Online Footprint - A Serious Game for Reducing Digital Carbon Emission

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Abstract. Life is getting digital more than ever as technology improves. While the Internet is responsible for two percent of global greenhouse gas emissions, it is underestimated as a pollutant. Since public awareness is one of the most important preservation methods, it can contribute to protecting the environment from carbon emissions by raising people's understanding. In this regard, serious games, as a type of gamification transmitting educational content besides entertainment, immerse the player in enjoyment while teaching them a specific topic or enhancing their skills in a field. This study proposes a serious game, taking the digital unseen carbon footprint and its effects on the landscape into the topic. The game considers SDG goals provided by the United Nations Department of Economic and Social Affairs. In this regard, the research uses SDGs 4 and 7 by providing quality education for all and access to sustainable energy by changing people's everyday habits.

Keywords: Online learning, Internet footprint, Climate change, Serious games, SDGs.

1 Introduction

Carbon footprint, which refers to the total amount of greenhouse gasses emitted directly and indirectly by an organization, person, product, or event (Gombiner, 2011), is one of the most undesirable and inevitable issues of the current era human beings are dealing with. The amount of the released carbon into the air has a solid connection with the people's living environment quality. Hence, the amount of emitted greenhouse gasses is being monitored to guarantee a safe habitat for the current and upcoming generations (Pătărlăgeanu et al., 2020). Since the carbon footprint includes gasses other than only carbon dioxide, the amount of global warming each activity causes is calculated by measuring its effect considering the equivalent amount of all

emitted gasses as carbon (Gombiner, 2011). This ecological footprint has a prominent role in climate change which the world is tackling, and urgent solutions are required to hinder the planet from being uninhabitable (Matthews et al., 2008). However, prior to looking for methods of dealing with it, it is important to be aware of its minor causes, as well as the more obvious ones.

Following the emergence of the Internet, it conversed from being a medium for only a minority of society to an everyday factor in the whole of humanity's life. Hence, it raised plenty of questions concerning the impact it puts on social interactions and communities and the accessibility of the resources. This novel technological invention transformed the planet by bringing new enlightenment. Its pervasive use not only functions on its own but also penetrates the everyday activities and functions of the people. For instance, in shopping, the Internet is being used in both innovative and familiar ways (Haythornthwaite and Wellman, 2002). While the capabilities of this technology captivated people, and they assumed that the Internet would be a cure for the planet's climate change problem by reducing the greenhouse gas amount emitted by plenty of activities, they underestimated the carbon footprint of the Internet itself. According to Gombiner (2011), global Information Technology (IT) emits approximately two to four percent of the current greenhouse gasses. This amount is generated in two ways, first, the manufacture and shipment of the required hardware, such as servers, personal devices, etc., and second, the energy needed for power and cooling these systems.

According to Hurst (2017), if the Internet were a country, it could be ranked as the 5th most pollutant compared to the various countries' contamination rates. The Google search engine can serve as a great example to understand energy usage and the Internet's carbon footprint. According to Pandia's 2007 news, this corporation has more than one million worldwide servers processing about one billion search queries daily. In 2009, Kuhn, in a CNN news report, revealed Google's servers as 100,000 per quarter. In addition to these servers' production and distribution of greenhouse gas outputs, each user's Google search has an additional emission. To speed up the search results, Google uses more servers than needed, consuming plenty of unnecessary energy. Due to Alex Wissner-Gross, a physicist from Harvard, each Google search emits seven grams of carbon dioxide, equaling boiling a teapot or driving a car for 52 feet. Considering the different statistics by various organizations, even if this amount is an average of one gram, with one billion daily searches, the related CO2 amount reaches one billion grams, similar to driving 2,375,000 miles with a car.

Additionally, Alex Wissner-Gross has an estimation regarding watching pictures or videos on web pages. According to him, each second viewing media on the Internet produces 0.2 grams of CO2. With the approximately two billion daily videos on YouTube, considering a ten-second watch for each, four billion grams of carbon dioxide is emitted each day by only watching videos (Gombiner, 2011). Another surprising and underestimated rate is related to emails. Depending on being spam, regular, or containing a photo attachment,

emails can vary in carbon footprint amount. They may respectively produce an approximate amount of 0.3, 4, and 50 grams of carbon dioxide. Considering a business user, one person could emit 135kg of CO2 yearly by only sending emails. If the adult users of the UK only stop sending one 'thank you' email, they can reduce 16,433 tonnes of carbon emission yearly (Griffiths, 2020).

