Developing Lafayette Park Minecraft World to Broaden Participation in Computing

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Abstract. In this project, we developed Lafayette Park World, a Minecraft Education game and programming environment, for youth to learn programming in a socio-cultural context. Lafayette Park is a historical site of the Women's suffrage movement and a symbol of exercising First Amendment rights. Lafayette Park World gives learners opportunities to explore the Park virtually, compete to locate and identify women's suffrage protest signs and build architecture by programming on the Minecraft Education Platform. Students learn about gender equity and civic engagement, along with programming concepts. Programming in the World can be done either with blocks or in Python.

Introduction

Technological and computing skills have become crucial in our modern society because many careers require mastering them. School systems in the United States have begun to offer computer science education for all K-12 students as a requirement or a mandatory course [12]. However, providing all students equal opportunities to access high-quality computer science education has been challenging.

According to the research literature in this area, students from underrepresented backgrounds (e.g., women, African American, Latinx, indigenous) not only have less exposure to C.S. education but also reported a lower sense of belonging and lower self-efficacy [5], [12], [14]. In 2020, only 3.74% of the total 53,722 computer science degrees awarded went to Black or African American students, and 8.49% went to Latinx students. At the bachelor's degree level, 82.4% of degrees awarded went to men, 17.6% to women, 2.8% to Black or African American men, and only 0.8% to Black or African American women [4]. Since young children's early curiosities and confidence in C.S. are often critical for their future academic and career decisions, it is essential for computer educators to take advantage of popular game software to build early interest in students [4], [12].

When teachers introduce C.S. concepts to students, contexts matter. Traditional C.S. curriculums tend to have a narrow focus on robotics, computer programming, and physics. However, C.S. curriculums are intimately related to societal, cultural, and artistic practices [9]. Similarly, C.S. learning is often mediately by these practices [13].

Minecraft [10] is a game series in which players can explore virtual landscapes and solve challenges or use pre-programmed coding blocks to build things from their imagination. Researchers and educators have considered it potentially transformative for fostering learning and cognitive skills [6]. Since an early version of Minecraft in 2009, millions of children worldwide have spent hundreds of thousands of cumulative years playing the game [9]. Minecraft Education [8] is a learning platform based on Minecraft, where players can learn computer programming and create their own Minecraft games, called "worlds," through programming. We chose to use Minecraft Education as the platform for our socio-cultural game and programming environment because:

1) Minecraft is one of the most popular game platforms for children aged 6-14 [6]. This age range aligns with the targeted age range, 11-18, i.e., middle and high school age, of our broadening education intervention. It is highly likely that these students either play or played Minecraft games. They may either be interested in Minecraft or have fond memories of it. Their positive experience with Minecraft could serve as a foundation for developing an interest in computer programming.

2) Minecraft allows us to create a virtual world that reflects reality: the identity of the players and the socio-cultural context. We want these students' identities to be represented to encourage engagement, particularly from underrepresented students. Minecraft allows us to create characters of different races, genders, and cultures. It also allows us to create buildings, landscapes, objects, and events that resemble the real world, which helps the students to relate.

3) Minecraft education allows players to program with blocks or Python in game worlds. Block-based programming, in general, has significantly lowered the barriers for beginners to get their feet wet with programming. The drag and drop of blocks replaced typing and removed the possibility of syntax errors, which may be frustrating to beginners. Python, a popular programming language choice for beginners, suits the youth with some block-based programming experience. Having both block-based programming and Python in Minecraft Education not only grants youth with various levels of programming exposure to use our proposed programming environment but also facilitates the transition from block-based programming to Python later.

4) Minecraft Education is no-cost or low-cost for users and has a free trial for both teachers and students. It is already included in the Microsoft license of some educational institutions. Its license for individuals is low-cost ($12 per year).

Lafayette Park Minecraft World. In this project, Faculty and students of the Excellence in Computing Innovation and Education (ExCITE) team designed Lafayette Park World, a Minecraft Education game and programming environment, for youth to learn programming in a socio-cultural context. The World mimics the real-world Lafayette Park, a historical site of the Women's suffrage movement and a symbol of exercising First Amendment rights. Women suffragists marched across Lafayette Park every day during January and February 1917 to protest in front of the White House and demanded President Woodrow Wilson's support to give all American women voting rights [6].

