Design of a Creative Thinking and Problem-Solving Training Board Game With a GenAI Diagnostic Mechanism

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Abstract

Creative thinking and problem-solving abilities have long been recognized as critical core competencies in the workplace. However, without realistic scenarios or practical experiences, it remains challenging to achieve effective learning transfer. To help learners apply their knowledge in practical situations, this study designed and implemented an educational board game, “Production Crisis – Six Hats Decision Meeting”, which incorporates a GenAI diagnostic mechanism. Learners were placed in a company facing production workforce shortages, taking on roles as department managers or specific job positions. Guided by the Six Thinking Hats creative thinking framework, they engaged in simulated meeting discussions to collaboratively develop optimal solutions. In the game, a GenAI NPC developed in this study acted as the facilitator, responsible for real-time diagnosis of discussion content. When learners deviated from the current thinking hat perspective or when disputes arose, the GenAI NPC identified and explained these issues to maintain discussion focus and depth, thereby enhancing the effectiveness and systematicity of the discussions. A total of 20 learners participated in the empirical evaluation. The results showed that the board game significantly enhanced learners' learning effectiveness. Moreover, the mean scores of overall flow and game acceptance were significantly higher than the median score of the scale (3), and learners experienced a moderate cognitive load, demonstrating the positive impact of this educational board game on learning. Additionally, 85% of learners believed that the GenAI NPC's judgments and explanations regarding the thinking hats had a positive effect on learning, providing precise assistance in making judgments during discussions, offering clear explanations, and helping learners better understand the principles of creative thinking.

Keywords: game-based learning, situated learning, Six Thinking Hats, creative thinking, generative AI

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Introduction

Creative thinking and problem-solving abilities are among the most critical workplace competencies for the 21st century (Tushar & Sooraksa, 2023). Creative thinking, in particular, represents a highly valuable capability that is closely associated with job performance and quality of life (Worwood & Plucker, 2017). However, research reveals a gap between employers' expectations and the actual skills possessed by graduates (Tushar & Sooraksa, 2023). To cultivate this core competency, this study adopted the Six Thinking Hats framework proposed by creative thinking pioneer De Bono (1985). Through six thinking hats of different colors, learners are guided to engage in systematic and in-depth structured thinking.

However, during the process of skill development, traditional lecture-based or discussion-based teaching methods often lack authentic contexts and interactivity, which makes it difficult to stimulate learning motivation and facilitate learning transfer. Game-based learning (GBL) provides an effective solution by integrating instructional content with the engaging and entertaining elements of games. Through GBL, learners not only experience a positive state of flow during gameplay (Hou, 2015), but the game environment also contributes to enhancing their learning motivation (Chan et al., 2023).

In recent years, Generative Artificial Intelligence (GenAI) has been widely applied in the field of education. Its application has extended beyond content generation to include adaptive learning strategies and the provision of learning scaffolding. Moreover, researchers have incorporated GenAI as Non-Player Characters (NPCs) in educational games, where these NPCs function as scaffolding agents that guide learners' reflection during role-playing activities (Chien et al., 2025). Building on this development, the present study integrates the collaborative advantages of board games with GenAI's real-time diagnostic capabilities to design an educational board game titled "Production Crisis – Six Hats Decision Meeting". The game aims to train learners to apply the Six Thinking Hats framework for creative thinking and problem-solving in a contextualized decision-making scenario, utilizing a GenAI NPC as real-time diagnostic scaffolding to ensure the effectiveness and systematicity of group discussions.

Creativity cultivation interventions grounded in collaborative, task-oriented learning have been shown to significantly enhance university students' creative thinking and problem-solving abilities (Li & Yu, 2025). Building on this foundation, the present study adopts a realistic corporate scenario in which learners are placed in a company facing a production workforce shortage. Participants assume the roles of department managers or specific job positions, including the Factory Director, Manufacturing Support Section Manager, Engineering Manager, Human Resources Manager, and Recruitment Specialist. The game is conducted in the form of simulated meeting discussions, with the learning objective of enabling learners to apply the Six Thinking Hats framework in context, understand the distinct thinking orientations represented by each hat, and collaboratively formulate optimal solutions.

Game Mechanics:

(1) Each player draws a "Role Card" and reads the corresponding role information.
(2) Each player is provided with the following materials:
    a. Several "Information Cards" containing background facts or data relevant to the assigned role.