Considering the effect of the Internet on different sectors' carbon footprint, while the reduction of business travel will reduce the related emitted gasses (Nairn, 2007), a significant increase will be needed in the Internet's capacity to replace face-to-face meetings with desirable quality video conferences. Consequently, the increased Internet capacity will increase energy consumption and, subsequently, carbon footprint (Baliga et al., 2007). As Owen (2010) quotes Saul Griffith, a green technology innovator, the Internet's carbon footprint may exceed air travel, a major pollutant in this regard, by almost two times. Generally, while this replacement would contribute to carbon emission reduction, the Internet's footprint should also be considered for a more precise calculation (Baliga et al., 2009). The Data Centers supporting the cloud computing architecture and the users' requests are the other major digital causes of greenhouse gasses with their huge energy consumption (Thakur and Chaurasia, 2016). Considering the US, for instance, since it burns coal, a brown energy source, as the main fuel for electricity production, the issue has gained more importance (Le et al., 2010).

Information and communication technologies (ICTs) affected even the movie sector. The Internet provided new means for producers and users in terms of platforms for watching and distribution methods such as webcasting, streaming, and downloading specific content. While the penetration of the Internet to the movie industry decreased the distribution and production costs, the energy efficiency of the increased opportunity for downloading the media contents should be considered, including various factors like manufacturing laptops and other Internet-related materials (Hochschorner et al., 2015). However, regarding the knowledge industry, Chowdhury (2010) states that even if people do not transfer digital content via the Internet, the related power is being consumed in any case. Hence, the small portion of knowledge-related transactions in the Internet carbon footprint is neglectable compared to the environmental and financial costs of physical knowledge distribution.

However, according to UNESCO (2021), the current global challenges, including climate change affected by carbon footprint, could be an education topic for learners of all ages. Such training will prepare the future generation to take vise solutions and actions regarding the current and upcoming environmental issues. This approach, called Education for Sustainable Development (ESD), is a subtopic of Sustainable Development Goal (SDG) 4. Hence, increasing public awareness about reducing carbon footprints and sustainable development can also lead to the desired outcome in the long term in addition to the physical methods dealing with the carbon footprint. For this purpose, serious games serving educational content besides entertainment are a remarkable sample of educational medium for the young generations

regarding a more sustainable future (Alvarez and Djaouti, 2011). Currently, serious games encompass a broad spectrum of topics, including health (Clochesy et al., 2015), military (DeFalco et al., 2018), ecology (Ameerbakhsh et al., 2019), heritage (Vaez Afshar et al., 2021), language learning (Johnson, 2007) and many other fields for both youngsters and higher education students.

This research proposes a serious game to introduce the hidden carbon emission of the Internet and the related activities to the players and make them aware of their daily activities' effect on the sustainability of the surrounding environment. The proposed game teaches the users the amount of carbon emission for various online activities such as broadcasting, emailing, Googling, etc. The players are informed and awarded based on the carbon amount they reduced or increased in a metaphoric ratio according to their selections during the assigned tasks. They also observe its effect on the jungle trees they are responsible for. To develop the Online Footprint game, the researchers reviewed the currently available serious games and the related studies in sustainability and carbon emission.

2 Literature Review

Plenty of researchers developed and investigated the role of serious games in sustainability and carbon footprint, considering the climate change issue. For instance, Dib and Adamo-Villani (2014) developed and evaluated the effect of a serious game in sustainable building development education for the undergraduate students enrolled in various related courses to cover the corresponding gap in the curriculum of the relevant faculties due to the importance of the topic in the current era. The research compared procedural and declarative knowledge gained by students while playing the game versus traditional educational methods. SimGreen is a serious game focusing on the companies' sustainability regarding reducing their environmental effects. Zhang and Zwolinski (2015) proposed a serious game engaging the players to find various methods to tackle environmental issues. In another study, Xu et al. (2014) generated a serious game framework named Makahiki for sustainability with built-in content, gaming elements, and mechanics playable on various devices. The framework had already been used to develop some games via different organizations. Whittaker et al. (2021) focused their study on the effect of rewards and points on the game's ultimate consequence regarding sustainability outcomes. Additionally, while Knol and De Vries (2011) declare the unpopularity of serious games among students, they claim the positive effects of the EnterCities game on the players' energy-related life activities.

