Enhancing Cybersecurity Learning with In-Game Feedback

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Abstract: This paper presents the development and evaluation of *The XSS Game* (TXG), an enhanced multi-opposing-role-playing educational game designed to teach Cross-Site Scripting (XSS) attacks to second-year undergraduate computer science students. TXG enables players to assume three distinct roles: Attacker, Defender (Developer), and User, each offering unique perspectives on cybersecurity challenges. Building upon feedback from the evaluation of TXG Version 1, this study focuses on incorporating various types of in-game feedback (affirming, reflective, explanatory, and personalised) and introducing a player statboard to enhance student engagement, motivation, and knowledge retention. TXG Version 2 incorporates a variety of feedback types aimed at reinforcing learning and promoting self-reflection. Confirmatory feedback helps players quickly assess the correctness of their answers, while explanatory feedback provides in-depth reasoning to enhance understanding. Affirming feedback is used to motivate players, particularly when they succeed in completing roles, and personalised feedback offers tailored guidance based on players' individual progress. The player statboard is introduced as a central feature, displaying player achievements, skills, and progression throughout the game, offering real-time feedback to sustain engagement and foster continued learning. Expert evaluations of TXG Version 2 indicated that the diverse feedback mechanisms, especially personalised feedback and the statboard, were effective in promoting learner engagement and self-reflection. However, the evaluations also identified areas for improvement, particularly regarding the clarity and readability of the feedback and statboard, while suggesting potential UI/UX enhancements. The study posits that with the suggested improvements, TXG Version 2 offers significant potential for improving cybersecurity education through a dynamic, engaging, and interactive gameplay experience. This study contributes to existing research on game-based learning by showcasing how game mechanics such as multi-opposing roles, simulations, in-game feedback and player statboards, can be integrated to enhance the learning of complex cybersecurity concepts. Furthermore, it provides a development framework for creating educational games in cybersecurity and beyond, demonstrating the effectiveness of a flexible, interactive, and immersive approach to teaching critical security concepts.

Keywords: Game-Based learning, In-Game feedback, Feedback mechanisms, Educational games, Cybersecurity education, Cross-Site scripting attacks

1. Introduction

In today's digital landscape, Cybersecurity is of utmost importance and can have ramifications across a wide range of industries and sectors. Hence, it is vital that everyone, including students, professionals, and the general public, understands its importance. Nonetheless, several examples exist that demonstrate a lack of cybersecurity awareness among these groups. For instance, a wide range of companies, such as media organisations, retail chains, and financial institutions, have been impacted by cybersecurity breaches (Chen et al, 2025). These incidents demonstrate the severe consequences that can result from failing to prioritise cybersecurity, including financial losses, reputational damage, and even risks to human life. Hence, in order to prevent/mitigate such incidents, many countries, including the US, Canada, and several members of the European Union, have launched initiatives to promote strong cybersecurity practices among the public (Van Steen et al, 2020).

1.1 Goals and Scope of the Paper

This study presents the continuation of a multi-opposing-role-playing game, named The XSS Game (TXG) (Weeratunge & Hjelsvold, 2025), to teach Cross-Site Scripting (XSS) attacks to second-year undergraduate computer science students. The players can experience the game through the eyes of three roles, where some act as opposing roles.

The roles in TXG are as follows:

- Attacker: An adversarial role with high technical expertise that tries to exploit vulnerabilities in web applications.
- Defender (Developer): An opposing role with high technical expertise that tries to develop secure web applications against adversaries.
- User: A user role with low technical expertise that utilises the developed web applications.

The primary intended learning outcomes of TXG are:

- Understand how to identify the different types of XSS attacks from multiple perspectives.
- Develop secure applications that incorporate preventive measures to mitigate XSS attacks.
- Offer an interactive and enjoyable approach to learning cybersecurity.

More information about TXG can be found in Weeratunge & Hjelsvold (2025).

TXG Version 1 was evaluated in a second-year undergraduate computer science course. The players commented that they found the multi-opposing-role-playing with real-life scenarios approach useful to their learning and proposed to have even more varied interactions, multiplayer, and replayability functionalities. In addition, several players indicated that the TXG Simulator Zone provided an immersive experience and proposed more tasks and additions to it. Moreover, many players praised the timely and clear confirmatory and explanatory feedback given in TXG, coupled with the reflective pre- and post-game surveys, as vital to the learning experience.

