation rubric were presented to each expert on a 5-point Likert scale (Strongly Disagree to Strongly Agree) and qualitative feedback provided in open-ended sections.

The summary of the validation results is provided in Table 5 that includes the mean scores and major qualitative comments obtained on the basis of the answers of the experts.

TABLE 5. Expert Validation Results for the Conceptual Framework

Validation Criterion	Mean Score (n=6)	Interpretation	Summary of Expert Comments
Content Relevance	4.7	Very High	Framework comprehensively represents the constructs of SL and CT; strong alignment between theoretical foundations and game design elements.
Clarity of Framework Components	4.5	High	Diagram and written description was concise and well-organized; proposed the use of color or spacing to distinguish between constructs.
Theoretical Alignment	4.8	Very High	The combination of SL and CT theory was coherent and logically aligned to the principles of game design.
Practical Applicability	4.6	High	Framework can be used to develop educational games and in adaptive multiplayer environments, and is a useful resource to educators and developers.
Overall Mean	4.65	High to Very High Agreement	Experts confirmed the framework's theoretical robustness, pedagogical soundness, and practical relevance.

The mean score of 4.65 is high to very high, which demonstrates that the six experts have a high degree of agreement with the framework, which proves that it is valid and can be used. Three key strengths were highlighted in qualitative feedback:

1. Good theoretical cohesion in line with the existing models on social and critical learning (Bandura, 1977; Facione, 1990; Coleman and Money, 2019; Irabor et al., 2023).
2. Real-world application, because the framework offers explicit design instructions to adaptive, multiplayer-based collaboration (Myers et al., 2023; Tan and Chong, 2023; Jatayu et al., 2024).
3. Clarity and organization, where specialists report a visual representation to be an effective connection between theory and design (Shaheen and Fotaris, 2024).

Although small recommendations were made such as improving the readability of the diagram and providing brief descriptions of each construct, which were later included into the final framework. These improvements are a characteristic of the DDR process (Richey and Klein, 2014; Wang and Hannafin, 2005; Kholid and Supriyadi, 2023) as it is iterative in nature, which confirms the theoretical basis and practical application of the conceptual framework. The results of the validation thus confirm that the proposed Conceptual framework is theoretically based, pedagogically consistent, and practically implementable, which is why it is ready to be further developed as a prototype and empirically tested.

DISCUSSION

The expert validation process has confirmed not only theoretical correctness but also practical feasibility of the proposed framework and its ability to properly integrate SL and CT concepts within the game mechanics of a multiplayer educational game. Namely, the described framework clearly shows how learning can happen through reflective, collaborative interaction and feedback, which is in accordance with the principles of Bandura's Social Learning Theory and the Community of Inquiry (CoI) framework, highlighting the importance of social interaction for the development of new knowledge. The experts emphasized that collaborative features, live interaction, and mission-based gameplay help create an environment conducive to SL, allowing learners to watch, replicate and negotiate meanings together. As for CT, the framework successfully represents the main cognitive operations like analysis, evaluation,

inference and self-regulation by means of solving problems, receiving adaptive feedback and engaging in mission-like tasks and challenges. These game mechanics reflect the ideas presented in the models by Facione and Paul-Elder who stress the importance of critical and structured thinking during learning activities.

Thus, the integration of SL and CT within one model creates a solid background for the development of multiplayer learning games. The convergence of social interaction and cognition provides for a balanced model of collaborative learning and reasoning, reflecting a constructivist approach to learning. Based on the findings of the expert validation, the proposed framework can be seen as a practical solution that allows for structuring interactions in a way that facilitates educational activities. The proposed framework and its detailed mappings of theoretical constructs to game mechanics can be used as a guideline when developing games intended for learning purposes. In practice, the suggested model can provide for developing games with various adaptive and educational functions. Theoretically, this work makes it possible to establish closer ties between educational psychology and computer game design. Moreover, it lays the grounds for further investigation of the topic, including prototype development and user evaluation of multiplayer educational games.

CONCLUSION & FUTURE WORK

This paper designed and validated a conceptual framework for multiplayer educational games serving as agents for social SL and CT. This framework drew from existing pedagogical theories and included constructs of collaboration, communication, feedback, reflection, analysis, evaluation, and self-regulation. Employing DDR methodology, the conceptualization process involved translation of theoretical constructs into concrete game-related components to accommodate the cognitive and social dimensions of learning. Expert review provided evidence for the high theoretical relevance, well-designed structure, and practical value of the proposed framework. It allowed recognizing the great potential that the framework possessed to foster the development of multiplayer games characterized by adaptiveness, collaboration, and reflection in problem-solving and interaction. Thus, the developed framework offers a structured approach to linking theory and practice, whereby all gameplay features are aligned with specified pedagogical functions and contribute to the achievement of desired learning results by means of involvement and reflection.

The present study made an important contribution to the field of educational game design by addressing the link between pedagogy and technology in developing such software. The integration of SL and CT constructs into game mechanics offered a replicable framework for designing multiplayer games aimed at fostering learners' 21st century competencies. Further research should be devoted to the empirical verification of the validity and effectiveness of this framework by developing prototypes and conducting pilot testing among potential learners. Incorporation of the adaptive intelligence functionality and use of learning analytics can provide additional benefits.

