Evaluating Students’ Art History Learning Performance and Game Flow Experiences in an Educational Game

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Abstract

Educational games can be interactive learning tools to enrich art history education. ARTé: Mecenas is an educational video game that supports students’ learning of art history topics. To explore players’ enjoyment in ARTé: Mecenas, the gameplay studies were conducted at two southern public universities in the United States. The studies adopted a scale measuring players’ enjoyment based on the EGameflow scale (Fu et al., 2009), which comprised six factors (i.e., Concentration, Goal Clarity, Challenge, Autonomy, Immersion, and Knowledge Improvement). The findings have shown students’ game flow experiences in ARTé: Mecenas and their learning improvement through the gameplay. The results confirmed students’ game flow experiences and learning performance. Additionally, students’ gameplay patterns in ARTé: Mecenas were revealed via the clustering analysis, which addressed students’ persistence issues and possible reasons for the different learning achievements via the gameplay.

Keywords: art history game, educational game, game flow, game mechanics, clustering.

Introduction

Educational games have been developed to support learning for over two decades. Numerous research articles have been published in the last decades and demonstrated the learning efficacy of educational games (e.g., Tüzün et al., 2009; Hwang et al., 2013; Muntean et al., 2018). Research studies have revealed student motivation in educational games (e.g., Burguillo, 2010), emotional identification (e.g., Christinaki et al., 2014), narrative design in games (e.g., Dickey, 2006), effects of gender differences (e.g., Yang & Chen, 2010), and promotion of self-efficacy in game-based learning (e.g., Hung et al., 2014). Previous game research has involved different subjects at different educational levels, such as mathematics learning in an elementary school (e.g., Kebritcki et al., 2010), computer science education in a high school (e.g., Papastergiou, 2009), English vocabulary learning for college students (e.g., Yip & Kwan, 2006), and civil engineering in higher education (Ebner & Holzinger, 2007). Many of these research studies have acknowledged the significant impacts of educational games on learning from different perspectives.

To better understand the impacts of educational games and the underlying reasons causing the effects, some studies have adopted the flow theory to evaluate players’ enjoyment during gameplay to understand their experiences. These studies have reported that games can generate and model players’ enjoyment via setting performance expectations and completing a certain difficult level of game tasks (Klimmt et al., 2009). Game enjoyment is also related to a player’s self-esteem. A delightful game can improve a player’s competence in the game and
further promotes the player’s self-esteem (Klimmt et al., 2009). Therefore, it is worthy and beneficial to probe players’ game flow experiences to evaluate their enjoyment during the gameplay.

In this study, we aim to investigate (1) students’ game flow experiences when playing the game ARTé: Mecenas, (2) the association between students’ game flow experiences and learning performance, and (3) students’ gameplay patterns in ARTé: Mecenas.

Theoretical Background

Csikszentmihalyi (1990) was the first scholar to evaluate flow experimentally. According to Csikszentmihalyi (1990), flow is an experience "so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it, even when it is difficult or dangerous." The flow state is a state of complete engagement in an activity that involves an optimal experience (Csikszentmihalyi, 1990). The optimal experience integrates cognition, motivation, and emotion. Csikszentmihalyi (1990) mentioned eight elements of the flow state and proposed a three-channel flow model composed of boredom, flow, and anxiety. The flow state is linear from the beginning of the task and starts to change with the progressed tasks and challenges (Kiili, 2005). A flow experience aligns a person's skills with a certain level of task challenges in that the skills can be adapted to the challenges (Sweetser & Wyeth, 2005). Therefore, a task that generates a flow experience needs to be goal-oriented and rule-based with proper skills and mental involvement (Sweetser & Wyeth, 2005).