The main motivation of this study is to investigate how to incorporate in-game feedback within a cybersecurity educational game, namely TXG Version 2, in terms of engagement/motivation and knowledge improvement. To provide players with enhanced feedback, TXG Version 2 will feature a player statboard that displays player skills and achievements. Accordingly, a key objective of the upcoming TXG Version 2 evaluation is to examine how different types of in-game feedback (affirming, reflective, explanatory, and personalised), combined with the statboard feature, could influence learners' motivation, engagement, and overall learning within the game.

Specifically, this paper explores the following research questions:

- RQ1: How can different in-game feedback, such as affirming, reflective, explanatory, and personalised, be integrated within a cybersecurity educational game?
- RQ2: How can a player statboard be incorporated in a cybersecurity educational game to influence learner motivation, engagement, and knowledge?

The main contributions of this study include:

- A design of an enhanced web-based educational multi-opposing-role-playing game, TXG (The XSS Game), to teach XSS attacks for all audiences.
- The analysis of how to integrate in-game feedback and player statboards into an educational game.
- An enhanced development framework that can be used to create educational games for a range of subject domains.

2. Background

2.1 Cross-Site Scripting (XSS) Attacks

Cross-Site Scripting (XSS) attacks involve injecting malicious scripts into trusted websites by exploiting vulnerabilities in web applications. These attacks occur when user input is improperly validated or encoded, allowing harmful code to run in another user's browser (KirstenS, 2024).

Once the victim receives the code injected by the attacker, the victim's browser cannot detect that the script is dangerous and will execute it as if it originated from a trusted source. Consequently, the malicious script can access sensitive data, including cookies and session tokens stored in the browser. It can even alter the content displayed on the webpage (KirstenS, 2024). OWASP (Open Worldwide Application Security Project) ranks XSS as number three on its Top 10 Web Application Security Risks list due to its severity (The Open Worldwide Application Security Project, 2024).

2.2 Related Work

Firstly, existing educational games on XSS attacks will be presented. Gaurav et al (2021) presents four web-based games designed to teach system administrators and entry-level IT users about web application security, namely SQL Injection, Broken Authentication, XSS, and Sensitive Data Exposure. These games were developed using Unity (Unity Technologies, 2024) and are based on the Learning Mechanics-Game Mechanics (LM-GM) framework (Lim et al, 2015) (Arnab et al, 2012). The study also conducts a limited evaluation involving eight players by collecting objective player data through Unity analytics and subjective feedback via a questionnaire. The games featured in Google (n.d.) and Hussain (n.d.) also provide educational methods for teaching XSS

attacks to college and industry audiences. These games present various scenarios where individuals might encounter XSS attacks.

In-game feedback has been featured in several educational games. Burgers et al (2015) presents a brain-training game that utilises a range of feedback, including evaluative, comparative, positive and negative. The study states that positive feedback enhances intrinsic motivation through competence and autonomy needs while fostering long-term motivation and play. Similarly, Hwang & Kang (2023) mentions that the players appreciated and reported increased self-confidence after receiving positive and encouraging affirming feedback in a math game.

Moreover, several studies have investigated personalised feedback in educational games. Nelson et al (2014) incorporated visual cues into a virtual world-based assessment, highlighting the objects with which students needed to interact. This personalisation enhances the effectiveness of game content delivery by aligning with learners' preferred instructional strategies and directing their attention to relevant information during learning or assessment. Similarly, Hooshyar (2022) presents an educational game, named AutoThinking, aimed at enhancing the computational thinking of students. The game adapts to individual needs/playstyle and even provides adaptive feedback, hints, and tutorials, according to the learners' level of skills.

Several educational games have employed player statboards or an equivalent in their design. For instance, The Hechinger Report (n.d.) utilises a personal dashboard that displays earned points and badges, in addition to tracking academic behaviours, such as attendance, GPA, and engagement in school activities. Similarly, Shoelace (n.d.) presents a player activity report that tracks the number of questions each learner answers and provides accuracy statistics. Furthermore, this report acts as an effective tool for evaluating student engagement and emphasising the significance of accuracy.