We chose to model Lafayette Park with the women suffragist picket in our Minecraft World because:

1) What the Park and the event represent in gender equity aligns with our broadening participation effort in computer science and can empower our youth players.
2) We are located in D.C. Our targeted audience, the K-12 students of the DC metro area, will likely have visited the White House and Lafayette Park area. This familiarity may increase their sense of relatedness with the virtual world and interest in playing the game.

The Lafayette Park Minecraft World integrates history, citizenship education, and computer science. Lafayette Park World gives learners opportunities to explore the Park virtually, compete to locate and identify women's suffrage protest signs and build architecture by programming on the Minecraft Education Platform. Students learn about gender equity and civic engagement, along with programming concepts.

Design

Faculty and students of the ExCITE team designed the Lafayette Park World together, and the second author, a student with prior experience in Minecraft games, implemented it. To incorporate diverse views, we enlisted both male and female, Black, African American, and Latinx students as designers and reviewers of the World.

The World includes the following components: 1) a landscape that reflects the real world, 2) a game, and 3) an area that allows players to build their structures. Players cannot modify the existing structures.

1) **Landscape that reflects the real world:** The landscape of the Lafayette Park World is a recreation of the real-world Lafayette Park and its surrounding area. We researched maps and pictures of the park and the area on the internet and designed the World to include the following to reflect the rich culture and history of the area and immerse players into the World:
    - The park itself, where the women suffragists picketed,
    - The White House, where the women suffragists picketed,
    - The Lincoln Memorial, which is a nearby and prominent landmark on the National Mall honoring the 16th president, Abraham Lincoln,
    - The Washington Monument, which is a tall obelisk that honors George Washington, one of the founding fathers of America,
    - Other buildings that reflect various aspects of D.C. urban life.

2) **Game:** The gameplay of the Lafayette Park World is designed to be fun, educational, and immersive. Players can play the game alone or jointly explore and build in the same World. We designed an exploration game in the park for the players to find protesting signs around the park, and one who finds a sign first can claim a point by clicking the button next to the sign. Each player's points are accumulated and displayed on a leaderboard to make the game more competitive and engaging. We researched the slogans used in the women's suffrage movement and chose ten for the signs, such as "Women demand equality," "Women's Liberation," "Votes for Women," and "Speak your mind, even if your voice shakes."

3) **Programming sandbox:** The world also includes a building area with sixteen spaces for students to build their own structures using blocks, programming code, or both. It allows students to express their creativity and develop problem-solving skills. Students can program in Python, Microsoft MakeCode for Minecraft [7], or Tynker[3] to create simple shapes or patterns, automating the repetitive process of laying blocks to build. They can then manually add small details. Students can develop creativity, logic, and programming skills by building both manually and with code.

Students can learn essential programming concepts and skills: 1) use variables to store and change data, e.g., the number of blocks or type or block to build with; 2) use loops to repeat actions or instructions, such as building a wall or moving an agent; 3) use nested loops to create more complex patterns or structures, e.g., a pyramid or a spiral; 4) use functions to group and reuse code, such as drawing a shape; 5) use lists to store and access multiple values, such as coordinates or names. By coding in Minecraft, students can practice and apply these concepts and skills in a fun and engaging way. We designed the following examples to showcase programming concepts, e.g., variables and loops:

- Place a tree at a location,
- Build a cube,
- Build a square with an Agent (loop),
- Build a cube with an Agent (nested loops).

Implementation

The World was implemented on Minecraft Education based on the "Small Scale White House" map [1] we found online. The World includes the following and was tested on both Minecraft and Minecraft Education.

- The park, with its lawns, trees, flowers, benches, statues, and fountains,
- The White House. The People can go inside the White House and see some of its rooms, such as the Oval Office, where presidents meet with foreign leaders; the State Dining Room, where state dinners are held; and the Blue Room, where receptions are hosted,
- The Lincoln Memorial with the 36 Doric columns, which represent the states in the Union at the time of Lincoln's death, and a Lincon's chair in place for the seated statue.
- The Washington Monument, and
- buildings, including a hospital, a library, a fire department, restaurant buildings, hotels, and a bank.

