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User-Centered Evaluation of Gamification Elements for Traffic Safety Learning Systems among Adolescents

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Abstract. Knowing about traffic safety is crucial for teenagers who are preparing to learn to drive. Texts, images, and practice questions are typical ways of learning, but they provide few opportunities for learners to experience complicated traffic situations in a safe way. This study used a mixed-methods approach combining interviews and a questionnaire. Five participants aged 16 to 18 were first interviewed, after which a questionnaire evaluating eight gamification elements was developed based on the interviews and existing literature. A total of 60 responses were received, 58 of which qualified as participants in the research and were included in the analysis. The questionnaire data showed that real-world traffic scenarios received the highest mean ratings for learning support and engagement, at 4.14 and 4.12, respectively, while timely feedback achieved the second-highest rating for learning support, at 3.93. The results suggest that design elements of traffic safety education should prioritize the acquisition and practical application of traffic knowledge, while also accommodating individual preferences regarding competition, immersion, and time efficiency.

Keywords: traffic safety, gamification, learning games, teenagers, mixed methods

1. Introduction

By the age of 16 to 18 years, most teenagers have begun learning the basics of driving and traffic regulations; however, they still do not have any practical experience with traffic issues. While the conventional approach will provide theoretical knowledge, it is very difficult for the learner to gain practical experience in such situations.

Gamification is likely to enhance learning, interest, and engagement according to previous research; however, their conclusions differ [1-3]. This is because research on gamification involves several components, which make it hard to evaluate the significance of any one component to the learners. Traffic safety games involve the use of feedback, rewards, challenges, leaderboards, role-playing, and real-world traffic scenarios, among others [4, 5]. In this study, the aspects of gamified designs that teenagers aged 16-18 find most beneficial in terms of traffic safety learning were defined, and the way by which teenagers differentiate between gamification elements increasing interest in traffic safety and helping them to learn was clarified. Using the results of both interviews and questionnaires, the study found that the most effective methods for learning were real-world

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traffic scenarios and feedback, whereas the reward system, leaderboard, and role-playing depended on individual preferences.

2. Literature review

Gamification usually involves applying game design elements to non-game activities, including education and serious games. Previous reviews found that gamification can have positive effects, but learning type, design, and learning context can affect the results [6]. Sailer et al. found that different elements are related to different psychological needs; therefore, game elements should not all be treated as the same type of design [7].

In terms of learning support, Alyamani et al. found that feedback in simulated driving tasks reduced certain driving errors, showing that feedback could help learners adjust their behavior by helping them understand their mistakes [8]. Peterson et al. found that teenagers paid attention to interactive elements and outcomes in virtual reality games, giving them opportunities to engage with real-world issues in a safe environment [9]. Rewards, points, and leaderboards are more closely related to motivation; Mekler et al. found that these factors could increase the number of tasks completed by learners [10]. Hong et al. conducted a systematic review of gamification and showed that designs need to consider learners and the functions of different elements [11]. Therefore, this study groups the responses into three areas: learning support, engagement, and boundary conditions.

3. Methods

3.1. Research design

This study used an exploratory sequential mixed-methods design. The first stage used semi-structured interview, explored how teenagers aged 16-18 understood traffic safety learning games' different design elements, and distinguished between the functions of "improving engagement" and "supporting learning". Stage two developed a questionnaire based on the themes emerging from the interviews and related literature to evaluate the level of learning support and engagement associated with eight gamification elements.

3.2. Participants and recruitment

Convenience sampling was employed during the interview phase; a total of 5 students aged 16-18 were recruited; all participants were the researcher's classmates. Although their learning environments were similar, their interest in games and traffic safety experience differed. During the questionnaire phase, recruitment information was published via a class group chat, and participation was entirely voluntary. All participants provided informed consent; the consent of the guardian was also obtained when necessary. In both stages, participants were recruited from within the researcher's sphere of access, and the questionnaires were completed voluntarily by students; this may have made it more likely that students with similar backgrounds or a greater interest in the research topic participated, causing selection bias and limiting the sample's representativeness regarding other adolescents aged 16–18.

3.3. Interview procedure and qualitative analysis

The semi-structured interview covered participants' experiences with games, experiences of traffic safety learning, views on different gamification elements, and how they distinguish related concepts

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such as "fun games" and "better learning outcomes". All participants were assigned codes Participant 1 (P1) through Participant 5 (P5) to protect their privacy and reduce concerns about expressing differing opinions.

The interview analysis followed Braun and Clarke's six-step thematic analysis method [12]. The researcher recorded and labeled content such as "correction", "immersion", "engagement", "efficiency", and different preferences. The data were organized into three themes: learning support, engagement, and boundary conditions. The analysis was conducted by the researcher alone, without a second reviewer, which may have introduced bias.

