Final Project Report

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Executive Summary

The goal of this project was to design an educational technology which addresses a socially-relevant problem space. We asked, **how might we make STEM learning more accessible to traditionally underserved or uninterested students**?

Our target learner is a creative middle schooler with low to medium prior interest in STEM: often girls and minorities. To combat learners' preconceived notions, lack of confidence, and lack of interest, our intervention aims to:

1. Make STEM subjects appeal to this population, thus increasing their likelihood to engage in the first place;
2. Encourage grit, growth mindset, and self-confidence throughout the learning process; and
3. Build intrinsic motivation to pursue higher-level STEM learning through positive role modelling.

After performing primary and secondary research, competitive analysis, prototyping, and user research, our final output is a web-based game called Sparkville. Through apprenticeship-like challenges, players practice skills and concepts foundational to interdisciplinary, creative STEAM careers. Challenge mentors also provide players with a preliminary understanding of what it takes to be a professional in that field. Through exposure and practice in lots of different careers, players can connect the skills needed for these careers to their own interests, so they can view these careers as a potential path.

The goal of the game is to break down the barriers between underserved students and STEM in a fun, entertaining way, while building intrinsic motivation to pursue next steps in STEM learning. Based on feedback from user testing with Pittsburgh middle schoolers, we believe this game has market viability and could transform the way children view STEM careers.

Learner Profile

Sparkville aims make STEM subjects accessible to "underserved" populations - children who struggle with math, creative learners, or children who believe that "STEM is not for me." This game is designed for players ages 10 to 14 to build their confidence and motivation before they reach high school.

Students should have fulfilled the typical education of someone their age, so they should have somewhere between a fifth and ninth grade education. Though this game is accessible to English speakers from diverse ethnic or national backgrounds, careers and mentors featured will be based on industries in the U.S. The game will be captioned for deaf and hard of hearing players. This game will be accessible on mobile phones and desktop computers, available free or for a small fee via app stores. We hope to limit cost so it can benefit a wide range of students, but we will be limited to students who have access to computers or smartphones.

Unmet Need

A large portion of underserved STEM candidates are women. Women make up half of the total U.S. college-educated workforce, but contribute to 25% or less of the workforce in multiple STEM fields. There have been many studies investigating why women don't enter STEM fields at the same rate as their male peers. One problem is the prevalence of gender-based stereotypes. One study found that girls as young as six held beliefs that boys were more competent at robotics and programming, and reported less motivation to pursue these subjects themselves. Even though gender achievement in STEM topics is at parity through early high school, as girls approach college they are less likely to pursue advanced math and science classes or STEM majors.

Another issue is lack of role models. When girls don't see women in STEM, it can be difficult to believe they could have successful careers in the field (exacerbated further for ethnic minorities). Finally, girls may be taught to fear failure and avoid risk, which can cause a feedback loop leading them away from STEM—they don't practice STEM because they believe they won't be good at it, and then when they try they are easily discouraged by challenges.

While this research refers to female populations, issues of fear, demotivation, and lack of role models also apply to minority populations. Therefore, we do not want to tailor our intervention based on gender alone, but attempt to reframe the STEM workforce as one that is diverse and welcoming for all individuals and skillsets.

Problem Statement

There are various organizations and initiatives that attempt to encourage STEM interests among girls and minorities. For example, Girls Who Code is a nonprofit that aims to support and increase the number of women in computer science by equipping young women with computing skills. However, such organizations may already seem inaccessible or unappealing to children who have a hard time envisioning their future within STEM. Many of these organizations are high-touch and expensive — another barrier to entry — and may require participants to be physically present, as in camps or afterschool programs. Finally, many existing solutions are solely educational, rather than entertainment or lifestyle-focused. Sparkville fills these gaps through a focus on inclusivity, exploration, accessibility, and everyday entertainment.

Deeper Problem Understanding

Early in the design process we performed research to gain a deeper understanding of motivations, barriers, and best practices to encourage attitudinal change among our target learners. Our methods included secondary research of literature in the field, and primary interviews with educators, designers, and middle school program leaders.