Related work suggests that positive and affirming feedback mechanisms foster intrinsic motivation, self-confidence, and sustained engagement, while personalised feedback tailored to player skill levels enhances the effectiveness of learning. Furthermore, the use of clear, structured statboards to track achievements and progress supports self-assessment and reinforces goal-oriented learning behaviours. While several educational games are designed to target different in-game feedback and player statboards, there seems to be no educational games that combine these elements, particularly in the field of cybersecurity. Moreover, each one of the above aspects has its own set of merits and complications, and thus, the combined application within a cybersecurity educational game could lead to an improved learning experience. Hence, this is the main research gap this study wishes to address.

3. Implementation

The TXG implementation consists of an HTML, JavaScript, and CSS-based UI frontend, with a Flask backend (Pallets Projects, 2010). Players accessed the game via a shared application link.

As described in earlier sections, gameplay involves multiple opposing roles: Attacker, Defender, and User. To support evaluation, players completed built-in pre- and post-game surveys. More information about TXG implementation can be found in Weeratunge & Hjelsvold (2025)

3.1 Educational Game Development Framework

TXG Version 1 introduced the above implementation as a framework for developing educational games across disciplines. It allowed developers to build quiz-based games with multiple levels, opposing roles, interactive simulations, and built-in pre- and post-game surveys for evaluation. TXG Version 2 extends this framework by incorporating various forms of detailed in-game feedback, such as affirming feedback to acknowledge correct actions, reflective feedback to encourage deeper thinking, explanatory feedback to clarify concepts, and personalised feedback tailored to individual performance. In addition, TXG Version 2 introduces a player statboard that tracks and displays players' skills, achievements, and progression throughout the game, providing continuous visual feedback to motivate learners, sustain engagement, and support knowledge development over time.

3.2 Example Gameplay

TXG is a role-playing game where players assume different roles to answer scenario-based XSS questions, often supported by images. As shown in Figure 1, players select answers from tiles (box E) to progress and can access additional XSS resources (KirstenS, 2024) and gameplay details via options in box A. One of the

additions in TXG Version 2 is a mini version of the player Statboard, which players can extend to view more detailed stats (Box D).

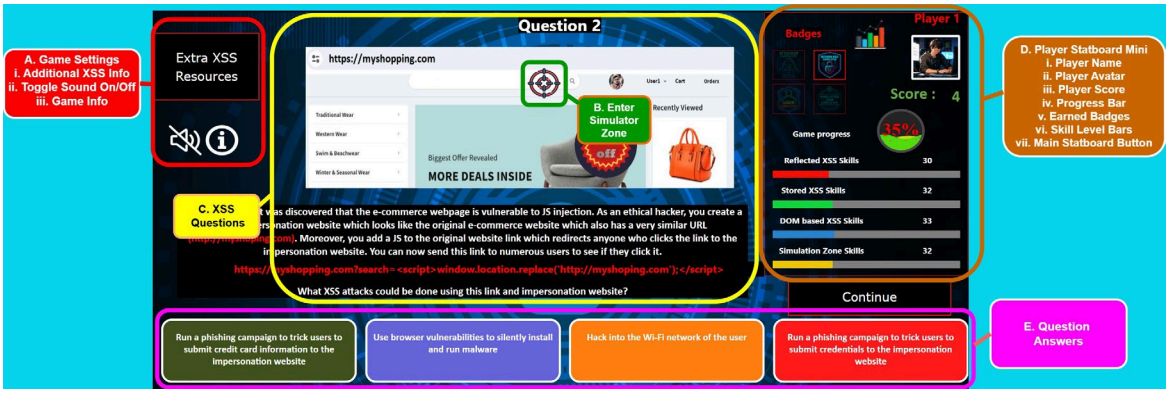

Figure 1: The revised TXG UI: A. Game Settings, B. Simulator Zone Button, C. XSS Questions, D. Player Statboard Mini, E. Question Answers

4. Design Considerations of In-Game Feedback and Player Statboard in TXG Version 2

4.1 In-Game Feedback

As mentioned in earlier sections, several types of in-game feedback are utilised in TXG Version 2. This section will describe these types in detail.

