Learning Effectiveness of Integrating Peer Assessment and Board Games in a Computational Thinking and Artificial Intelligence Unit: Taking Speech Recognition as Examples

Mu-Sheng CHEN[a*], Ting-Chia HSU[b]
[a, b]*Technology Application and Human Resource Development, National Taiwan Normal University, Taiwan*
*mushengchen946@gmail.com

Abstract: This study aims to investigate the impact of peer assessment and educational board games on computational thinking (CT) and artificial intelligence (AI) courses using a two-factor experimental design. Combining educational technology, we designed an AI speech recognition course suitable for first-year students with no prior knowledge of CT or AI. The goal is to develop their foundational understanding and application of CT and AI. By employing educational board games, the study seeks to enhance learning enjoyment, increase students' self-efficacy in CT, and reduce their learning anxiety. Additionally, through the strategy of peer assessment, the study aims to provide benefits to students in both evaluating and being evaluated, thereby improving their learning outcomes and engagement.

Keywords: Computational thinking, artificial intelligence, educational board game, peer assessment, speech recognition

1. Introduction

The rapid development of technology in today's world has significantly transformed our lives. The continuous advancements in technology have led to the widespread influence of AI which is impacting numerous domains (Schmidhuber, 2015). AI has profound implications for various professional fields, such as medical diagnosis, AI-powered job interviews, and big data analysis. The progression of these technologies has greatly altered our societal perceptions and perspectives. Consequently, it has become crucial to cultivate people's abilities to operate and comprehend these technologies, with CT being the fundamental and vital concept. In contemporary society, CT has become an essential skill for everyone to possess (Yadav et al., 2014).

Research suggests that game-based learning can promote and sustain students' motivation and engagement (Clark et al., 2016). Well-designed educational games can encourage deeper thinking among students. In recent years, many researchers have incorporated the concept of board games into education. Gee (2005) showed that by establishing clear learning goals, board games can be effective tools for promoting self-directed learning, problem solving, and deep learning. Due to the collaborative nature of board games, students can experience educational board games through social interaction, peer-to-peer engagement, and mutual learning (Wu et al., 2014). What's more, research on AI education indicates that visualizing and gamifying AI course content can effectively enhance students' interest in learning (DeNero & Klein, 2010).

The primary value of peer assessment lies in the close interaction among peers. In typical classroom settings, the number of students far exceeds the number of teachers, resulting in limited feedback received by each student. Peer assessment can address this

issue by allowing students to provide feedback to one another. Research has found that peer feedback can be more direct and personalized compared to feedback from teachers (Topping, 2009). From another perspective, teacher feedback may be perceived by students as authoritative and non-negotiable, while peer feedback tends to be more diverse, fostering interactive discussions among peers (Cole, 1991).

This study aims to improve the situation of students with low self-efficacy in CT when they first start learning, using educational board games and peer assessment. Typically, low self-efficacy in CT is associated with increased learning anxiety and decreased engagement among students (Bandura, 1977; Pellas, 2014). Therefore, this study employs educational board games to enhance learning enjoyment, boost students' self-efficacy in CT, and reduce their learning anxiety. Additionally, the use of peer assessment strategies is expected to provide benefits to students in both evaluating and being evaluated, thus enhancing their learning outcomes and engagement. This study will address the following research questions:

- Are there significant differences in achievement in CT and AI learning among university students who take the four aforementioned courses using AI speech recognition?
- Are there significant differences in self-efficacy in CT among university students who take the four aforementioned courses using AI speech recognition?
- Are there significant differences in learning anxiety and engagement among university students who take the four aforementioned courses using AI speech recognition?

2. Literature review

2.1 The application of board games in education

According to the claims of Situated Learning Theory, "knowledge is a product of the interaction between learners and the context, deeply influenced by activities, social contexts, and culture." As stated by Lave and Wenger (1991), through authentic contexts that guide students' explorations, the most significant learning occurs when students engage in the process of exploration. Learning that arises from such experiences is profound and effective. Educational board games simulate contextual scenarios that enable students to explore and learn within those contexts. In the past few years, the use of board games has made it possible to address different types of learning, especially in the field of CT (Menon et al., 2019).

Educational board games can help students develop critical thinking, problem-solving skills, analytical abilities, reasoning, organization, planning, and communication skills (Hinebaugh, 2009). Compared to traditional learning, integrating educational board games into the curriculum can further enhance students' logical thinking, critical thinking, and deductive reasoning skills (Hinebaugh, 2009). In the past, many subjects such as mathematics, language, history, and science were taught using traditional methods. To enhance students' learning outcomes and spark their motivation and interest, educators have incorporated board game elements into their lessons, allowing students to engage in communication with others and improve their interpersonal skills. Additionally, Cheng (2018) used educational board games for language learning, and the results showed that the games effectively improved students' learning outcomes while reducing their learning anxiety.

