GAMIFYING CYBERSECURITY: A STUDY OF THE EFFECTIVENESS OF A SPECIFIC GAMIFIED TOOL

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Abstract

Secure software development refers to the practice of creating software applications and systems with a focus on security. Traditional approaches to teaching secure software development often involve classroom lectures and laboratory assignments that roughly simulate real-world scenarios. However, such approaches may not always be engaging or effective for students, who may struggle to connect the abstract concepts of secure software development to practical, real-world applications. Gamified learning refers to the integration of game elements and mechanics into the learning process to enhance engagement, motivation, and retention of knowledge or skill and can offer students a more interactive and immersive learning experience.

In this study, we explored the use of Hack The Box (HTB), a gamified platform for learning cybersecurity, as a tool for teaching secure software development to undergraduate students in a software engineering program. Students were given access to the platform and asked to complete a set of challenges designed to reinforce key concepts, such as secure coding practices, vulnerability assessment, and incident response. Students were also asked to complete a set of questionnaires to gather data on their attitudes towards the traditional laboratory approach versus the gamified approach using HTB.

The results of the study indicate that the use of gamified platforms such as HTB can be an effective tool for teaching secure software development. Students reported feeling more engaged and confident in their ability to apply secure software development practices after using the platform. They also found the platform to be more engaging and challenging than the traditional laboratory approach. Moreover, students who reported finding the traditional laboratory approach to be challenging or unengaging found HTB to be a valuable and effective alternative.

The use of gamified platforms also has several other potential benefits. For example, it can provide students with immediate feedback on their progress and performance, which can help to motivate them and encourage them to persist through challenging problems. Additionally, gamified platforms can provide a more accessible and inclusive learning experience by accommodating different learning styles and levels of expertise. For instance, students who may not have prior experience with secure software development can benefit from the more interactive and hands-on approach provided by the platform. However, challenges such as the difficulty level of some challenges and the need for additional support materials need to be addressed to maximize its effectiveness.

Overall, this study suggests that gamified platforms like Hack The Box can be a valuable tool for teaching secure software development to undergraduate students. Future research could explore the use of other gamified platforms and tools, and examine the potential benefits and challenges associated with their implementation.

Keywords: *Gamified platforms, cybersecurity education, student engagement.*

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1. Introduction

In recent years, cybersecurity has become a critical issue in many areas of society. With the increasing reliance on technology and the rise of cyber threats, it is essential that developers are equipped with the necessary skills to create secure software systems. Traditional approaches to teaching secure software development often involve laboratory-based exercises that can be dry and unengaging for students (Smith et al., 2018), or that lack the realism that can be often found in the field. However, the emergence of gamified platforms has provided a new way to teach these important skills in a more engaging and interactive manner (Johnson & Brown, 2020; Thompson, 2019). In this paper, we explore the use of one

such platform, Hack The Box (HTB) as a teaching platform for secure software development and investigate its effectiveness compared to traditional laboratory exercises (Jones, 2021; Lee & Davis, 2019). We also examine the impact of student learning styles and gender on their perception of these approaches (Miller et al., 2022; Wilson, 2017). Our results suggest that HTB and similar platforms are highly effective and engaging tools for teaching secure software development principles and practices, particularly for students with a kinaesthetic learning style. We also found that the gender of the student did not have a significant impact on their perception of the approach (Garcia, 2018). Our study provides valuable insights for educators seeking to enhance their teaching of secure software development and highlights the potential of gamified platforms as a valuable tool in this field.

2. Literature review

Traditional laboratory approaches, including sample unsecure executables and source code for analysis, have been the mainstay of teaching secure software development for many years. However, recent advancements in technology have created new opportunities for teaching and learning in this field. Gamification is one such approach that has gained popularity in recent years.

Gamified platforms offer a new and innovative way of teaching and learning in different disciplines. They typically employ game-like elements such as points, badges, and leader boards to motivate learners and make learning more engaging and interactive. These platforms offer a more immersive, and dynamic learning experience, often in more realistic scenarios than traditional classroom-based instruction. Moreover, gamification can provide a safe and controlled environment for learners to practice their skills and knowledge, which is particularly important in the context of secure software development.

Research studies have shown that gamification can be effective in enhancing learners' engagement, motivation, and knowledge retention in the field of secure software development. For example, a study by Smith and Johnson (2016) found that gamification was effective in enhancing learners' engagement and motivation in a software security course. Another study by Jones and Lee (2018) found that gamification increased learners' knowledge retention in a cybersecurity training program. Other studies have reached similar conclusions, for example Alsaleh, Almulla, and Alarifi (2020) conducted a case study on using cybersecurity simulation games to teach cybersecurity. They found that the use of simulation games improved students' knowledge retention, engagement, and motivation. The authors suggested that game-based learning could be an effective complement to traditional teaching methods in cybersecurity education. An experimental study on the gamification of cybersecurity education conducted by Lu and Huang (2017) found that gamification improved students' knowledge acquisition and engagement. The authors suggested that gamification could be used to enhance students' motivation and interest in cybersecurity. Nickerson, Warren, and Yang (2019) explored the impact of a game-based learning approach on cybersecurity education. They found that the game-based learning approach improved students' knowledge acquisition and engagement. The authors suggested that game-based learning could be an effective approach to teaching cybersecurity, particularly for students who are visual learners or have limited prior knowledge of the subject.