4.1.1 Confirmatory feedback

Confirmatory feedback simply states whether the answer is correct or not, without providing additional information (Wouters & Van Oostendorp, 2013). As seen in Figure 2, players receive immediate confirmatory feedback regarding their answer choices as soon as a question is answered.

4.1.2 Explanatory feedback

Conversely, explanatory feedback provides additional information about an answer, such as why it is correct or not. Several studies maintain that explanatory feedback is more effective than its counterpart (confirmatory feedback) at helping novice students learn and develop a deeper understanding (Johnson & Priest, 2014) (Mayer & Johnson, 2010). Players receive detailed, immediate explanatory feedback regarding their answer choices, as seen in Figure 2.

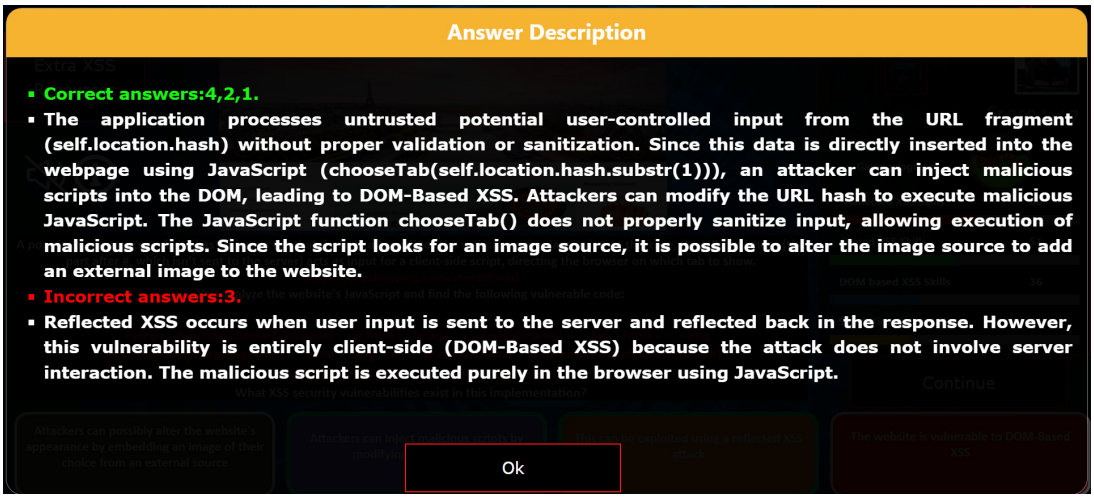

Figure 2: TXG confirmatory and explanatory feedback after the player submits answers

Cognitive Theory of Multimedia Learning (Mayer, 2005) suggests that learners benefit more when new information is immediately integrated into existing mental models, by reducing the amount of mental effort needed to track whether previous actions were correct. Moreover, immediate feedback prevents misconceptions from persisting, supporting more efficient learning (Shute, 2008). Hence, immediate feedback in TXG helps players quickly understand whether their choices are correct, reinforcing learning in real-time and

keeping the gameplay flow smooth and engaging. It reduces uncertainty, builds confidence, and supports faster error correction, which is especially important in educational games like TXG, where immediate reinforcement strengthens knowledge retention and keeps players motivated to continue.

4.1.3 Affirming feedback

Affirming feedback is used in TXG to motivate the player and increase engagement with positive feedback. This is specialised for the chosen player role and is selected from a list of pre-generated feedback. Hence, the player will be shown randomly selected feedback that is relevant for their situation and would likely see a different message each time. The goal of this approach was to make the affirming feedback seem more natural and less mechanical. This affirming feedback can be seen in box C in Figure 3. Some examples of this affirming feedback are shown below,

Attacker

> *"Attacker role accomplished. You've stepped into the adversary's mind and exposed the mechanics of XSS with skill."*
>
> *"Infiltration successful! You've completed the Attacker role and unlocked key insights into web security flaws."*

Defender

> *"Defender role complete! You've fortified the system and shown strong awareness of XSS vulnerabilities."*
>
> *"You held the line! Completing the Defender role shows your skill in identifying and neutralising web-based attacks."*