2.2 The application of peer assessment in education

Peer assessment is a mode of evaluation where learners assess each other, particularly those who have similar levels of learning. This approach has been successfully applied in elementary, middle, and high schools, including very young students, as well as those with special educational needs or learning disabilities (Ehly & Topping, 1998). Numerous studies have demonstrated that peer assessment can enhance the effectiveness and outcomes of learning (Cartney, 2010; Cartney & Rouse, 2006; Cassidy, 2006; Panadero et al., 2016; Topping et al., 2000). Importantly, both the assessors and the assessed benefit from peer assessment. Assessors can identify their own shortcomings by evaluating their peers' work, while also identifying areas for improvement in others (Yorke, 2003).

The primary value of peer assessment lies in the close interaction among peers. In typical classroom settings, the number of students far exceeds the number of teachers, resulting in limited feedback received by each student. Peer assessment significantly addresses this issue, and research has found that peer feedback can be more direct and personalized compared to feedback from teachers (Topping, 2009). Teacher feedback may be perceived by students as authoritative and non-negotiable, while peer feedback tends to be more diverse. Moreover, peer assessment promotes communication and discussion among students (Cole, 1991). Willey and Freeman (2006) proposed that peer assessment can effectively enhance learning outcomes and engagement, particularly in STEM-related courses.

3. Research Methodology

To investigate the learning outcomes of college students using peer assessment in an AI speech recognition board game course, this study focuses on first-year university students. The instructional experiment is conducted in an Introduction to Computer Science course, with students aged between 18 and 19 years. The students' semester of enrollment is used as the basis for grouping, resulting in four groups. The experimental design follows a two-factor design. To minimize potential experiment interference from other factors, the course is taught by the same instructor, ensuring consistent teaching content, duration, and progression.

We designed an AI speech recognition course which includes topics such as an introduction to CT and AI concepts, explanation and application of speech recognition, personalization of recognition models, and subsequent practical applications, as shown in Fig. 1. The course incorporates CT, speech recognition, machine learning, and peer assessment through the BookRoll learning management content platform. Operational tools include the use of the MIT App Inventor platform and the Personal Audio Classifier (PAC) platform. The board game utilized is AI 2 Robot City. Each class session lasts for 3 hours, and instruction is conducted over a period of 2 weeks, resulting in a total of 6 hours of instruction.

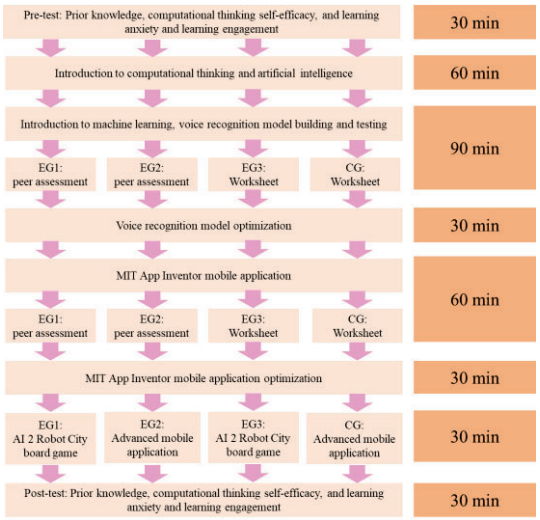

Figure 1. AI speech recognition course.

Peer assessment will be conducted on the BookRoll platform, using an anonymous and randomly assigned approach. Only students who submit their assignments to the platform will be eligible to participate in the peer assessment, ensuring a complete matching of submissions. During the peer assessment process, students will receive an anonymous peer's assignment along with a peer assessment form. Assessing students will use the criteria specified in the peer assessment form to assign scores, and they can also provide qualitative feedback. To ensure the quality of peer feedback during peer assessment, teachers will explain the meaning of the scoring items and advise students to provide effective scoring

explanations.

AI 2 Robot City combines three main concepts: CT, AI, and IoT. By utilizing the MIT App Inventor platform and PAC platform, players can train their own individualized speech recognition models. These models enable players to control the smart cars within the board game using their trained models. The process of training the models provides insights into the speech recognition process. Once the speech recognition models are trained, players can engage in the board game where they can cultivate the concepts of CT.