LITERATURE REVIEW

In their article "Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes," Allan Wigfield and Jenna Cambria discuss the impact of beliefs and goals on learner motivation and achievement. In their review of scholarship in the field of motivation, they summarize that "when individuals believe they have the capability to succeed at different activities they will be more likely to engage in them, persist in the face of difficulties, and do well on those activities." Further, they discuss attainment value, defined as the importance learners ascribe to tasks that align with their sense of identity.

These principles reinforce the learning science behind Sparkville: that in order for players to build grit, confidence, and intrinsic motivation to pursue STEM learning goals, the game should provide them with feelings of competence and inspiration. Introducing players to diverse and nontraditional mentors through each challenge, and giving players the option to learn more about mentors' paths, will inspire players to envision possible future selves which would motivate them to pursue higher level STEM coursework.

Additionally, Sparkville's features were informed by findings from a 2005 case study from Girls Creating Games, an extracurricular program which taught girls coding skills. Their curriculum stemmed from similar findings: that "personal barriers [for girls in computing] include lack of self-confidence, lack of fluency in technology skills, lack of early positive experiences, lack of information about careers and a belief that technology careers require a solitary lifestyle in front of a computer." Their program aimed to make technology skills more relevant to participants through dispositional learning and reflection. In one module, participants identified their skills and interests and were encouraged to explore different roles in game production that might suit them. The program gave participants an understanding of the basic skills that computing tasks require, as well as a vocabulary to articulate their personal strengths and interests.

This was a key insight in the development of Sparkville: that if players could reflect on their likes and dislikes after participating in STEAM challenges, they would feel more confident and clear when choosing to pursue their interests. By tying success to the reflection activity and encouraging exploration within the town, this also eliminates players' fear of failure. Like GCG, Sparkville helps players experience success in STEAM subjects and pinpoint the topics that make them feel most engaged and successful. These principles informed the design of the explorer's journal, where players reflect on their experiences after challenges.

Finally, we discussed the project with Dr. Jessica Hammer, a principal investigator and game designer in Carnegie Mellon's OH!Lab. Based on this conversation, we consulted with Culyba's Transformational Framework. The framework informs how to develop games which "change players in a specific way that transfers and persists beyond the play session." Two phases specifically informed our design: the player transformations phase, and the barriers phase. Based on this direction, we decided that the most addressable barriers and transformations in the scope of the game were attitudinal. We decided to focus on increasing interest and motivation in STEM through modeling and narrative, rather than purely through skillbuilding challenges.

INTERVIEWS AND CONTEXTUAL INQUIRY

Several sources of primary research also drove the design of Sparkville. One population of insight was Carnegie Mellon's TechNights, an extracurricular STEM learning meetup for middle school girls facilitated by CMU students. We wanted to

understand what motivated girls to attend, as well as their prior exposure to STEM topics.

Through conversations with participants and parents, we learned that many girls heard about the program through their participation in another, like Pittsburgh FIRST LEGO League and robotics challenges. Many parents of the girls were also involved in STEM careers themselves, like engineering or information technology. Though TechNights is designed to be a safe space for girls to take risks and learn new topics, these findings confirmed that many interventions aimed at breaking barriers to entry for underserved STEM populations already require some amount of motivation and familiarity. This further highlighted that to successfully engage traditionally excluded students, Sparkville would need to appeal to a broad audience, and not just "STEM power-students."

When asked why they liked engaging in extracurricular STEM learning, TechNights girls said that they weren't learning anything new in their classes in school. They were often bored, and sought out more engaging topics outside of school. One girl said, "We've learned about rain for FOUR years," indicating the repetitiveness and lack of appeal of a typical classroom. This is an area where career-based learning might provide students with novel content and encourage them to choose relevant coursework when they reach high school.