The Lincoln memorial, most part of the White House, and the buildings around the Park had already been built in [1]. We created the park and the Washington Monument, modified the exteriors of the White house, and implemented the games and the programming sandbox.

Figure 1 shows a bird's-eye view of the park. When loading into the game, players will be placed in front of the White House fence where the women suffrages picketed. They will see female characters with different skin colors representing suffragists, as shown in Figure 2.

Figure 1. Lafayette Park Minecraft World Birds-eye View

Figure 3. Female Characters with Various Skin Colors Representing Suffragists

When turned around, with their backs facing the White House, they will see the view of Figure 3 and be welcomed by three Non-Player-Characters (NPCs), i.e., characters that are not controlled by the player but can perform commands and interact with player characters. One NPC will explain the exploration game. Another NPC will explain that they will be given a camera to take pictures in the World. They can save these pictures into a PDF file to show to others. The third NPC will provide them with the cameras.

Throughout the game, players can be teleported to different locations on the map and see more of the world without walking significant distances. While they collect signs, the leaderboard is updated in real time and can be viewed by all the players in the World.

Figure 3. View from the White House

Figure 4. shows the building area. This area is partitioned into sixteen blocks to allow multiple players or teams to build in the same world, each in their own partition.

Figure 4. Building Area

Figure 5. shows the code that animates the process to create a square with a loop.

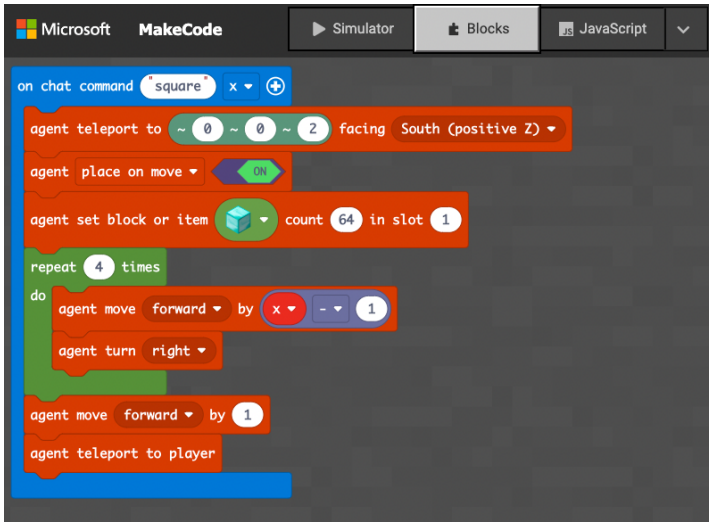

Figure 5. Sample MakeCode for Building a Square in Real-time with an Agent.

To keep the students engaged in the World, we also implemented a mini parkour game in which the player's character needs to jump from one landing place to another without falling. If they fail, they must return to the beginning of the parkour game. In a group setting, this parkour game can entertain the students who finish the exploration game earlier than the others.

We also developed the following supplemental materials[5]: 1) a lesson plan for using the World in K-12 classrooms or higher education outreach activities, 2) instructions and video clips on how to download, host, and play the game and how to use the example source code, and 3) source code for creating architecture examples in the World.

Evaluation

To investigate the effectiveness of the World on increasing K-12 students' interests in computing, we first invited three high school students to play a prototype of the Lafayette Park World game and asked for their feedback. After refining it according to their suggestions, we offered a programming workshop to K-12 students, using the World, and collected survey and interview data. The workshop was one and a half hours long and was implemented following our supplemental lesson plan adapted to the number of the participants. The survey was anonymous, implemented on Qualtrics, and administered at the end of the workshop. Its questions can be found in Appendix A. The Interview questions can be found in Appendix B.

The workshop had seventeen participants, including twelve high schoolers, five middle schoolers, and one elementary schooler. We collected both quantitative and qualitative data. Thematic analysis [2] was used to make sense of the qualitative feedback. The qualitative data provides a sense of theoretical validation on the descriptive quantitative survey items, as it corroborates quantitative results. Thirteen participants responded to the survey. The overall response rate was 76.4%. Per the result, all respondents had taken programming courses before, and four of them had been programming regularly for the past few years before the workshop. Ten respondents played Minecraft games before.