This study will utilize the CT Self-Efficacy Scale developed by Yağcı (2019), which consists of four dimensions: problem-solving, collaborative learning and critical thinking, creative thinking, and algorithmic thinking. Additionally, the study will employ the Learning Anxiety and Engagement Scale developed by Chang (2014), which includes three dimensions: anxiety, playfulness, and enjoyment. Both scales will be assessed using a 5-point Likert scale. Pretests and posttests will be conducted for achievement measures as well as the two scales. Subsequently, a two-factor analysis of covariance (ANCOVA) will be employed for data analysis.

References

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191-215. https://doi.org/10.1037/0033-295X.84.2.191

Cartney, P. (2010). Exploring the use of peer assessment as a vehicle for closing the gap between feedback given and feedback used. *Assessment & Evaluation in Higher Education, 35*(5), 551-564. https://doi.org/10.1080/02602931003632381

Cartney, P., & Rouse, A. (2006). The emotional impact of learning in small groups: highlighting the impact on student progression and retention. *Teaching in Higher education, 11*(1), 79-91. https://doi.org/10.1080/13562510500400180

Cassidy, S. (2006). Developing employability skills: peer assessment in higher education. *Education + Training, 48*(7), 508-517. https://doi.org/10.1108/00400910610705890

Cheng, Y.-C. (2018). The Effect Of Using Board Games In Reducing Language Anxiety And Improving Oral Performance. *Electronic Theses and Dissertations,* 899. https://egrove.olemiss.edu/etd/899

Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of educational research, 86*(1), 79-122. https://doi.org/10.3102/0034654315582065

Cole, D. A. (1991). Change in self-perceived competence as a function of peer and teacher evaluation. *Developmental Psychology, 27*(4), 682–688. https://doi.org/10.1037/0012-1649.27.4.682

DeNero, J., & Klein, D. (2010, July). Teaching introductory artificial intelligence with pac-man. In *First AAAI Symposium on Educational Advances in Artificial Intelligence.*

Ehly, S. W., & Topping, K. J. (1998). *Peer-assisted learning.* L. Erlbaum Associates.

Gee, J. P. (2005). Learning by design: Good video games as learning machines. *E-learning and Digital Media, 2*(1), 5-16. https://doi.org/10.2304/elea.2005.2.1.5

Hinebaugh, J. P. (2009). *A board game education.* R&L Education.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge university press.

Menon, D., Romero, M., & Viéville, T. (2019). Computational thinking development and assessment through tabletop escape games. *International Journal of Serious Games, 6*(4), 3-18. https://doi.org/10.17083/ijsg.v6i4.319

Panadero, E., Jonsson, A., Strijbos, JW. (2016). Scaffolding Self-Regulated Learning Through Self-Assessment and Peer Assessment: Guidelines for Classroom Implementation. In: Laveault, D., Allal, L. (eds) *Assessment for Learning: Meeting the Challenge of Implementation*. The Enabling Power of Assessment, vol 4. Springer, Cham. https://doi.org/10.1007/978-3-319-39211-0_18

Pellas, N. (2014). The influence of computer self-efficacy, metacognitive self-regulation and self-esteem on student engagement in online learning programs: Evidence from the virtual world of Second Life. *Computers in Human Behavior, 35*, 157-170. https://doi.org/10.1016/j.chb.2014.02.048

Schmidhuber, J. (2015). Deep learning in neural networks: An overview. *Neural networks, 61*, 85-117. https://doi.org/10.1016/j.neunet.2014.09.003

Topping, K. J. (2009). Peer assessment. *Theory into practice, 48*(1), 20-27. https://doi.org/10.1080/00405840802577569

Topping, K. J., Smith, E. F., Swanson, I., & Elliot, A. (2000). Formative peer assessment of academic

writing between postgraduate students. *Assessment & Evaluation in Higher Education, 25*(2), 149-169. https://doi.org/10.1080/713611428
Willey, K., & Freeman, M. (2006-02). Improving teamwork and engagement: The case for self and peer assessment. *Australasian Journal of Engineering Education*, 1-19. https://search.informit.org/doi/10.3316/aeipt.157674
Wu, C.-J., Chen, G.-D., & Huang, C.-W. (2014). Using digital board games for genuine communication in EFL classrooms. *Educational Technology Research and Development, 62*(2), 209-226. https://doi.org/10.1007/s11423-013-9329-y
Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education (TOCE), 14*(1), 1-16. https://doi.org/10.1145/2576872
Yorke, M. (2003). Formative assessment in higher education: Moves towards theory and the enhancement of pedagogic practice. *Higher education, 45*(4), 477-501. https://doi.org/10.1023/A:1023967026413