Regarding carbon footprint reduction, Archana et al. (2016) developed a game using Bloom's Taxonomy for the course design in their research. In the game, the player gets knowledge and directly experiences the issue by replacing objects in an office area to reduce carbon emissions. In the study by

Yang (2009), a gamified learning tool was proposed to educate non-experts about designing and deciding on energy-related issues in their homes. It is a sample of low-budget computation for public awareness.

Despite all the existing research on sustainability and carbon footprint in various fields, the lack of serious games and relevant studies specifically regarding Internet-related carbon footprint in the literature inclined the researchers toward developing the Online Footprint serious game.

3 Methodology and Game Design

The methodology of the game follows a broad literature review mentioned previously. After the background phase of the study, among the various age ranges, the study chose middle school students aged 11 to 13 as its target audience. Afterward, the possible functionalities that the Internet could have for this age range were listed. Later, to fulfill the game's primary purpose, at the level design stage, using XMind Software, the researchers created a comprehensive mind map for conveying all the intended information to a user engagingly. As a result of this process, the game design part proceeded with the game development phase, which will be discussed more in the paper. However, the game is still in its alpha phase due to time constraints, and the first stage has only been developed (Fig. 1).

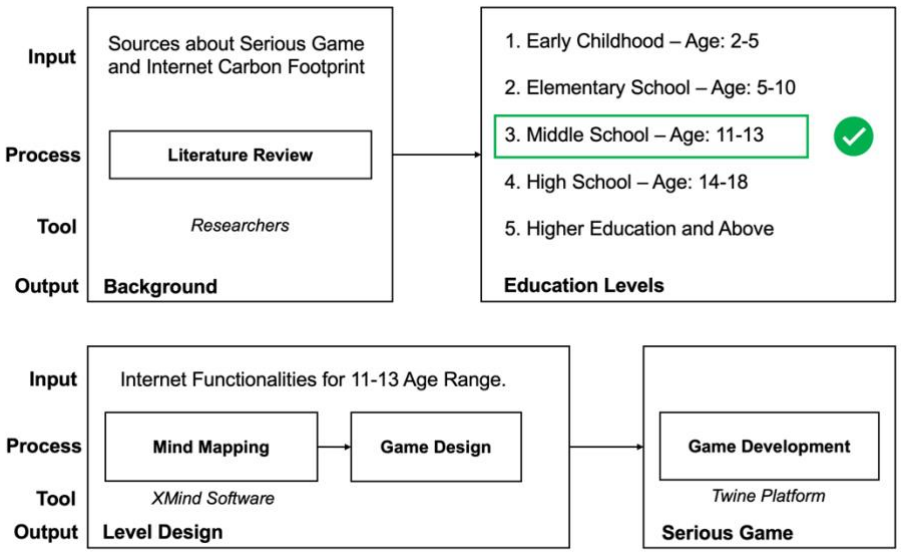

Figure 1. Methodology.

The online Footprint game assigns the player a Jungle to take care of at the beginning of each level. The player also got informed of some important information about that jungle. Subsequently, the game asks some duties or questions to the player, and in each of them, the player should make the best decision to produce as little carbon as possible. While doing the required activities, besides being aware of the emitted carbon dioxide amount, the player will also observe its effect on the trees he/she is responsible for (Fig. 2).

At the end of the level, the game demonstrates the same jungle to the player with the number of trees successfully preserved. Players understand the carbon footprint they leave behind by their daily activities during the game, which has penetrated their lives and left them unaware of their impact on the environment. Since the Internet has an important role in the lifestyle of everyone at any age nowadays, this game can target a wide spectrum of various ages. The game serves the SDG 7 goal provided by the department of economics and social affairs of the United Nations by contributing to affordable, reliable, sustainable, and modern energy access for all by changing people's everyday habits regarding their Internet-related carbon footprint.

