Shall We Play a Game? : Building Capture the Flag Games for Non-Traditional Players

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***Abstract*—Capture the Flag contests are a common way to develop and exercise cybersecurity skills. One of the ways to reach underrepresented groups, such as women and minorities, is provide learning options that reduce cultural bias. This research used a game framework designed for the participants to build a series of Capture the Flag challenges together and create an original Capture the Flag competition for their peers at a university or conference to play.**

Keywords— CTF, cybersecurity, adaptive gamification, design

I. Introduction

Gamification, or using game-type elements in non-gaming contexts, has the potential to improve user experience and engagement [1]. Electronic versions of Capture the Flag (CTF) contests have been adopted as a popular gaming model in the cybersecurity community and cybersecurity education. The games are used to develope and exercise cybersecurity skills and recruit [2]. These contests generally have themes and test different capabilities in teams or for single competitors. Like the rest of cybersecurity, CTF contests typically attract fewer underrepresented minorities [3]. The games reflect the interests of the designers, who are usually established cybersecurity professionals rather than underrepresented minorities [4]

Women and underrepresented minorities have not been attracted to cybersecurity programs and computer science in general, resulting in a lack of diversity in the potential workforce [5]. One of the ways to reach underrepresented groups, such as women and minorities, is provide learning options that reduce cultural bias [6]. Cybersecurity education researchers Codish and Ravid advocated for adaptive game framework that allows a game to be tailored to users of the game [7]. A tailored game has greater potential for greater enjoyment and engagement, which is key both in cybersecurity education and recruitment [8]. However, games in general reflect the gendered bias of the designers in the portrayal of characters, and in the style of activities [9]. Putting underrepresented minorities in the designer's role has resulted in designs that are more inclusive for all [10].

This research used a game framework designed for the participants to build an original Capture the Flag game for their peers at a university or conference to play. The platform not only captures the competitor's performance, but also gives the creators feedback on which challenges are most popular and effective.

Experiential learning theory provides students with a four step process that moves from concrete learning experience to contemplation and conceptualization, and finishes with active experimentation [11]. Using a stable technology platform to deliver the game content, this research frees the participants' creativity to devise the challenges from story and visual perspectives. Finally by taking on the "creating" role in Bloom's taxonomy the participants achieve the highest level learning that has the greatest longevity [12].

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II. Background

The research of gamification in many disciplines including Science, Technology, Engineering and Math (STEM) has resulted has resulted in the recognition of the need for adaptive gaming to achieve the greatest efficacy [13]. While games cannot be one size fits all [1], there are design principles that can be applied to improve engagement [14]. Furthermore though the popularity of gamification is growing, resources to support the game delivery are scarce, and open source is a key option to support such sharing [1]. To achieve the high level of user acceptance and learning, the learning must be like playing [15]. Even outside the academic setting, user evaluation shows game-based learning models have a high level of acceptance if enjoyment is adopted as a design principle. [16].

III. Theory

This research used design science research (DSR) approach, which is research into or about design using design as a research method or technique [17]. It can be an iterative process, as information from an evaluation influences the design of another element [18]. In this research an artifact consisting of a mobile application with an administrative interface was created used to deliver the game content.

Choosing the design science approach is common in gamification research [19]. The artifact created to instantiate the research content provides a user interface to experience the game, and an instrument to directly collect data about the experience [20]. For adaptive gaming the iterative approach of DSR based on the evaluation of the collected data mirrors the adaptive nature of the framework.

IV. Procedure

The participants agree on a theme for their CTF game. The participants then form teams of 2-3 people and choose a cybersecurity challenge to deliver. A list of common cybersecurity challenges tested in CTF games was provided including the following: encryption, SQL injection, Python,

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UNIX statements, etc. The teams chose from the list or create their own. The teams then choose a character related to the theme of the game who will provide backstory for their challenge. A challenge has a "flag" associated with it that can be an answer to question, entry of a string of characters, or the correct identification of an image. The teams also find free-for-use graphics or create original graphics to identify their character and enhance the visuals of the game. The game platform is built on the Google Firebase Platform. The Firebase platform supplies an area to store files, a database component, and an authentication component. The game content is a series of entries in a database, with Angular JS (JavaScript) screens. A sample version of the game can be seen in Figure 1, in this case a superhero theme. At the end of the game the competitors are invited to give feedback only for the challenges they completed. (Figure 1)

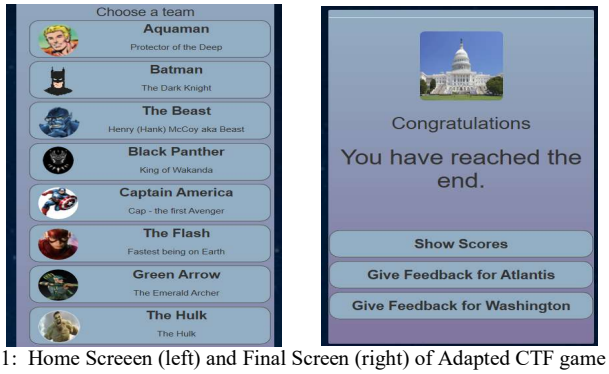

Fig 1: Home Screeen (left) and Final Screen (right) of Adapted CTF game

After the game is constructed, a link to the content is created and can be distributed to invite more participation. At the end of an agreed upon time-period, scores are calculated and winners announced. Game designers also can receive recognition based on how the challenge was perceived.

V. Discussion and Future Directions

The first iteration of the adaptive game framework revealed some things to be addressed. The selection of challenges adjusted so that all the challenges are at least attempted. To further the enjoyment of the games, scores and a leaderboard need to be more prominent [21].

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