Sweetser and Wyeth (2005) proposed a game flow model to evaluate a player's gameplay experience called GameFlow. The model merges the flow state elements into computer games, which includes eight factors: (1) concentration, (2) challenge, (3) skills, (4) control, (5) clear goals, (6) feedback, (7) immersion, and (8) social interaction (Sweetser & Wyeth, 2005). Fu et al. (2009) presented a scale in the context of e-learning games, known as EGameFlow, based on Sweetser and Wyeth's GameFlow model (2005). Their study was conducted using four different e-learning games to test the validity and reliability of the EGameFlow scale. The scale consists of eight factors: (1) Concentration, (2) Goal Clarity, (3) Feedback, (4) Challenge, (5) Autonomy, (6) Immersion, (7) Social Interaction, and (8) Knowledge Improvement. According to Fu et al. (2009), Concentration relates to a player’s focus on the game task and can be achieved when the task has clear goals and timely feedback is provided. Goal Clarity requires game tasks to be clearly explained at the beginning of the gameplay. Feedback helps players acquire the knowledge to complete game tasks. Challenges in a serious game address the player’s competence and promote increasing the competence level. Autonomy is a player’s perceived sense of control over the gameplay action. Immersion is a player’s deep involvement during the gameplay. Social Interaction relates to the collaboration with peers in the game. Knowledge Improvement replaces the player’s skills factor in the original GameFlow model to address the goals of educational game development. Overall, the EGameFlow scale not only detects a player's enjoyment through the game flow experience in a learning game but also reflects learning states during the gameplay.

Previous studies have used GameFlow, EGameFlow, or other methods to detect a player’s game flow experience (e.g., Sweetser et al., 2020). Some studies have reported the impacts of game mechanics on the game flow experiences (e.g., Kiili et al., 2014). However, few research studies have addressed students' in-game actions and their impacts on the game flow experiences. The in-game actions can be indicatives of gaming strategies that can provide helpful information about specific game mechanics and their importance to the flow experience.
Moreover, there are some contradictory findings regarding the relationship between flow experience and learning. For example, Liu (2014) reported a positive but insignificant correlation between student game flow experience and learning outcomes, while Barzilai and Blau (2014) noted a significant prediction of flow on learning. Hence, it is necessary to investigate the relationship between students’ game flow experience and learning performance.

Method

Study Design

In Fall 2017, gameplay studies were conducted at two southern public universities in the United States to evaluate the learning effectiveness of the educational game - ARTé: Mecenas (v2). Participants were mainly recruited from two undergraduate art history survey II courses. Participants were required to play the game within two weeks. Initially, 109 students consented to the gameplay studies. Before attending the studies, these participants had completed a unit on Renaissance art as part of the course instruction. Participants who did not play the game or finish the post-test were excluded from the analyses. In the end, 80 participants (61%) played the game and took both pre-tests and post-tests. Additionally, students were requested to complete a questionnaire after the post-test.

Instrument

ARTé: Mecenas (Thomas et al., 2016) is an educational video game that transports students into the 15th and 16th century Italian Renaissance (see Figure 1). During gameplay, players command history as the head of the Medici family, one of the most influential families of the time. True to the life of the Medici, players must balance relationships with powerful city-states, merchant factions, and the Catholic Church or risk excommunication, exile, and bankruptcy. As patrons of such luminaries as Michelangelo and Da Vinci, they learn to use their wits to build a banking empire, establish their reputation, and commission artworks. While playing the game, students are immersed in an experience that helps them grasp the role of art given societal norms. ARTé: Mecenas creates a relevant art history experience, deviating from traditional memorization to engage students with the curriculum at a deeper level.

The game’s objective components were established based on the learning objective components of the expected achievements. Each game level has its unique game objectives. In the first game level of ARTé: Mecenas, the main task is to establish the wealth and reputation of Banco Medici in Florence. The related content topics mainly focus on the Medici’s impacts on society and the support for artworks in Florence. In the second game level, the players need to expand the wealth and influence of Medici’s family to foreign markets. The content topics involve increasing the Medici’s impacts on other foreign cities and the artworks of religious figures such as the Magi in works by Francesco di Pesello and Fra Angelico. Other artists such as Nanni di Banco and Andrea del Castagno are introduced at this level. In the third game level, the main task for the players is to preserve the Medici’s wealth and status in Florence and abroad. This level covers the topics such as the early career of Leonardo da Vinci, the rise of Humanist ideals, the links to the Greco-Roman past, and the introduction of oil paintings from Northern Europe through commissions to Joos van Ghent and Hugo van der Goes. In the fourth game level, which is the last level for the players to increase the Medici’s influence and art patronage of the Medici. Michelangelo’s art was raised at this level, the Academy of Art and Design was established, and the Medici’s impacts arose.
Measurement

Knowledge of Art History. Subject matter experts in art history designed and validated the test content. The pre-test and post-test had the same content items, including 28 multiple choice questions to assess the art history topic covered in ARTé: Mecenas. Each question was scored one point.