3.4. Questionnaire development and measures

The eight gamification elements in the questionnaire were determined based on interview results and relevant literature, including real-world traffic scenarios, feedback, levels or challenges, immersion, role-playing, progress bars, points or rewards, and leaderboards. Participants used a 1-5 scale to evaluate the eight elements in terms of learning support and engagement. Finally, they selected the three elements they most wanted to retain and identified the single element they would retain above all others. A total of 60 responses were received. 58 responses were included after excluding 2 responses that did not meet the age criteria.

4. Results

4.1. Participant characteristics

As shown in Table 1, the age distribution of the 58 participants was balanced: 23 participants (39.7%) were 16 years old, 19 participants (32.8%) were 17 years old, and 16 participants (27.6%) were 18 years old. 36 participants (62.1%) played games 1-5 days per week, and the remaining 22 participants (37.9%) reported frequencies at either end of the range; this indicates that the sample included both highly active players and low-frequency players. In the context of experience with traffic rules, 31 participants (53.4%) only learned some everyday traffic rules, 13 participants (22.4%) had theoretical study, exam preparation, or driving experience, and 14 participants (24.1%) only self-studied or had no prior study.

Table 1. Participant characteristics

Characteristic	Category	n	%
Age	16 years	23	39.7
Age	17 years	19	32.8
Age	18 years	16	27.6
Video-game frequency	Rarely play or less than a day	12	20.7
Video-game frequency	1–2 days per week	18	31
Video-game frequency	3–5 days per week	18	31
Video-game frequency	6–7 days per week	10	17.2
Traffic-rule knowledge/experience	Some everyday traffic rules	31	53.4
Traffic-rule knowledge/experience	Theory study, test preparation, or driving experience	13	22.4
Traffic-rule knowledge/experience	Self-study only or no prior study	14	24.1

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4.2. Descriptive ratings of gamification elements

As shown in Table 2, the mean ratings in real-world traffic scenarios for learning support and engagement were 4.14 and 4.12, the highest ratings among eight elements. It also had the highest rating in "selected in top three" and "single select element", demonstrating that the element possesses both educational value and appeal. Feedback's mean for learning support was 3.93, higher than the engagement rating of 3.76, and 30 participants (51.7%) chose it in the "top three"; this showed feedback is primarily used for correcting errors and facilitating understanding. The mean engagement ratings for levels, challenges, and audiovisual immersion were 3.84 and 3.78, higher than their learning support rating, demonstrating that participants preferred to relate to these elements more with interest and immersive experiences. The leaderboard's mean value and the retention rate were the lowest (2.74, 3.22, 13.8%, 3.4%). This illustrated that a competitive mechanism was not a priority for most participants.

Table 2. Descriptive ratings and selections for eight gamification elements

Element	Learning support	Engagement	Selected in top three (%)	Single element (%)
Real-world traffic scenarios	4.14	4.12	39 (67.2)	17 (29.3)
Feedback	3.93	3.76	30 (51.7)	12 (20.7)
Levels/challenges	3.57	3.84	27 (46.6)	7 (12.1)
Audio/visual immersion	3.40	3.78	21 (36.2)	7 (12.1)
Role-playing	3.38	3.72	18 (31.0)	8 (13.8)
Progress bar	3.31	3.72	20 (34.5)	3 (5.2)
Points/rewards	3.12	3.62	11 (19.0)	2 (3.4)
Leaderboard	2.74	3.22	8 (13.8)	2 (3.4)

As shown in Figure 1, real-world scenarios received similar highest ratings for learning support and engagement. Feedback was an element rated more highly for learning support than for engagement, while the remaining six elements were rated more highly for engagement. The comparatively low scores for leaderboards demonstrated that competition was not a priority in this sample.

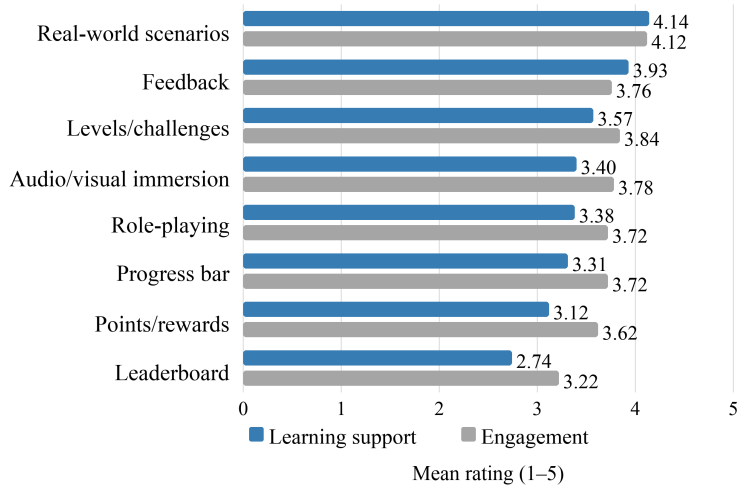


Figure 1. Mean learning-support and engagement ratings (photo credit: original)