User

> *"Great job! You've learned firsthand the potential dangers of XSS and how attackers might target users like you."*
>
> *"Awesome work! You've discovered how XSS attacks can affect your experience and what to look out for as a user."*

The above affirming feedback is displayed in the player statboard as soon as a player completes a role. However, if a player decides to view the player statboard before completing a role, affirming feedback is used to encourage the user to keep playing the game to enhance their skills. These messages are given below,

Attacker

> *"Keep pushing forward! You're building valuable skills that will help you understand web vulnerabilities better."*
>
> *"You're making great progress! Each step brings you closer to becoming an expert in exploiting web vulnerabilities."*

Defender

> *"Keep up the great work! Every defensive measure you implement brings you closer to mastering web security."*
>
> *"You're doing an amazing job! Each challenge you face is a step toward becoming a skilled defender of web applications."*

User

> *"Nice job! Your efforts are building crucial awareness that will keep you safe in the digital world."*
>
> *"You're on the right track! The knowledge you're gaining now will make you more cautious and confident as a web user."*

4.1.4 Personalised feedback

TXG provides personalised feedback to the player depending on their playstyle. When a player finishes a role, feedback is presented that reflects on the player's answer choices and their implications. Moreover, TXG will

recommend the player to replay certain levels to further improve specific player skills. Hence, this personalised feedback features clear, specific goals focused on improving particular aspects of performance, combined with the reflection of player actions and their consequences. This focus on enhancing specific player skills is supported by theories of learning, such as self-regulated learning (Zimmerman, 2002) and deliberate practice (Ericsson et al, 1993). This personalised feedback can be seen in box E in Figure 3.

In TXG, affirming and personalised feedback are provided to the player after they complete a role, serving as a method of reflection. Consequently, affirming and personalised feedback in TXG are not only intended to motivate and guide players but also to act as reflective mechanisms that support deeper learning processes. This approach is based on reflective learning from experiential learning theory (Kolb, 1984), where learners, during the Reflective Observation stage of Kolb's learning cycle, critically review their actions and outcomes to gain insights that inform future behaviour. Thus, by incorporating reflective feedback into the player's post-role experience, TXG fosters a learning process whereby players can internalise their experiences, critically assess their cybersecurity skills, and refine their knowledge and strategies in subsequent plays.

4.2 Player Statboard

The player statboard, shown in Figure 3, acts as the main in-game feedback mechanism in TXG. Box A displays tabs for each player role, enabling players to switch between roles they've played. Each tab shows the corresponding skill level bars (as seen in Box B), allowing players to track their progress and assess their performance for each role individually. In addition, box C presents the affirming feedback while box E shows the personalised feedback, according to the playstyle of the player. The statboard differentiates between affirming feedback (general positive reinforcement) and personalised feedback (tailored to the player's unique playstyle). This dual-feedback approach was designed not only to reward achievement but also to facilitate improvement through customised guidance.

Box D displays core game elements, including the player's name, avatar, score, progress bar, and earned badges. These elements are prominently featured to highlight player achievements and encourage continued engagement. Badges are awarded for completing various roles and simulation zones, offering clear goals and recognising important milestones.

Lastly, the main gameplay UI shown in Figure 1 also features a compact version of the player statboard to provide more condensed feedback to the player (box D in Figure 1).