General Questionnaire. The general questionnaire included 16 items (see Appendix A1). Two five-point Likert-scale items measured the game’s overall entertainment (i.e., with 1 being the least entertaining game to 5 being the most entertaining game) and game difficulty (i.e., with 1 being the easiest game to 5 being the most challenging game), respectively. The other 14 items were seven-point Likert scale, from 1 being strongly disagree to 7 being strongly agree. These items were students’ self-evaluations about this game.

Game Flow. In the game flow questionnaire, six factors (i.e., Concentration, Goal Clarity, Challenge, Autonomy, Immersion, and Knowledge Improvement) were adapted from the scale of EGameFlow (Fu et al., 2009) were applied to measure players’ game flow experiences. Two factors (i.e., Feedback, Social Interaction) from EGameFlow were excluded. The exclusion reason is that the game does not have direct feedback and social interaction mechanics. The game was built in a reality-simulated environment where each action could result in possible consequences as being a well-known celebrity (Medici) in history. There is no absolute right or wrong answer for each choice made in the game, but the consequences can still indirectly provide the player clues to being successful in the game. Therefore, the ARTé: Mecenas in-game feedback system is hardly being measured using the EGameFlow scale. In addition, ARTé: Mecenas is a single-player game. The version used in the studies does not have in-game communities that support social interaction. Therefore, the factor of Social Interaction does not apply to this game setting. The details of game flow items are presented in Appendix Table AII. All the items are on a seven-point Likert scale, with 1 being strongly disagree to 7 being strongly agree. Missing values on an item were replaced by the sample mean of that item. Two items in the survey were removed since the items’ content was reversed. One item was "I am burdened with tasks in the game that seem unrelated," evaluating the factor of Concentration. The other item was "When I make errors, I cannot progress in the game," evaluating the factor of
Autonomy. The composite scores for each factor were computed as the sum of the corresponding item scores. A confirmatory factor analysis was run using the lavaan package (Rosseel, 2012) in R version 3.5.2. The results have shown that $\chi^2(237) = 464.0.34 \ (p < .0001)$, CFI = 0.84, RMSEA = 0.109, SRMR = 0.076, which indicates a fair fit for evaluating these factors of enjoyment using the current dataset. The standardized factor loadings (SFL) are shown in Appendix Table AII.

**Analyses.** Several statistical methods and a clustering approach were deployed. First, a pair-sample t-test was used to test the change in students’ learning from the pre-test to the post-test. Normalized learning gains were calculated using the formula below (Ruipérez-Valiente et al., 2016).

$$\text{Normalized Learning Gain} = \begin{cases} \frac{\text{Post}_\text{test} - \text{Pre}_\text{test}}{\text{Max}_\text{score} - \text{Pre}_\text{test}} & \text{if } \text{Post}_\text{test} \geq \text{Pre}_\text{test} \\ \frac{\text{Post}_\text{test} - \text{Pre}_\text{test}}{\text{Pre}_\text{test}} & \text{if } \text{Post}_\text{test} < \text{Pre}_\text{test} \end{cases} \quad (1)$$

where $\text{Max}_\text{score}$ is 28 for both pre-test and post-test.

Multiple linear regression analyses were applied to examine (a) the relationship between student learning performance and game flow factors and (b) the most significant game flow factors for overall game entertainment. A linear model can be written as

$$y_j = \beta_0 + x_{j1}\beta_1 + \cdots + x_{ji}\beta_i \quad (2)$$

where the outcome of object $j$ is modeled as a linear function of predictor values $x_{j1}, \ldots, x_{ji}$ with coefficients $\beta_1, \ldots, \beta_i$, and $\theta_j$ represents the unexplained component.