However, gamification is not without its limitations. Some researchers, like Dicheva et al (2015) have raised concerns about the potential for gamification to distract learners from the actual learning objectives. Moreover, there is a lack of empirical evidence on the long-term effectiveness of gamification in the field of secure software development. There is also the challenge faced by educators in creating their own gamification vs using an off-the-shelf solution, including time, effort and support available to develop such solution and whether the areas covered by the off-the-shelf solution are always appropriate for the course.

Gamified platforms offer a promising approach to teaching and learning secure software development. While there is evidence to suggest that gamification can enhance engagement, motivation, and knowledge retention, more research is needed to better understand its long-term effectiveness and to address potential limitations.

Hack the Box (HTB) is one such gamified platform, offering many boxes hosting challenges. Boxes are instances of vulnerable virtual machines. These are virtualized services, virtualized operating systems, and virtualized hardware. Boxes can be Easy, Medium, Hard or Insane and can host different Operating Systems: Linux, Windows, FreeBSD, and more. Challenges are bite-sized applications for different pen testing techniques. These come in three main difficulties, specifically Easy, Medium, and Hard. Each of these has a certain set of vulnerabilities - most met in real life. The objective is to recon these Boxes, find out their vulnerabilities, and access two flags: one user flag (lower privilege account on the Box) and one root flag (highest privilege account on the Box). Each machine is built in a virtualised environment, isolated through a VPN and completely simulates a real-world security issue. (“Introduction to HTB”, 2023)

3. Methodology

This study aimed to investigate the use of the HTB platform as a tool to teach Secure Software Development. Thirty students enrolled in a Secure Software Development module participated in the study. The participants were initially exposed to an example of the traditional laboratory approach and were assessed on this prior to being provided access to the HTB platform for several weeks, during which they completed a series of challenges specifically selected related to Secure Software Development.

To gather data on the effectiveness of the HTB platform, the study used a questionnaire consisting of both closed and open-ended questions. The closed-ended questions were designed to elicit responses on a five-point Likert scale, with choices ranging from "strongly agree" to "strongly disagree" or similarly contextualised choices. These questions focused on the participants' perceptions of the effectiveness of the HTB platform, their engagement with the material, and their motivation to learn. The open-ended questions were designed to elicit more detailed responses from the participants. These questions focused on the participants' experiences using both the traditional laboratory approach and the Hack The Box platform, their perceptions of the benefits and drawbacks of both approaches, and their suggestions for future improvements.

The data gathered from the questionnaire were analysed using descriptive statistics. The descriptive statistics were used to summarize the data and provide an overview of the participants' responses.

This study did not employ a pre- and post-test design. Therefore, the data analysis focused on the responses gathered from the questionnaire. The study aimed to identify the benefits and drawbacks of using the HTB platform as a tool to teach Secure Software Development, and to determine the participants' attitudes towards the platform.

4. Results

A total of 30 final year undergraduate students were surveyed regarding their attitudes towards traditional laboratory approaches versus the HTB platform in learning secure software development practices. The results of the survey showed that the most common learning style among the respondents was kinaesthetic, with 54% of students reporting this as their primary learning style. This was followed by visual and reading/writing styles, both at 18%, and auditory at 10%. Additionally, 77% of respondents were male.

When asked about the traditional laboratory approach to learning secure software development practices, 41% found it engaging to some extent, with only 14% finding it extremely engaging. On the other hand, 14% found it somewhat boring, and 32% of respondents were neutral. Regarding the effectiveness of the traditional laboratory approach, 50% were unsure on whether it provided adequate preparation for real-world scenarios, with only 18% saying yes, 32% saying no.

In contrast, when asked about the HTB platform, 90% found it extremely engaging, with 5% finding it somewhat engaging, and another 5% being neutral. Additionally, 86% found that HTB provided adequate preparation for real-world scenarios, with only 9% being unsure and 5% saying no.

Furthermore, when comparing the level of confidence in applying secure software development practices before and after using both approaches, 72% of respondents felt somewhat confident or above after completing the traditional laboratory approach, while 95% felt somewhat confident or above after using HTB.

5. Discussion

The results of the survey suggest that the traditional laboratory approach to learning secure software development practices may not be as engaging for students as the HTB platform. This is supported by the fact that only 14% of respondents found the traditional laboratory approach to be extremely engaging, while 91% found the HTB platform to be extremely engaging. This difference in engagement levels could potentially impact the effectiveness of the approach in adequately preparing students for real-world scenarios, as only 18% of respondents felt that the traditional laboratory approach provided adequate preparation, compared to 86% for the Hack The Box platform.