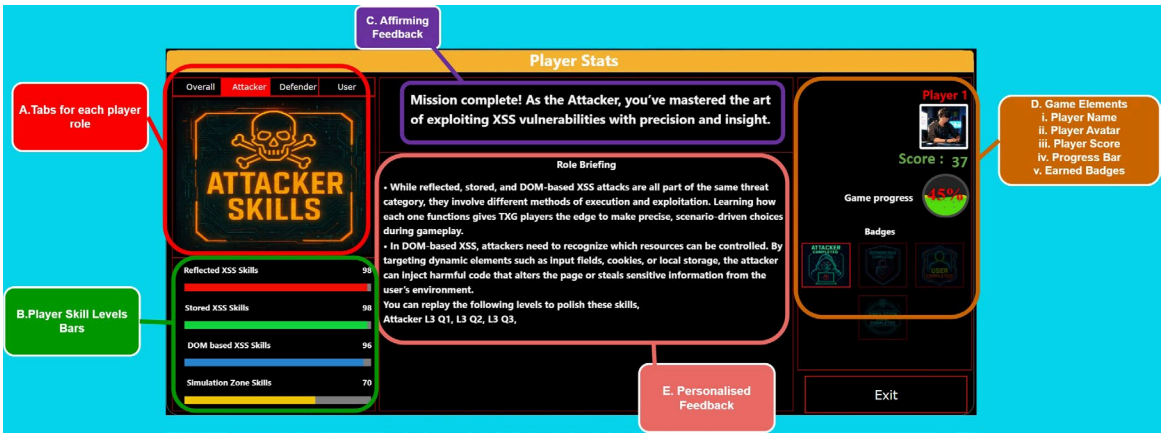

Figure 3: TXG Player Statboard with skills levels and different in-game feedback

5. Results and Discussion

5.1 Data Collection

TXG Version 2 design was evaluated by 2 experts in game-based learning. For evaluation, the experts were presented with access to the game via a shared application link along with an evaluation rubric to guide the process. The evaluation rubric focused particularly on assessing the effectiveness of in-game feedback mechanisms and the player statboard in supporting learner engagement, reflection, and skill development. In addition, the experts were encouraged to provide open-ended feedback on the gameplay experience. It is important to note that, according to Sikt – the Norwegian Agency for Shared Services in Education and Research, no approval was required since the data collection did not involve any personal data.

It should also be noted that the expert comments that are presented in the following sections are presented as they were received in order to convey their original meanings and have not been edited for grammar.

5.2 RQ1: Integrating Different In-Game Feedback Within a Cybersecurity Educational Game

Expert evaluators indicated that in-game feedback was plentiful, useful and promising.

> *"Timely feedback and it is important to provide different feedback during gameplay."*
>
> *"One thing I like about the game is that it provides ample feedback. A player would have all the feedback they need, perhaps more than what the player actually needs."*
>
> *"Useful feedback but can be overwhelming at times."*
>
> *"Yes. They do very often act as a motivator. But positive and constructive feedback during gameplay is also important."*

However, expert comments stated that the delivery of the feedback could be improved in terms of UI/UX aspects and enhanced relevance to the target player group.

> *"Feedback seems a bit much. Maybe if it has clear connections to a given course with a clear target group (students studying the topic). "*
>
> *"Need to be divided into sections and made more easily readable."*

Moreover, evaluators mentioned that the personalised feedback was useful but needs to be more specific and readable. Comments also recommended to split personalised feedback from the rest of the feedback and provide it as a summary towards the end of the game, as concluding remarks.

> *"Personalised feedback can have potential here. But still feel a bit generic."*
>
> *"It blends with the other types of feedback. Did we have a summary at the end? If not – the game should – and then the personalised feedback could be given then (splits it from the other feedback)"*
>
> *"Some feedback given as part of the end-survey of the game is needed."*
>
> *"Would have been good to receive some concluding remarks, sort of as the take-home message."*

Based on the comments, this study finds that although TXG in-game feedback shows promise in helping students learn XSS topics, there is much room for improvement in terms of UI/UX enhancements and feedback quality. Hence, improvements, such as better readability, more concise and relevant feedback, should be made before having the TXG Version 2 tested by students.

5.3 RQ2: Incorporating a Player Statboard in a Cybersecurity Educational Game

Evaluation also yielded positive comments regarding the design of the player statboard.

> *"Important feature. Most players always like to compare themselves to others, or to the max possible score."*
>
> *"Provides a variety of useful feedback for the roles."*

However, the comments indicated that improvements should be made in terms of UI/UX and better feedback quality.

> *"Ok. But feedback still hard to read and understand."*
>
> *"Role briefing is hard to read. This should be displayed more like a bullet point list. It is not clear what is general feedback and what is direct feedback to the player."*

Moreover, comments also suggested that, currently, the player statboard is geared towards skilled players and suggested utilising the player statboard in assisting less skilled players with hints and guidance.