Technights leader Natalie Sauerwald, a computational biology Ph.D. candidate at Carnegie Mellon, provided feedback on her experience working with TechNights middle schoolers over the past three years. When presented with our initial idea of a career exploration game for middle schoolers, she confirmed that this is an area of interest for students. She has moderated women in STEM panels for the girls, who were curious and excited to understand what it meant to be a STEM professional. They asked questions about college majors, indicating foresight and planning. She dismissed our fears that the content would be uninteresting, saying that "[Unlike at TechNights], we don't teach kids high-level concepts mainly because we're bad at explaining them." Sauerwald argued that kids will rise to the challenge of complex concepts, and they have a desire to see adults model interesting skills.

Megan Fahey, director of the Summer Engineering Experience for Girls at CMU, echoed Saurwald's claims. She emphasized the importance of simply exposing children to different careers. She said she met a few girls who thought "I like biology, so I have to be a doctor;" but when a guest speaker talked about biomedical

engineering and wearable computing, they became very excited. Simply offering information about other options goes a long way to encourage careers in STEM.

Fahey also discussed the importance of extracurricular opportunities as a way for students to practice and build skills beyond simply acquiring more content knowledge. Children can learn content in school, but outside programs and tools can provide a space to improve soft skills as well, such as teamwork, patience, and confidence. With these principles in mind, we began to design Sparkville.

Solution Overview

In its current form, Sparkville is a five minute concept video of a web-based game where players can explore “apprenticeship” challenges related to their interests. Students move an avatar around town, where each building holds a mentor’s workspace. Players enter the building to begin undertaking challenges. The challenges are creative and interdisciplinary with STEM and other subjects. Some examples include jewelry design, industrial design, animation engineering, and science journalism. Challenges help students learn by exploring tasks and concepts central to the career.

After completing each challenge, students reflect on their experience. This prompts them to consider the relevance of this job to their own interests and potential future. If they want to learn more, they can explore the mentor’s story or click on provided links to explore the topic more deeply on another website. Students can also customize their avatar if they’d like, earning new outfits as they complete various challenges. We hypothesize that we could reach currently underserved STEM audiences through this game, embedding STEM curricula within an approach shaped by creativity, narrative, and exploration. Students who seek entertainment, challenge, and connection would play this game in their free time.

Case for the Solution

This solution addresses several of the barriers facing underserved STEM learners. Inspiring, diverse mentors can both combat gender, ethnic, and dispositional stereotypes, and provide role models for children playing the game. Potential fear of failure will be alleviated greatly by the game’s focus on personal narrative and entertainment, as well as the open-ended reflection feature of the explorer’s journal.

The wide range of jobs should appeal to players, since they are unlikely to be exposed to them in other areas of life. We believe this approach will attract players that aren't engaged with typical STEM organizations or education.

Mentor challenges should be challenging enough to keep students interested, but not too challenging that students will become frustrated. We hope that students view them as mini games, and choose to play and replay them for their entertainment value as well as educational purpose. Future iterations of challenges might include levels of difficulty which grow with the player. Additionally, since challenges are self-contained and modular, students can get invested quickly and explore all the jobs that interest them. With precedents from online community-based games like Neopets or Club Penguin, we are hoping to generate mass-market adoption and entertainment-based use.

Competitive Analysis

In our competitive research, we looked for mass-market software or apps which supplement classroom STEM learning with fun, collaborative, and applied exploration of these topics for ages 10-14. We also looked at various other tools that are used to introduce students to different career paths. Several of these are listed below.

After performing this competitive analysis, we noted that many programs are financially or time-intensive, often requiring substantial commitment. Many of these tools need in-class assistance from an adult, while others require students to attend in-person. Others target specific skills, such as coding, but are only focused on that one skill and don't provide information about alternate skills and careers. Many are also framed for girls-only, which limits the issue of technological agency to a gender-based argument. We were unable to find a broadly-appealing, inexpensive web-based edutainment game which aimed to transform players' perception of STEM fields. This is where we believe Sparkville can shine.