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In response to the question about "the three elements they most wanted to retain", 39/58 participants chose real-world traffic scenarios (67.2%), 30/58 participants chose feedback (51.7%), and 27/58 participants chose levels and challenges (46.6%). When only one element could be retained, 17/58 participants chose real-world scenarios (29.3%), 12/58 participants chose feedback (20.7%), and 8/58 participants chose role-playing (13.8%). The average learning support rating for role-playing was not outstanding, but in single-element selection, it was the third most frequently selected. This result suggests that the average may mask the stronger personal preferences of some participants.

4.3. Interview findings

The interviews reflected three main themes: learning support, engagement, and personal preferences. P1 and P5 thought that feedback was the most important; P3 thought that real-world traffic scenarios could enhance the sense of immersion, and P4 chose real-world traffic scenarios because they were directly related to traffic rules. However, there was no consensus on the form of feedback: P1 preferred a brief explanation, P2 believed that difficult problems required more detailed feedback, and P4 preferred to try first and receive a hint if they became stuck. These differences suggest that whether feedback is effective depends not only on whether it is given, but also on how detailed it is and when it occurs.

4.4. Attitudes and individual preferences

Table 3 showed that participants did not directly equate interest with learning outcomes: 45 participants (77.6%) thought that a fun game did not necessarily mean better learning outcomes; 33 participants thought that knowing the reason for mistakes is more helpful than receiving a reward. In contrast, only 22 participants (37.9%) thought that a leaderboard would increase willingness to continue learning. Meanwhile, 42 participants (72.4%) hoped they could choose whether to enable rewards and leaderboards. The four results both demonstrated that participants were more likely to emphasize feedback that helped them understand errors and differed in their acceptance of competitive elements. Therefore, these elements are better suited as optional features rather than as a core mechanism.

Table 3. Attitude-item responses

Statement	Agree	%
A game being fun does not necessarily mean people learn better.	45	77.6
Knowing the reason for a mistake is more helpful than receiving a reward.	33	56.9
Leaderboards would increase willingness to continue learning.	22	37.9
Rewards and leaderboards should be optional.	42	72.4

4.5. Integration of qualitative and quantitative findings

The results from the interviews and questionnaire showed a degree of similarity regarding the importance of real-world scenarios and feedback: both datasets showed that participants were more likely to associate these two elements with understanding rules, identifying errors, and practical application. However, the interview and questionnaire results were not entirely consistent. Immersion was highlighted in the interviews but did not rank first in the questionnaire results. Role-

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playing did not receive a particularly high overall rating but ranked third in the single-element selection. This may be because the interview sample was small, making it more likely that individual opinions would be highlighted. However, the questionnaire results made overall trends easier to identify.

5. Conclusion

Both the interview and questionnaire results showed that participants consistently linked real-world traffic scenarios and feedback to learning support rather than engagement. Real-world traffic scenarios assisted participants in comprehending rules and implementing them in practice, while feedback facilitated the recognition and correction of mistakes. However, the current research concentrates on subjectivity and cannot prove the effectiveness of these factors on learning performance.

It was clear from the findings that interest and support for learning were distinct results. Elements like immersion, reward, and challenge could encourage participation, but if there was any weak relationship between the element and traffic rules, it could distract the learners or affect their learning process. The leaderboard got the lowest overall ratings, but certain participants were driven by competition. Therefore, it would be better to let the learners have the option of choosing when to use rewards and the leaderboard.

However, the two key limitations of this research were that the subjects for the research were classmates of the researcher, and the analysis of the interviews was done by one researcher only. Thus, these results cannot be used to represent the whole teenage population of ages 16 to 18 years. Moreover, this study was based on the opinions of participants and not on a learning test.

This study combined interviews with 5 students and 58 valid questionnaire responses. It was revealed that actual situations and feedback were the elements that have been connected to learning support most consistently. Engagement, on the other hand, was mostly associated with challenges and immersion, while attitudes to role-playing, reward systems, and leaderboards depended on individual preferences. In designing traffic safety learning games, it was recommended to give priority to accurate rules, feedback, and meaningful context before considering engagement-related elements. Further research might include creating prototypes and evaluating them in terms of learning outcomes, efficiency, and sustainability.

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