> *"But, it acts more like (positive) feedback on progression and score. But, if my score was low – it would have the opposite effect. The design should therefore consider this – and help less skilled players with possible clues. Let them try again."*

Thus, the comments suggested that the design of the TXG Version 2 player statboard is a useful and promising feature that could be used to provide player accomplishments, assistance and guidance, especially for less

skilled players. However, improvements should be made in terms of UI/UX and enhanced feedback quality before being released for player testing.

5.4 Educational Game Development Framework

Expert evaluation also suggested that this game format could serve as a foundation for an educational game development framework.

> *"Playing the different roles gives several perspectives to increase knowledge. Can see this applied in other games."*
>
> *"The simulation zone challenge of testing my knowledge is interesting. Provides sort of a break from the gameplay. Interesting to see how this can be applied in other contexts."*
>
> *"Has potential to be used for other educational games. This current game has ONE goal in mind. What if we designed a game with two (or several) goals in mind. Would the player then be distracted enough to forget about the security issues? This can be designed with a gameplay where the player need to access different online stores to buy/collect items, adding info about themselves, etc"*

Hence, this study argues that with the suggested improvements, the TXG Version 2 game format has the potential to act as an educational game development framework in the domain of cybersecurity and beyond. TXG Version 2 extends the educational game development framework presented in Weeratunge & Hjelsvold (2025) with detailed in-game feedback and a player statboard. Researchers and developers could use this to accelerate their educational game development.

6. Limitations and Future Work

6.1 Limited Sample Size

The main limitation of the study is the limited sample size in the expert evaluation of TXG Version 2. Even though the expert evaluation provided valuable feedback and comments to improve the educational game, it would have been beneficial to have had the TXG Version 2 design evaluated by more experts. Such an evaluation could have yielded more detailed insights into how players/students perceive game features, including different in-game feedback and the player statboard, and how these can aid in player engagement, motivation and knowledge improvement. A more comprehensive evaluation is planned for Fall 2025 within a second-year undergraduate computer science course.

6.2 UI/UX Improvements

As presented in the Results and Discussion section, there are several possibilities for improvements in terms of enhanced text readability and better feedback quality. Thus, this study has identified improvements that should be made to the prototype before being tested by students.

7. Conclusion

This study presents the design of The XSS Game (TXG) Version 2, an enhanced multi-opposing-role-playing game designed to teach Cross-Site Scripting (XSS) attacks. Through the integration of multiple in-game feedback types (affirming, reflective, explanatory, and personalised) and the introduction of a player statboard, TXG Version 2 aims to improve student engagement, motivation, and knowledge retention. Expert evaluations of the first prototype of TXG Version 2 indicated that the diverse feedback mechanisms and statboard feature could be effective in supporting learners' progress and fostering self-reflection. The incorporation of various feedback types, particularly personalised feedback, aligns well with educational theories of self-regulated learning and reflective practice, further strengthening the game's role in improving cybersecurity education. While the TXG Version 2 design was seen as promising by the experts, there were several recommendations for further improvements in UI/UX design to ensure clearer presentation and enhanced readability.

The evaluation results also suggest that the TXG Version 2 game format offers the potential to serve as a robust educational game development framework for cybersecurity topics and beyond. Future work will focus on addressing the identified areas for improvement, particularly in terms of UI/UX design, as well as conducting a more comprehensive evaluation with actual players to further refine the game's features.

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Ethics Declaration: As mentioned in Section 5, the data collection did not involve any personal data and thus, according to Sikt – the Norwegian Agency for Shared Services in Education and Research guidelines, no approval was needed.

AI Declaration: Grammarly was used to check and correct the grammar of the study. This was the extent of AI use in the study.

References

Arnab, S. et al., 2012. Pedagogy-driven design of Serious Games: An overall view on learning and game mechanics mapping, and cognition-based models. *Serious Games Institute,* Volume 2, pp. 145--158.

Burgers, C., Eden, A., Van Engelenburg, M. D. & Buningh, S., 2015. How feedback boosts motivation and play in a brain-training game. *Computers in Human Behavior,* Volume 48, pp. 94--103.

Chen, C.-Y., Goh, B. W., Lee, J. & Li, N., 2025. The Effect of Cybersecurity Breaches on Analysts' Earnings Forecasts. *European Accounting Review,* pp. 1--27.