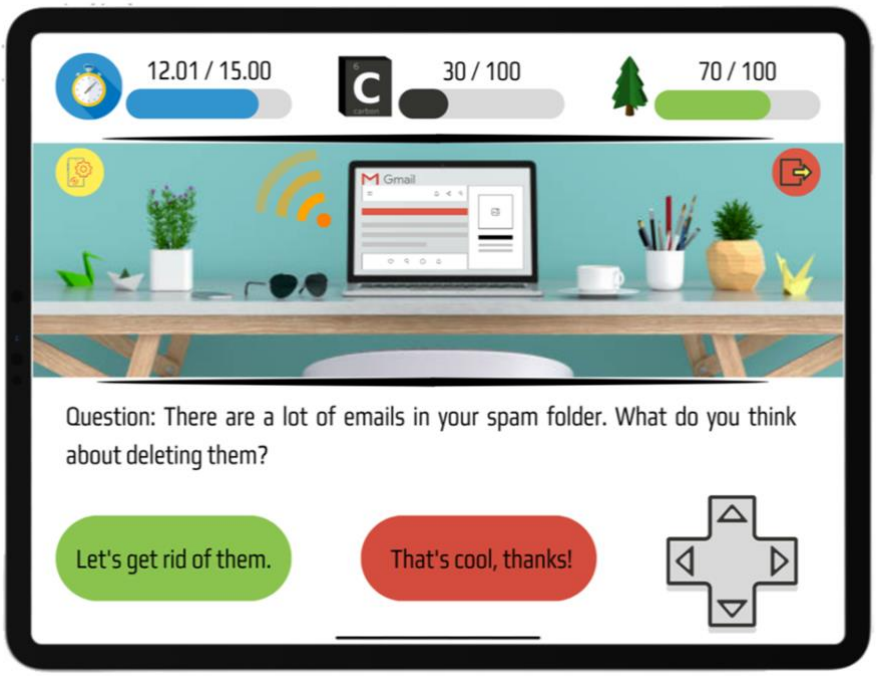

Figure 2. Game's interactive selection sample.

4 Game Development

The game's main goal is to transmit the mentioned data to the player and raise the user's awareness of their daily Internet-related activities. Hence, the paper seeks an easy-to-use platform fitting its aim to develop the game. Twine platform (Twine, 2021) is a free and open-source tool with almost no need for coding, generating interactive non-linear text-based games. The tool can be used online as a web application and installed easily on the desktop. The platform enables game development for non-experts in the game industry. It opens up the opportunity of providing any information in the form of an appealing digital game. Outcomes of the platform are in the form of HTML web pages, available for a mass user, with no need for a high technology device. The game development occurs in a branching system serving the game in a decision-making nature. This non-linearity and possibility of the various endings attract the player to play the game repetitively. By integrating the developed game with Twine macros, HTML, CSS, and JavaScript, it is able to publish a perfectly enhanced and complicated game (Fig. 3).

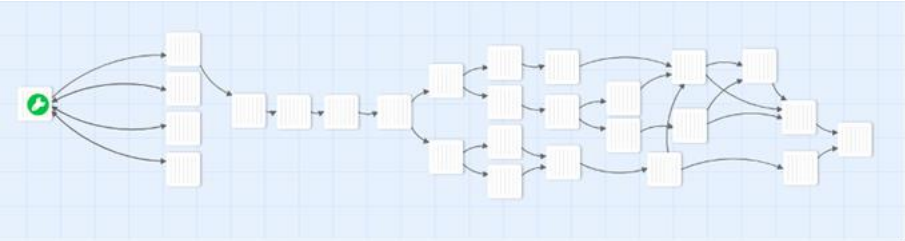

Figure 3. The development process of the game on the Twine platform.

5 Conclusion

To conclude, carbon footprint and global climate change are the planet's vital issues humans are tackling. However, while people are aware of many factors leading to carbon emission, plenty of everyday activities that seem innocent are responsible for this world's trouble. The Internet, which with its emergence facilitates peoples' lives and reduces the carbon emission of several activities, at the same time is responsible for a considerable amount of greenhouse gas production. Public awareness is one of the best and first solutions to facing such a phenomenon. To do so, an interactive and engaging method, immersing a wide range of ages, seems a wise decision. Hence, serious games conveying educational content besides entertainment can raise people's knowledge of the issue. Therefore, this paper proposes the development of a serious game regarding the Internet's unseen carbon footprint. The players would be aware of their daily online activities' carbon

emissions and their effect on the green infrastructure of the world. A game like Online Footprint may help people to change their lifestyle habits. In a pervasive and worldwide topic like the Internet, pretty small changes by each individual can make enormous changes in the world's carbon emissions.

As previously mentioned, the game is in the alpha stage due to time constraints. Hence, as a further study, the game has the potential to be expanded and published for use in schools to raise students' awareness of the issue as the game's first phase. At this level, the game can be evaluated while being used in the curriculum of a class. The test can compare the results of serious game education with conventional educational methods. Afterward, it can be developed for older age ranges, addressing the functionalities of the Internet in business, or higher education, for instance. In that case, the game can be a motivational application for the employees to teach them the required alerting information and directly influence their daily habits while doing their job-related tasks and duties by awarding them among co-workers.

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