Relative importance is considered, which indicates each predictor’s contribution to a multiple regression model (Grömping, 2006). In this study, the relative importance of predictors was measured using the Lindeman, Merenda, and Gold (LMG) method (Lindeman, 1980).

A clustering approach was implemented to seek student gameplay patterns, which can be indicative of student gameplay strategies applied in the game. Clustering is a popular unsupervised data analysis approach grouping a set of objects into a homogenous group (Bradley et al., 2000). In this study, the K-Means clustering algorithm was deployed. In previous research, the K-Means algorithm has been successfully used to probe student performance (e.g., Oyelade et al., 2010).

In a given dataset including $m$ data points $x_1, x_2, x_3, \ldots, x_m$ in $\mathbb{R}^d$, the K-Means algorithm categorizes data into $k$ clusters having $k$ points $\{T_i\} \ (i = 1, 2, \ldots, k)$ in $\mathbb{R}^d$ (see Equation (1)).

$$\frac{1}{m} \sum_{q=1}^{m} \left[ \min_i d^2(x_q, T_i) \right] \quad (3)$$

Each data point is assigned to its closest cluster using the Euclidean distance denoted by $d(x_q, T_i)$. The $k$ points $\{T_i\} \ (i = 1, 2, \ldots, k)$ are known as cluster centroids. The Euclidean distance of its averaged squared value between a new data point and its closest cluster centroid is minimized, as shown in Equation (3). The K-Means algorithm is an iterative approach that executes $z$ times of iterations to find clusters and update the cluster centroids until it reaches the local minimum (Bradley et al., 2000). We used 10-fold cross-validation to evaluate the performance.
In this study, each player’s in-game actions were logged. Therefore, we retrieved nine features based on the game mechanics from the log data and applied the K-Means clustering approach. These features included:

1. Average elapsed time: the average time in seconds spent on each action in the game
2. Average wealth: the average wealth achieved in the game
3. Average rep: the average reputation scores achieved in the game
4. Average soul: the average soul scores achieved in the game
5. Average alum: the average amount of stocked alum in the game
6. Average wool: the average amount of stocked wool in the game
7. Average linen: the average amount of stocked linen in the game
8. Reached Highest Level: the highest game level that the player reached in the game
9. Duration seconds: the time duration in seconds between the first login date/time and the last login date/time

Results

According to the analysis results of students’ performance, the increase in student learning from pre-test to post-test was significant ($\overline{\text{mean increase}} = 1.38$, pre-test = 4.89 ± 1.94, post-test = 6.26 ± 2.14, $t(79) = 5.53$, $p < .001$, $d = 0.62$). The average normalized learning gains reached 2.5%. The regression result indicated that the overall model, including the pre-test performance score and six game flow factors, significantly explained 24% of the variance ($R^2 = 0.24$, $F(7, 72) = 3.3$, $p < .01$). The pre-test performance score significantly increases by 0.44 on the post-test score when controlling the rest of the predictors. Among these six game flow factors, Knowledge Improvement significantly predicted students’ post-test scores ($\beta = 0.11$, $p = .04$), and it explained 4.88% variances after decomposing $R^2$.

According to the students’ self-evaluation results, they thought that the game was entertaining to some extent ($n = 80$, $M = 3.56$, $SD = 1.03$). The game difficulty was also acceptable for them ($n = 80$, $M = 3.13$, $SD = 0.85$). They agreed that their knowledge was increased in all four game levels (see Table I). Among all the participants, 60% reached the highest game level (i.e., level 4) based on the game log data. Each game flow factor was positively associated with students’ achieved game level. Among all the factors, students’ achieved game level had the moderate positive linear relationship with the factors Knowledge Improvement ($r = .4$, $p < .001$) and Concentration ($r = .38$, $p < .001$).