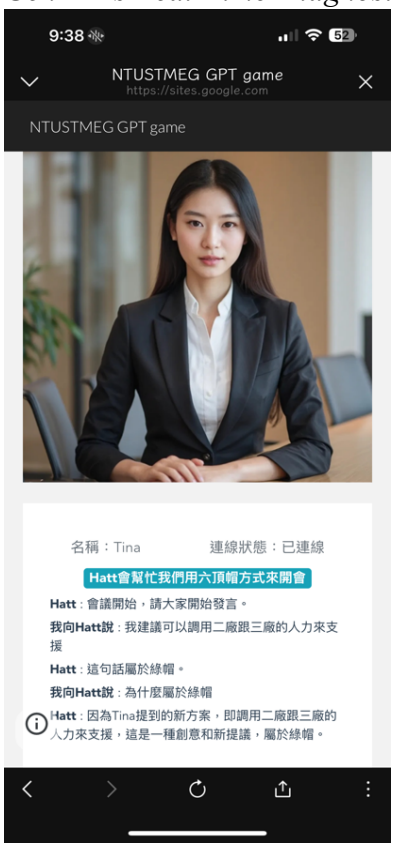
b. A “Six Thinking Hats Manual” that explains the core concepts and key points of each hat (cognitive scaffolding).
c. Several “Thinking Cards”, including one example card each for the Green, Yellow, Black, and Red hats.

(3) The game incorporates a “virtual human” character created using AI voice synthesis to serve as the Blue Hat facilitator. This virtual human explains the meeting objectives and guides the discussion process (procedural scaffolding).
(4) Players conduct discussions according to the hat sequence displayed on the “Game Board” (procedural scaffolding).
(5) When players speak, they place chips of different colors to represent their contribution to the thinking of that particular hat.
(6) When a player’s statement deviates from the scope of the current hat, another player may present an “Objection Card”, prompting the GenAI to immediately provide a diagnostic assessment of the thinking issue.
(7) Finally, players vote to determine the most effective solution, and the group’s solution score is calculated.

Figure 1
Virtual Human Serving As Meeting Facilitator (Blue Hat) Guiding the Meeting

Figure 2
Learners Conducting Meeting Discussions Using the Six Thinking Hats Framework

Figure 3
GenAI As Real-Time Diagnostic Scaffolding



In the game, the GenAI NPC developed in this study functions as an expert, responsible for real-time diagnosis of discussion content. When learners deviate from the perspective of the current thinking hat or when disputes arise during discussion, the GenAI identifies and explains the issue to maintain focus and depth, thereby enhancing the effectiveness and systematicity of the discussion.

Method

This study employed a single-group pretest-posttest experimental design. The participants were 20 Taiwanese adults aged 18 years and above, divided into four groups of five members each. Only 10% of the participants had prior experience learning or applying the Six Thinking Hats. Before the experiment, all participants signed informed consent forms. The experimental session lasted 90 minutes, consisting of three stages: 15 minutes for the pretest and game introduction, 60 minutes for the gameplay activity, and 15 minutes for the posttest and questionnaire. The pretest and posttest assessed participants' basic understanding and application of the Six Thinking Hats. Both tests contained the same 12 questions, with the item order rearranged to minimize potential memory effects.

For measuring flow, this study adopted the Kiili Flow Scale (2006), translated and revised by Hou and Li (2014). The scale comprises two subscales: flow antecedents and flow experience. The flow questionnaire demonstrated high internal consistency (*Cronbach's* α = 0.904). Regarding learners' acceptance of the game, this study employed the Technology Acceptance Model modified by Hou and Li (2014) based on Davis (1989). The scale includes three dimensions: perceived usefulness, perceived ease of use, and game design elements. The

game acceptance scale demonstrated high reliability (*Cronbach's α* = 0.940). For cognitive load, Paas's (1992) cognitive load measure was used. In addition, five questions were developed to examine players' learning experiences with the virtual human and the GenAI NPC diagnostic scaffolding.

Result

A Wilcoxon signed-rank test (Table 1) showed that participants' posttest scores on the Six Thinking Hats cognition (*M* = 80.70, *SD* = 13.88) were significantly higher than their pretest scores (*M* = 51.40, *SD* = 23.23). This result confirms that the educational game-based learning activity designed in this study effectively enhanced learners' mastery of the Six Thinking Hats.