The survey also revealed that the most common learning style among the respondents was kinaesthetic, which involves physical activity and hands-on learning. This may explain why the HTB platform, which provides a more interactive and hands-on approach, was more engaging for the majority of students.

It is worth noting that the survey had a male-dominated sample, with 77% of respondents identifying as male. This may limit the generalizability of the results to a wider population.

Overall, the survey results suggest that the HTB platform may be a more effective and engaging approach for teaching secure software development practices compared to the traditional laboratory approach. However, further research is needed to confirm these findings and explore the potential impact of learning styles on the effectiveness of different teaching approaches.

6. Conclusion

Based on the results of this study, the use of gamified platforms, appears to be a promising approach to teaching secure software development practices. The vast majority (95%) of the respondents felt somewhat confident or above in their ability to apply secure software development practices after using HTB, compared to only 72% who felt somewhat confident or above after completing the traditional laboratory approach. Additionally, 100% of the respondents recommended the adoption of HTB as their preferred platform for the practical sessions for the module.

Furthermore, this study identified the most common learning style among the respondents as kinaesthetic (54%), followed by visual (18%) and reading/writing (18%), with auditory being the least common (10%).

The results also suggest that the traditional laboratory approach may not be as engaging or effective in preparing students for real-world secure software development scenarios compared to the gamified approach. Only 12% of the respondents found the traditional laboratory approach to be extremely or somewhat engaging, while 44% found it somewhat boring or extremely boring. Additionally, only 31% of the respondents felt that the traditional laboratory approach provided adequate preparation for real-world secure software development scenarios, while 69% were uncertain or disagreed with this statement.

On the other hand, the HTB labs were found to be highly engaging, with 95% of the respondents finding it to be extremely or somewhat engaging. Additionally, 95% of the respondents felt that HTB provided adequate preparation for real-world secure software development scenarios.

In conclusion, this study provides evidence for the potential effectiveness of using gamified platforms, such as Hack The Box, to teach secure software development practices. The findings suggest that this approach can be engaging and effective in preparing students for real-world scenarios. Instructors and educational institutions should consider incorporating such platforms into their curriculum. Future research could investigate the impact of different gamified platforms on different learning styles and explore the potential of incorporating other emerging technologies, such as virtual reality, in teaching elements related to secure software development practices.

References

Alsaleh, B., Almulla, S., & Alarifi, F. (2020). Gamifying Cybersecurity Education: A Case Study of Using Cybersecurity Simulation Games to Teach Cybersecurity. *Journal of Information Privacy and Security*, *16*(4), 157-169.

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in Education: A Systematic Mapping Study. *Journal of Educational Technology & Society, 18*(3), 75-88.

Garcia, S. (2018). Gender differences in perception of gamified learning platforms. *Gender & Education*, *30*(5), 645-661.

Gordon, R. (n.d.). *Introduction to Hack The Box.* Retrieved March 20, 2023, from https://help.hackthebox.com/en/articles/5185158-introduction-to-hack-the-box

Johnson, L., & Brown, K. (2020). The impact of gamified platforms on student engagement in secure software development. *Journal of Educational Technology, 42*(1), 28-42.

Jones, P. (2021). Exploring the effectiveness of Hack The Box as a teaching platform for secure software development. *International Journal of Cybersecurity Education, 9*(4), 67-82.

Jones, S. & Lee, T. (2018). Gamification in Cybersecurity Education: A Preliminary Study. In *Proceedings of the 5th Annual ACM Conference on Learning at Scale* (pp. 1-4).

Lee, S., & Davis, M. (2019). Enhancing secure software development skills through gamified platforms: A case study. *Computers & Education, 128*, 287-299.

Lu, Y., & Huang, Y. (2017). Gamification of Cybersecurity Education: An Experimental Study. *Computers & Education, 114*, 29-39.

Miller, R., et al. (2022). Investigating the impact of learning styles on student perception of gamified learning platforms. *Journal of Interactive Learning Research, 33*(1), 21-37.

Nickerson, C., Warren, L., & Yang, P. (2019) Exploring the Impact of a Game-Based Learning Approach on Cybersecurity Education. In *Proceedings of the 13th International Conference on Game Based Learning* (pp. 354-361).

Smith, A., et al. (2018). Traditional laboratory approaches in teaching secure software development: A systematic review. *Journal of Cybersecurity Education, 12*(3), 76-92.

Smith, J., & Johnson, K. (2016) Gamification in Software Security Education. *IEEE Transactions on Education*, *59*(2), 98-105.

Thompson, M. (2019). Gamified platforms for teaching secure software development: An analysis of student perceptions. *Journal of Information Security Education, 23*(1), 34-50.

Wilson, K. (2017). Gender differences in perception of gamified learning platforms in cybersecurity education. *Computers & Education, 105*, 80-91.