Table I

<table>
<thead>
<tr>
<th>Game Level</th>
<th>Number of Participants</th>
<th>Average Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>80 (100%)</td>
<td>5.54 ± 1.44</td>
</tr>
<tr>
<td>Level 2</td>
<td>70 (87.5%)</td>
<td>5.62 ± 1.25</td>
</tr>
<tr>
<td>Level 3</td>
<td>60 (75%)</td>
<td>5.75 ± 1.27</td>
</tr>
<tr>
<td>Level 4</td>
<td>48 (60%)</td>
<td>5.64 ± 1.41</td>
</tr>
</tbody>
</table>

In evaluating students’ enjoyment during the gameplay, the game flow analyses showed that students agreed on all six factors. According to the result of the Concentration factor, students could concentrate on the game activities related to the learning tasks ($M = 5.65$, $SD = 1.16$). Among all the game flow factors, Goal Clarity scored the highest ($5.98 ± 1.08$). The Challenge factor showed that the game improved players’ in-game skills, such as decision-
making (5.68 ± 1.15), which could help the player succeed. The result of the Autonomy factor indicated that students hesitated to decide if they could agree upon the survey items listed in Appendix Table AII (4.63 ± 1.16). In addition, students were undecided if they could immerse themselves in the game, especially on emotional involvement (4.31 ± 1.51). Regarding Knowledge Improvement, the game encouraged students to apply their prior knowledge to the game events and integrate new knowledge with their prior knowledge (5.68 ± 1.18).

All six factors overall explained 50% of the variance when exploring the game entertainment (\( R^2 = 0.50, F(6, 73) = 12.19, p < .001 \)). The Immersion factor significantly predicted game entertainment (\( \beta = 0.12, p < .001 \)) and explained 32% of the variance across the whole model. However, other game flow factors were not significant predictors for game entertainment.

Regarding students’ gameplay patterns, the K-Means clustering approach successfully identified four clusters. Players in cluster 3 and cluster 4 reached higher game levels than cluster 1 and cluster 2. Cluster 3 built the most wealth (Average wealth: 3892.88) and obtained the best reputation and soul scores (Average rep: 67.38; Average soul: 59.09) in the game. Cluster 3 also stocked most inventories, including alum, wool, and linen (Average alum: 18.63; Average wool: 22.09; Average linen: 18.02). These results indicated that the players in cluster 3 more actively traded goods in the game than in other clusters. Overall, cluster 3 understood the game mechanics better than other clusters. Compared to cluster 3, cluster 4 was possibly less cautious in making their in-game decisions based on their faster actions made in the game (Average elapsed time: 73.08). Less wealth, lower reputation and soul scores, and fewer stocked amounts of goods also showed the differences between cluster 4 and cluster 3. One possible reason causing these differences was that cluster 4 spent less time on the gameplay than cluster 3 (Duration seconds for cluster 4: 41825.66; Duration seconds for cluster 3: 46545). Hence, it is highly likely that cluster 4 could have reached the last game level (i.e., level 4) as cluster 3 if they had spent more time on the game.

On the other hand, cluster 1 gave up playing the game before accomplishing game level 2, which yielded the least wealth, the lowest scores on reputation and soul, and the shortest time spent on the game (Average wealth: 89.88; Average rep: 23.49; Average soul: 19.63; Duration seconds: 24748.24). The possible reasons they were not persistent in the gameplay can be the lack of interest in this game or other unseen covariates irrelevant to the game itself (e.g., fatigue). Cluster 2 completed the game level 2 but stopped playing the game after that. It seems that players in cluster 2 were struggling during the gameplay according to their slow actions made in the game (Average elapsed time: 278.78). These players in cluster 2 might need more straight guidance on understanding how the game mechanics worked to be successful in the game.