ACKNOWLEDGEMENT

This study was funded by the Ministry of Higher Education (MOHE) of Malaysia through the Fundamental Research Grant Scheme (FRGS 2023-1), No: FRGS/1/2023/ICT01/UTEM/02/2. The authors would also like to express our sincere thanks to Universiti Teknikal Malaysia Melaka (UTeM) for all their support.

REFERENCES

Akkaya, A. & Akpinar, Y. 2022. Experiential serious-game design for development of knowledge of object-oriented programming and computational thinking skills. *Computer Science Education*, 32(4): 476–501.

Aleven, V., Rummel, N. & Koedinger, K. 2021. Learning by doing: adaptive learning in intelligent tutoring systems. *International Journal of Artificial Intelligence in Education*, 31(3): 423–440.

Arnab, S. et al. 2014. Beyond serious games: the next generation of cultural artifacts. Lecture Notes in Computer Science, 83–96.

Ariya, P., Puritat, K. & Intawong, K. 2019. Knowledge expert co-creation-based conceptual framework for educational game. *Proceedings of the Joint International Conference on Digital Arts, Media and Technology* (ECTI DAMT-NCON), 184–187. IEEE.

Asadzadeh, A. & Shahrokhi, S.H. 2024. Serious educational games for children: a comprehensive framework. *Heliyon*, 10: e28108.

Bandura, A. 1977. Social Learning Theory. Englewood Cliffs, NJ: Prentice-Hall.

Bloom, B.S. 1956. Taxonomy of Educational Objectives. New York: Longman.

Clark, R.C. & Mayer, R.E. 2016. E-Learning and the Science of Instruction. 4th ed. Hoboken, NJ: Wiley.

Coleman, T.E. & Money, A.G. 2019. Student-centred digital game–based learning: a conceptual framework and survey of the state of the art. *Higher Education*, 79(3): 415–457.

Dallaqua, M.F. et al. 2023. Serious games research streams for social change: critical review and framing. *British Journal of Educational Technology*.

Facione, P.A. 1990. The Delphi Report: Critical Thinking. Millbrae, CA: American Philosophical Association.

Garrison, D.R., Anderson, T. & Archer, W. 2000. Critical inquiry in a text-based environment: computer conferencing in higher education. *The Internet and Higher Education*, 2(2–3): 87–105.

Hamari, J., Koivisto, J. & Sarsa, H. 2016. Does gamification work? – A literature review of empirical studies on gamification. Computers in Human Behavior, 54: 170–192.

Irabor, T.-J. et al. 2023. Exploring the potential of a serious game framework in developing systems-thinking skills. *Journal of Veterinary Medical Education*.

Jatayu, P.D., Nugroho, W. & Pratiwi, D.J. 2024. Game media based on local wisdom to improve primary school students' critical thinking abilities. *Progres Pendidikan*.

Karunamoorthy, S. & Mazalan, M. 2024. Boosting physical fitness in primary school students with learning disabilities: a conceptual framework design. *International Journal of Academic Research in Progressive Education and Development*.

Kholid, I. & Supriyadi, S. 2023. Developing and validating critical-heutagogy learning (CHL) to enhance lifelong learning: a Rasch analysis approach. Tadris: *Jurnal Keguruan dan Ilmu Tarbiyah.*

Kolb, D.A. 1984. Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs, NJ: Prentice Hall.

Lawshe, C.H. 1975. A quantitative approach to content validity. Personnel Psychology, 28(4): 563–575.

Mayer, R.E. 2014. The Cambridge Handbook of Multimedia Learning. Cambridge: Cambridge University Press.

Myers, C., Piccolo, L. & Collins, T. 2023. Democratising digital educational game design for social change. *Journal of Learning for Development*.

Othlinghaus-Wulhorst, J. & Hoppe, H. 2020. A technical and conceptual framework for serious role-playing games in the area of social skill training. Frontiers in Computer Science.

Paul, R. & Elder, L. 2014. Critical Thinking: Tools for Taking Charge of Your Learning and Your Life. Upper Saddle River, NJ: Pearson.

Piaget, J. 1973. To Understand Is to Invent: The Future of Education. Harmondsworth: Penguin.

Richey, R.C. & Klein, J.D. 2014. Design and Development Research: Methods, Strategies, and Issues. New York: Routledge.

Sahrir, M.S., Alias, N., Ismail, Z. & Osman, N. 2012. Employing design and development research (DDR) approaches in the design and development of online Arabic vocabulary learning games prototype. *Turkish Online Journal of Educational Technology*, 11(4): 108–119

Shaheen, A. & Fotaris, P. 2024. Enhancing digital game-based learning through reflective game design (RGD). European Conference on Games Based Learning.

Shute, V.J. & Ventura, M. 2020. Stealth Assessment: Measuring and Supporting Learning in Video Games. Cambridge, MA: MIT Press.

Tan, B.S. & Chong, K.S. 2023. Unlocking the potential of game-based learning for soft skills development: a comprehensive review. *Journal of ICT in Education*.

Vygotsky, L.S. 1978. Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

Wang, F. & Hannafin, M.J. 2005. Design-based research and technology-enhanced learning environments. Educational Technology Research and Development, 53(4): 5–23.

Zhang, C., Li, P., Fang, K., Mao, Y. & Ma, G. 2024. An educational simulation game framework and practice based on complex adaptive systems theory: for fostering systems thinking. *Lecture Notes in Computer Science*, 377–387.