- **Quantitative results.**

Table 1 below shows the quantitative results of the survey.

Table 1. Survey Result (N = 13)

Survey Questions	Average Response
Lafayette Park World Increased my interest in computing	3.62
Lafayette Park World Increased my programming knowledge	3.30
I would like to learn more about programming in Minecraft	3.69
Lafayette Park World increased my knowledge of the women's suffrage movement	4.23
I would like to build more structures by programming in the Lafayette Park World	3.80

We can see that the averages of all the items were above the mean of the scale (3.0). "The Lafayette Park World increased my knowledge of the women's suffrage movement" had the highest average (4.23). "The Lafayette Park World Increased my programming knowledge" had the lowest (3.30). This low increase in programming knowledge may be due to the limited time (25 minutes) spent on programming during the workshop or the level of programming knowledge the participants already had. It is worth noting that while the targeted audience for the World is students who are beginners in computer programming, six (more than one third) of the seventeen workshop participants had three to four years of programming classes.

- **Qualitative results (N = 5)**

The survey contains two open-ended questions: "How do you feel about Lafayette Park World and today's session?" and "What did you like and did not like about them? And why?" To learn more about the students' experience, we invited five students (three high school females, one middle school female, and one high school male) for individual and pair interviews. Two of the five interviewees played Minecraft games before, and the others didn't. All interviewees had programming exposure before the workshop. Among them, one student had gone through a three-year special program with a computer science course each semester. Three others are currently enrolled in special programs with computer science courses (two for the first semester, the other for the third).

We performed a thematic analysis on the qualitative responses from the survey questions and the interviews. We identified three major themes and summarized them below:

1. The World is an educational and entertaining tool for students to learn about and practice programming. Students, when responding to the open-ended survey question, used words such as "fun," "good," "awesome," "nice," "interesting," and "well-constructed" to describe the World and their experiences. Their interview responses helped us better understand why the World provided them with an enjoyable experience and whether the World helped increase students' interest in programming. When asked how much they liked the game, on a scale of zero to ten, with ten being the highest possible degree to enjoy a game, the ratings ranged from six to eight point five. All five interviewees indicated increased interest in computing and programming

outside of Minecraft. One female student said, "It (the World) was pretty fun, so it might motivate me to do some other programming." Three of the five interviewees also stated that they were interested in programming in Minecraft again.

One important subtheme was that the World introduces programming to beginners in a fun and interesting way. For example, a student who had already developed an interest in programming before the workshop said, "When it (programming) is put into the Minecraft game, I feel like people are inclined to think that it (programming) is more fun than it actually is." Another participant, who has already learned block-based coding before, emphasized that Minecraft, as a popular game environment for kids, is particularly helpful for beginners to learn about programming: "Having it (programming) in Minecraft…a game that kids are familiar with, I think it's a good introduction for it (programming)… for someone just starting out trying to get into programming." Similarly, one student indicated if they were going to teach other people how to code, they would "definitely make them play this game at least once…because I feel having them play this Minecraft education game would allow them to at least be more open to the idea of coding because they're put in an environment in a space where they can code while also having fun."

Another major subtheme was that the interactive features of the game make it enjoyable. One mentioned interaction with other players made their experience fun and interesting. Other students commented on interacting with the World by coding, for examples, "I enjoy doing it, and usually, I'm fine with programming, but programming in this game was actually pretty fun because you could interact with it," and "I liked how we could explore the park and talk to different NPCs." Another student also shared that interacting with the game gave them an opportunity for creative expression, "It allows you to go in the chat to code stuff. I think it promotes a lot of creativity."

2. Contextualizing programming in a socio-cultural context enhances the learning experience. The historical background underlying the game caught students' immediate attention. Students found that learning about history while programming at the same time was a meaningful educational experience. The lessons they learned about the women's suffrage movement seemed equally valuable to the students. For example, one student wrote, "This made me realize that without the women's suffrage protests, we wouldn't be here today." Another student commented, "I learned a lot about the history of Lafayette Park." One student reflected, "I like how I was able to get the freedom to do what I want in the world." One student commented that the game made them notice women's history and "what they had to go through in the past."