**Discussion**

This paper explored students’ game flow experiences of *ARTé: Mecenas* and examined whether there was an association between the game flow factors and students’ learning performance. The paper also probed students’ gameplay patterns in the game that indicated students’ gameplay strategies and potential issues encountered during the gameplay. Improving knowledge and skills is a core objective for developing an educational game and implementing the game in learning, which can further increase students’ perceived enjoyment of gameplay (Tiger, 2000). According to the findings, *ARTé: Mecenas* can be a useful supplementary learning tool that allows students to apply the knowledge acquired from classes to the game tasks and helps students expand their knowledge and skills.
Overall, the results confirmed the importance of students’ game flow experiences, which can significantly impact their dedication and persistence towards the game. The findings have shown that students could concentrate on the learning tasks in ARTé: Mecenas and had clear goals for these tasks. The challenges in ARTé: Mecenas matched students’ perceived skills within the game. However, the students probably had difficulty fully achieving autonomy within the game. Autonomy reflects a player’s freedom to make decisions during the gameplay (Kim et al., 2015) and is a player’s intrinsic motivation that ultimately increases the overall enjoyment of the gameplay (Przybylski et al., 2010). To improve players’ autonomy in the game, the teacher’s facilitation of how to play the game at the beginning of the studies can be helpful. This facilitation can reduce students’ confusion and improve their understanding of the game. Although the game has a short tutorial section at the very beginning before starting the game level, it has complicated mechanics that can still be challenging for some players, especially those who do not play games often in daily life. Without fully understanding the game mechanics, players can be frustrated and lose a sense of immersion in the game world. This issue perhaps has caused some students to quit playing the game in an early phase. Therefore, additional assistance from the teacher is necessary for successfully deploying the game into students’ learning.

In addition, lacking a sense of immersion can result in the early quit of the gameplay. The sense of immersion in the game typically involves the attachment to the game character (Teng, 2010). This indicates that increasing the attachment to the game can improve a player’s sense of immersion (Kim et al., 2015). Allowing customization in the game, such as the customization of a game avatar, can strengthen a player’s identification with the game and increase the attachment (Fischer et al., 2010). In ARTé: Mecenas, the player’s role of Medici is fixed but still has the possibility of customizing the avatar through other aspects, such as allowing the selection of appearance and dress style at the beginning of the game. Moreover, previous findings from our studies have shown that the sense of immersion in the game is the most crucial factor for game entertainment. Applying strategies to increase players’ immersion in an educational game can also improve game entertainment.

In previous studies, game analytics have been successfully used to evaluate the game design and gameplay performance (e.g., Hicks et al., 2016). This study exhibited the potential of using game analytics to understand students’ gameplay patterns. The findings have noted that game analytics can give a new perspective on evaluating students’ engagement in the game and reflect the potential issues of the game mechanism. The information retrieved from game analytics is more unbiased and valuable for understanding the game design and the impacts of game mechanics on students’ gameplay persistence and performance. It solves the limitation of adopting the external measurement of the game and supports more research topics related to educational games.

ARTé: Mecenas successfully balances the game’s entertainment and difficulty and provides players with enjoyable gaming experiences. However, some improvements can still be achieved in the future updated game version. The findings can also provide researchers and game designers in the educational game field with some insights regarding the importance of players’ game flow experiences and gameplay strategies and their impacts on student learning performance. The measurement of game flow also indicates a game's quality to some extent, which can help researchers and designers determine which aspects could be improved during the game design (Perttula et al., 2017).
Conclusion

Investigating perceived game flow experiences is crucial to evaluating an educational game. The game flow model measures players’ gameplay experiences and their perceived enjoyment of the game. In this study, the factors for measuring game flow include Concentration, Goal Clarity, Challenge, Autonomy, Immersion, and Knowledge Improvement. This measurement provides comprehensive information about students’ game flow experiences in ARTé: Mecenas. The findings confirm students’ learning performance and game flow experiences in ARTé: Mecenas. The results are also meaningful for researchers and game designers when considering designing or refining an educational game. Future studies are expected to comprehensively investigate the different treatment effects on learning between adopting the game and other learning technologies such as virtual realities or intelligent tutoring systems.

ACKNOWLEDGMENT

This research was based upon work supported by LIVE Lab at Texas A&M University College of Architecture - Department of Visualization and Triseum LLC, Bryan, Texas.