Ericsson, K. A., Krampe, R. T. & Tesch-Römer, C., 1993. The role of deliberate practice in the acquisition of expert performance. *Psychological review,* Volume 100, p. 363.

Gaurav, D. et al., 2021. *Cybersecurity training for web applications through serious games.* s.l., IEEE International Conference on Engineering, Technology & Education (TALE).

Google, n.d. *XSSgame.* [Online] Available at: https://xss-game.appspot.com [Accessed 08 04 2025].

Hooshyar, D., 2022. Effects of technology-enhanced learning approaches on learners with different prior learning attitudes and knowledge in computational thinking. *Computer Applications in Engineering Education,* Volume 30, pp. 64--76.

Hussain, J., n.d. *Cyber Security Game: Play injection attack game, SQL,XSS, injection web vulnerabilities — injection.pythonanywhere.com.* [Online] Available at: https://injection.pythonanywhere.com [Accessed 10 04 2025].

Hwang, D. & Kang, Y., 2023. How Does Constructive Feedback in an Educational Game Sound to Children?. *International Journal of Child-Computer Interaction,* Volume 36, p. 100581.

Johnson, C. I. & Priest, H. A., 2014. 19 The Feedback Principle in Multimedia Learning. *The Cambridge handbook of multimedia learning,* Volume 449.

KirstenS, 2024. *Cross Site Scripting (XSS).* [Online] Available at: https://owasp.org/www-community/attacks/xss/ [Accessed 10 04 2025].

Kolb, D. A., 1984. *Experiential learning: experience as the source of learning and development.* s.l.:Upper Sadle River: Prentice Hall.

Lim, T. et al., 2015. The LM-GM framework for serious games analysis. *Pittsburgh: University of Pittsburgh.*

Mayer, R. E., 2005. *The Cambridge handbook of multimedia learning.* s.l.:Cambridge university press.

Mayer, R. E. & Johnson, C. I., 2010. Adding instructional features that promote learning in a game-like environment. *Journal of Educational Computing Research,* Volume 42, pp. 241--265.

Nelson, B. C., Kim, Y., Foshee, C. & Slack, K., 2014. Visual signaling in virtual world-based assessments: The SAVE Science project. *Information Sciences,* Volume 264, pp. 32--40.

Pallets Projects, 2010. *Welcome to Flask — Flask Documentation (3.1.x)..* [Online] Available at: https://flask.palletsprojects.com/en/stable/ [Accessed 05 04 2025].

Shoelace, n.d. *Shoelace.* [Online] Available at: https://shoelacelearning.com [Accessed 15 04 2025].

Shute, V. J., 2008. Focus on formative feedback. *Review of educational research,* Volume 78, pp. 153--189.

The Hechinger Report,, n.d. *Can This Game-Like App Help Students Do Better in School?.* [Online] Available at: https://www.wired.com/story/can-this-game-like-app-help-students-do-better-in-school/ [Accessed 15 04 2025].

The Open Worldwide Application Security Project, 2024. *OWASP Top Ten | OWASP Foundation — owasp.org.* [Online] Available at: https://owasp.org/www-project-top-ten/ [Accessed 08 04 2025].

Unity Technologies, 2024. *Unity Real-Time Development Platform | 3D, 2D, VR & AR Engine — unity.com.* [Online] Available at: https://unity.com [Accessed 05 04 2025].

Van Steen, T., Norris, E., Atha, K. & Joinson, A., 2020. What (if any) behaviour change techniques do government-led cybersecurity awareness campaigns use?. *Journal of Cybersecurity,* Volume 6.

Weeratunge, N. H. & Hjelsvold, R., 2025. *Enhancing Cybersecurity Education Through Multi-Opposing-Role Gameplay and Simulations.* Levanger, Academic Conferences International.

Wouters, P. & Van Oostendorp, H., 2013. A meta-analytic review of the role of instructional support in game-based learning. *Computers & Education,* Volume 60, pp. 412--425.

Zimmerman, B. J., 2002. Becoming a self-regulated learner: An overview. *Theory into practice,* Volume 41, pp. 64--70.