Students were amazed at how a computer programming workshop could be connected to the historical knowledge they learned at their school. For example, one student mentioned, "It is interesting that … you get to go around and learn about like women's rights and stuff," and "we were actually just learning about that in school in AP US history … and I actually saw some of the quotes that were in the same …it was really an interesting experience to have it connected to what we're doing in school."

3. Challenges to the effectiveness of the World. First, technical glitches could affect the participants' experience. For example, two of the five interviewees had minimal time to play in

the world due to difficulty downloading the Minecraft software. The internet bandwidth of the workshop location was a bottleneck when all workshop participants downloaded simultaneously. Second, engaging with the game for a short amount of time may not be motivating enough for some students to take an interest in programming. For example, a female student commented, "It was a fun experience. But I don't think it would push me so much to the point where I'd want to pursue programming very hard. I think I'd need more exposure to coding in general for me to make that decision." Third, when planning workshops on the World, teachers need to consider students' programming skill levels and prior experiences. One participant indicated that they already passed the phase of learning block-based coding; another shared that they had not played Minecraft except at the workshop and already stopped programming after years of practice.

Limitations

First, our research was conducted with a small convenience and self-selected sample, of which more than one third had taken multiple years of programming classes before this study. Further research is needed to investigate the World's impact on youth who are beginners in computer programming. Second, some participants' experience with the World was affected by their difficulty downloading the software and the limited time to interact with it. For future workshops, we plan to ask participants or schoolteachers to download and install the software beforehand to avoid the network bottleneck. Still, internet access can be a barrier for some students who want to access Minecraft Education at home.

Conclusions

Our data shows that youth participants appreciated the social-cultural aspect of the World and enjoyed the explorational and creative learning experience in the World. We learned that, even in our small sample of students, there is a broad spectrum of exposure to computer programming. Age and grade level cannot necessarily predict a student's programming experience. We also learned that the increased interest in programming achieved through the limited time of one workshop must be sustained and continuously developed through follow-up activities.

Future work

We plan to 1) refine the World according to our participants' feedback, such as setting boundaries for the world, adding objects that players can break or alter, etc.; 2) develop additional coding examples to cover more programming concepts and provide multiple examples for each programming concept; 3) provide project ideas for builders to apply the concepts. We will then offer this workshop in middle or high school classrooms, particularly to underrepresented minority and female students who have not had extensive exposure to programming, and collect their feedback on the World. Such data would help us investigate further the World's impact on broadening participation in computing.

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References

[1] Blocks9250 on Planet Minecraft: *https://www.planetminecraft.com/member/blocks9250/*. Accessed: 2024-04-22.

[2] Braun, V. and Clarke, V. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*. 3, 2 (Jan. 2006), 77–101. DOI:https://doi.org/10.1191/1478088706qp063oa.

[3] Coding For Kids, Kids Online Coding Classes & Games | Tynker: *https://www.tynker.com*. Accessed: 2024-01-11.

[4] Computer Science | Data USA: *https://datausa.io/profile/cip/computer-science-110701*. Accessed: 2023-03-16.

[5] Lafayette Park Minecraft World Supplemental Materials: *http://tinyurl.com/lafayette-park-minecraft*. Accessed: 2024-01-19.

[6] Lane, H.C. and Yi, S. 2017. Chapter 7 - Playing With Virtual Blocks: Minecraft as a Learning Environment for Practice and Research. *Cognitive Development in Digital Contexts*. F.C. Blumberg and P.J. Brooks, eds. Academic Press. 145–166.

[7] Microsoft MakeCode for Minecraft: *https://minecraft.makecode.com/*. Accessed: 2024-01-11.

[8] Minecraft Education Homepage: *https://education.minecraft.net/en-us*. Accessed: 2024-01-10.

[9] Thompson, C. 2016. The Minecraft Generation. *The New York Times*.

[10] Welcome to the Minecraft Official Site: 2024. *https://www.minecraft.net/en-us*. Accessed: 2024-01-10.