Appendix

Table A1

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Item Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game entertainment</td>
<td>How much did you enjoy the game as a whole? (with 1 being the least entertaining game you have ever played and 5 being the most entertaining)</td>
</tr>
<tr>
<td>Game difficulty level</td>
<td>How difficult would you rate this game as a whole? (with 1 being the easiest game you have ever played to 5 being the most difficult)</td>
</tr>
<tr>
<td>The following statements pertain to ARTé: Mecenas as a whole.</td>
<td>The environment in the game motivated me to play more.</td>
</tr>
<tr>
<td>The game as a whole increased my knowledge.</td>
<td></td>
</tr>
<tr>
<td>The visuals in the game help me understand the concepts.</td>
<td></td>
</tr>
<tr>
<td>The following statements pertain to the ARTé: Mecenas perceived knowledge for each Level.</td>
<td>Level 1 increased my knowledge.</td>
</tr>
<tr>
<td>Level 2 increased my knowledge.</td>
<td></td>
</tr>
<tr>
<td>Level 3 increased my knowledge.</td>
<td></td>
</tr>
<tr>
<td>Level 4 increased my knowledge.</td>
<td></td>
</tr>
<tr>
<td>The following statements pertain to The game is fun.</td>
<td></td>
</tr>
</tbody>
</table>
The ARTé: Mecenas gameplay.

The game is engaging.
The game makes learning fun.
Playing the game helps me understand content in course lectures.
Playing the game helps me understand material in my textbook.
I would recommend this game to other students.
I would recommend that my teacher use this game as part of the course.

**Table AII**

*Game Flow Items*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Item</th>
<th>Content</th>
<th>SFL</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>C1</td>
<td>Most of the gaming activities are related to the learning task.</td>
<td>0.76</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>C2</td>
<td>Generally speaking, I can remain concentrated in the game.</td>
<td>0.76</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>C3</td>
<td>I am not distracted from tasks that the player should concentrate on within the game.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td>G1</td>
<td>Overall, game goals were presented in the beginning of the game.</td>
<td>0.71</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>Overall, game goals were presented clearly.</td>
<td>0.77</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td>Intermediate goals were presented in the beginning of each level.</td>
<td>0.85</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>G4</td>
<td>Intermediate goals were presented clearly.</td>
<td>0.85</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>L1</td>
<td>The game provides “hints” in text that help me make decisions.</td>
<td>0.63</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>L2</td>
<td>My skill gradually improves through the course of making decisions and seeing the consequences.</td>
<td>0.79</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>L3</td>
<td>The difficulty of the decisions increases as my skills improve.</td>
<td>0.7</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>L4</td>
<td>The game provides new decisions with an appropriate pacing.</td>
<td>0.74</td>
<td>0.67</td>
</tr>
<tr>
<td>AT</td>
<td>A1</td>
<td>I feel a sense of control over objects in the game.</td>
<td>0.84</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>The game supports my recovery from errors.</td>
<td>0.67</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>I know the next step in the game.</td>
<td>0.69</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>I feel a sense of control over the game.</td>
<td>0.89</td>
<td>0.46</td>
</tr>
<tr>
<td>IM</td>
<td>I1</td>
<td>I forget about time passing while playing the game.</td>
<td>0.77</td>
<td>0.64</td>
</tr>
<tr>
<td></td>
<td>I2</td>
<td>I become unaware of my surroundings while playing the game.</td>
<td>0.81</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>I3</td>
<td>I feel emotionally involved in the game.</td>
<td>0.77</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>I4</td>
<td>I feel viscerally involved in the game.</td>
<td>0.81</td>
<td>0.59</td>
</tr>
<tr>
<td>KI</td>
<td>K1</td>
<td>The game increases my knowledge.</td>
<td>0.93</td>
<td>0.37</td>
</tr>
</tbody>
</table>
K2 I catch the basic ideas of the knowledge taught in the game. 0.85 0.53
K3 I try to apply the knowledge in the game. 0.87 0.49
K4 The game motivates the player to integrate the knowledge taught. 0.81 0.58
K5 I want to know more about the knowledge taught. 0.78 0.62

*CT represents Concentration. GC represents Goal Clarity. CH represents Challenge. AT represents Autonomy. IM represents Immersion. KI represents Knowledge Improvement.

References


https://doi.org/10.1016/j.entcom.2014.08.002

Lindeman, R. H. (1980). Introduction to bivariate and multivariate analysis (No. 04; QA278, L553.).


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