Table 1
Learning Effectiveness of Six Thinking Hats — Wilcoxon Signed Rank Test Analyses

Dimension	*M*	*SD*	*Z*
Pre-test	51.40	23.23	-3.832***
Post-test	80.70	13.88	

***$p < 0.001$

Flow, game acceptance, cognitive load, and game experience were analyzed using one-sample Wilcoxon signed-rank tests (Table 2). The results showed that overall flow (*M* = 3.95, *SD* = 0.48) was significantly higher than the scale median (*Md* = 3, 5-point scale), indicating that the game-based activity design effectively facilitated learners' entry into a flow state and maintained a considerable level of focus and engagement. Regarding game acceptance, the results revealed that the mean score (*M* = 4.28, *SD* = 0.56) was also significantly higher than the scale median (*Md* = 3, 5-point scale), suggesting that learners experienced positive engagement and acceptance toward the game. For cognitive load, learners' perceived cognitive load (*M* = 6.20, *SD* = 1.58) was significantly higher than the scale median (*Md* = 5, 9-point scale), indicating that participants experienced a moderate level of cognitive load.

Table 2
Flow, Game Acceptance, Cognitive Load and Game Experience Descriptive Statistical Analysis — Comparison of One-Sample Wilcoxon Signed Rank Test Analyses With Scale Median

Dimension	*M*	*SD*	*p*
Overall Flow	3.95	0.48	0.000***
Flow antecedents	3.89	0.47	0.000***
Flow experience	3.99	0.59	0.000***
Game Acceptance	4.28	0.56	0.000***
Cognitive Load	6.20	1.58	0.005**
Game Experience	4.09	0.69	0.000***

***$p < 0.001$; **$p < 0.01$

Furthermore, regarding learners' experiences with the virtual human and GenAI NPC diagnostic scaffolding, the results showed that the overall game experience (*M* = 4.09, *SD* = 0.69) was significantly higher than the scale median (*Md* = 3, 5-point scale), indicating that the design of the virtual human and GenAI NPC diagnostic scaffolding effectively enhanced the learning experience. Notably, 85% of learners reported that the GenAI NPC's judgments

on the thinking hats had a positive impact on their learning, providing clear assistance in decision-making, offering explicit explanations, and facilitating understanding of creative thinking principles.

Conclusion

This study designed an educational board game, Production Crisis – Six Hats Decision Meeting, integrating a GenAI diagnostic mechanism to cultivate creative thinking and problem-solving abilities through simulated meeting scenarios. The results demonstrated that the game significantly enhanced learners' understanding and application of the Six Thinking Hats while fostering positive experiences in flow, game acceptance, and game experience. In particular, the real-time diagnostic scaffolding provided by the GenAI NPC received high recognition for its effectiveness in helping learners comprehend the cognitive dimensions of each thinking hat, promoting systematic discussions, and resolving disagreements. However, activities that require contextual knowledge, cross-departmental collaboration, and strategic thinking inherently belong to the domain of complex problem-solving, and therefore entail a moderate level of cognitive load. Nevertheless, analyses of learning performance, flow, game acceptance, and game experience suggest that while the game presented cognitive challenges, it simultaneously provided sufficient engagement and positive learning experiences. For learners with limited contextual knowledge, supplementary scaffolding could be implemented to reduce cognitive load and facilitate smoother immersion into the learning scenario.

The contribution of this study lies in presenting an innovative instructional model that integrates the collaborative strengths of physical board games with the real-time adaptive diagnostic capabilities of GenAI, effectively addressing the limitations of traditional teaching in contextualization and immediate feedback. The GenAI NPC played a pivotal role as diagnostic scaffolding, making judgments and providing explanations when players deviated from the current thinking hat or when disputes arose. Future research should adopt a quasi-experimental design incorporating control groups and a larger sample size to more rigorously validate the effectiveness of this hybrid learning model. Moreover, lag sequential analysis (LSA) could be employed to examine learners' behavioral and discussion patterns during gameplay, offering deeper insights into how GenAI-based diagnostic scaffolding influences real-time decision-making and behavioral dynamics.

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