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Design of an Online Educational Board Game for Membrane Technology Learning

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Abstract: The study developed an online educational game, Membrane Baby, integrating board game and online situated learning. The learners play the role of the Baby Trainer and have to utilize the feed of the 3 attributes of membrane to obtain membrane knowledge and win the game. We investigated learner's learning performance, learning motivation, learning anxiety and flow status. The results revealed that their learning performance has significantly improved, indicating that the game did effectively clarify the learner's misconceptions about Membrane technology. Although the learning motivation increased, there was no significant improvement.

Keywords: Misconception, online educational game, chemical learning, scaffolding, situated learning

1. Introduction

"Misconception" means any concept that differs from the commonly accepted scientific understanding of the term (Mary B. Nakhle, 1992). Moreover, science misconceptions are persistent, resistant to change, and deeply rooted in some concepts. Therefore, it is urgent to prevent or revise misconceptions as early as possible (Soeharto et al., 2019). Membrane technology is an area where the public is prone to misconceptions. It has been widely used in one's daily life, but since it cannot be seen with a naked eye, it is easy for people to ignore this applied technology, which generates relative misconceptions. Digital game-based learning is considered to effectively arouse learner's interest and learning motivation (Abdul Jabbar & Felicia, 2015; Clark et al., 2016), and flow (Sun et al., 2017). Similarly, board games could promote learners' interactive collaboration and learning motivation (Hou & Keng, 2021). Therefore, during the pandemic, this study expects a learning method that combines the mechanism of board games with online synchronization technology to improve learner's interest and motivation and gradually clarify the misconceptions about the knowledge of membrane technology in the game process so that the learners can achieve highly motivating learning experience in popular science. Thus, our research team (Mini Educational Game development group in e-Learning Research Center, National Taiwan University of Science and Technology, NTUSTMEG) developed an online educational game, "Membrane Baby" (Figure 1). A story was applied in the game as situated learning to facilitate the learners to involve in this activity. The learners play the role of the Baby Trainer and have to utilize the feed of the 3 attributes of membrane to obtain membrane knowledge and get the assistance from their peers. The three kinds of feed stand for 3 attributes of Membrane: Water stands for hydrophilic and hydrophobic. Wood stands for transparent and opaque. Fire stands for dense and porous. Furthermore, the learners are free to exchange their feeds for Knowledge Card as cognitive scaffolding and get the relative Membrane knowledge (Figure 2). The learners must answer the Membrane-related knowledge correctly in order to successfully capture the baby and win the game.

Figure 1. Game panel with the route

Figure 2. Knowledge Card and players answering section

2. Method

Participants in this study were 23 university students in Taiwan (11 males, 12 females) and grouped in 5 teams. All the participants joined the game with a personal computer and communicate with their own microphone. The researchers had the same questions of the pretest and posttest, but in different order. The questions were about the misconceptions of Membrane technology we mentioned in the game, including the three attributes, 20 questions in total. We evaluated the learners' flow status by Kilis's flow scale (2006), which was translated and revised by Hou, & Li (2014). The flow scale includes 2 dimensions, namely the flow antecedent and flow experience. All scales were scored on a five-point Likert scale. The reliability of the flow questionnaire (Cronbach's alpha=0.952) showed high internal consistency. Also, we explored the learners' anxiety by Krashen's Affective Filter Hypothesis (1981;1987), and the reliability of the anxiety questionnaire was 0.796 (Cronbach's α=0.796). Moreover, the learners' motivation was adapted by Pekrun's AEQ (2005), and the reliability of the motivation questionnaire was 0.786 (Cronbach's α=0.786). The procedure of the study was as follow: Pretest for 20 minutes, game for 60 minutes and posttest, learning motivation questionnaire, learning anxiety questionnaire and flow questionnaire for 20 minutes.

3. Results and Discussions

For learning performance, a Wilcoxon signed rank test was used to compare the results of learning performance between the pretest and posttest. The results showed there was a significant difference in the score for the pre-test and post-test (Z=-2.14, $p<0.05$) (see Table 1), and it suggested that learners' misconceptions of Membrane had been better corrected through the game. For learning motivation, a One-sample Wilcoxon Test was used. The motivation before the activity (M=4.26), during the activity (M=4.48) and after the activity (M=4.52) (see Table 2) were all above the median (the median in a five-point scale =3). The result showed that although there was no significant difference among the steps ($p>0.05$), the leaners had high motivation during the game. For learning anxiety, a one-sample Wilcoxon signed rank Test was conducted, (M=2.18) (see Table 2), it was significantly lower than median (the median in a five–point scale=3) (t=-5.214, p<.000), and it suggested that learners didn't feel anxious during the game. As for the flow, a one-sample Wilcoxon Test was performed, the overall flow score (M=4.25), flow antecedent sub-dimension (M=4.19), and flow experience sub-dimension (M=4.31) were significant all above the median (the median in a five-point scale =3) (t=9.945, p<.000) (see Table 2). The results indicated that learners were deeply involved in the game.

Table 1. *The mean and standard deviation of learning performance*

	M	SD	Z
pre-test	58.48	15.18	-2.14*
post-test	64.57	11.77	

*$p < .05$

Table 2. *The mean and standard deviation of learning motivation, learning anxiety and flow state*

	M	SD
Step 1 (before the activity)	4.26	1.05
Step 2 (during the activity)	4.48	0.73
Step 3 (after the activity)	4.52	0.67
Anxiety	2.18	0.75
Flow antecedents	4.19	0.70
Flow experience	4.31	0.55
Overall Flow	4.25	0.61

4. Conclusion

The study developed an online educational game, Membrane Baby, integrating board game and online synchronization technology with situated learning and scaffolding, trying to correct learners' misconceptions of Membrane technology in a fun way under the COVID-19. The results showed that the game can be helpful for learners to identify the 3 attributes of Membrane and also to correct the relative misconceptions in their daily life. The results of high motivation, low anxiety and high flow status also showed a high level of learning experience. It indicated that an online educational game integrated with board game mechanism and synchronization technology can be an effective way in promoting learners' learning performance. This game is suitable for students at 7th grade or higher and interested in applied science. Future study would employ different domain knowledge to compare the effectiveness of this game and continue to correct the misconceptions happened in our daily life.

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