COMPETITIVE SOLUTIONS

- **GirlStart:** Girlstart was established with the goal of harnessing innovative, nationally-recognized informal STEM education programs to encourage girls to become more interested and engaged in STEM. The initiative offers 6 core core STEM programs for kindergarten to grade 12 girls.

- **Techbridge Girls:** Guided by the philosophy that all girls need personal and consistent support to succeed, Techbridge Girls not only after-school and summer STEM programs in the San Francisco Bay Area to girls from low-income communities, it also provides useful resources for members of girls' support networks.
- **Black Girls Code:** The founder of Black Girls Code, Kimberly Bryant, created the organization so her pre-teen daughter would be the last only black girl in the room at a computer science camp. Black Girls Code has grown exponentially since then to now offer support for young women of color to achieve their STEM dreams.
- **Career Days:** Various schools offer career day events. Professionals from various fields come in and discuss their jobs with the students. Oftentimes the professionals are parents of the students or have some other connection with the school.
- **Filament Games' Breaking Boundaries in Science:** This game focuses on the life, personalities, and discoveries of three female scientists. There is an open-ended narrative and identity-driven exploration of workspaces through VR.
- **Simcoach Skill Arcade:** The Simcoach Skill Arcade is a workforce development and training platform that uses video games to expose the next generation to career paths and connect them with training, apprenticeships, and employment in their region. Young people can download free mobile video games to learn about careers and practice basic skills. Organizations identify and connect with players in their region.
- **Pretty Brainy:** Pretty Brainy is a nonprofit organization that aims to empower girls to develop their STEAM abilities. They provide girls age 10 to 18, as well as their collegiate mentors, growth opportunities in the STEAM field. They want to target an underserved population before they lose interest in science and math.

Educational Goals, Instruction, and Assessment

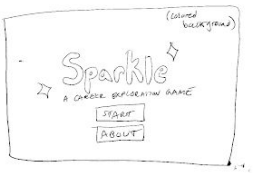
Sparkville aims to accomplish the following goals related to learners' declarative, conceptual and metacognitive knowledge:

GOAL	INSTRUCTION/FEATURES	ASSESSMENT
Broaden perception of who/which skills are valued in STEM (do I belong?)	● Mentors and challenges use creative skills that are not typically associated with STEM, such as art and writing	● Students identify broader skillset required for these jobs in their explorer notebook post-challenge
Improve beliefs around self-efficacy in STEM subjects (am I good at this?)	● Build skills through tangible challenges set for them by industry practitioners ● Deal productively with difficulties/"failure" in-challenge	● Self-efficacy survey at initial registration and periodically administered across play
Inform about different careers (Is this a potential career path?)	● Mentors discuss their careers and career paths, then provide challenge based on skills needed in that field	● Number of challenges completed
Maintain audience engagement (do I want to use this tool?)	● Practitioners set challenges that are short and entertaining, while still related to the field	● Average session duration ● Repeat visit behavior
Encourage users to think about their future (what will I do when I grow up?)	● Mentors model skill articulation and self-reflection for students (because I am this way I like this practice) ● Students reflect on their own capabilities and	● Explorer notebooks show signs of reflection and use of personal pronouns when thinking about career paths; "I may want to do this"

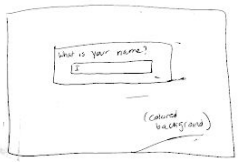
	interests	
can someone like me accomplish this? ● Provide positive, dynamic, diverse role models ● break down steps required for a challenge	● Vary the characteristics, backgrounds, and appearances of mentors ● Optional backstories for mentors - how I got here ● Mentors are welcoming and encouraging ● Challenges are designed to emphasize small skills needed to accomplish amazing things	● Number of challenges completed ● Number of views on a mentor backstory ● Users rate skills in explorer journals based on like/dislike
Give them a path moving forward (what should I do after this?)	● Mentors help students reflect on what they liked/disliked about particular challenges and which mentor challenges they should explore next based on skills ● Every challenge has a next step (links to external resources)	● Feature ideas: mentors in discussion boards; printouts for guidance counselors; scripts for talking with parents; links to camps or online challenges

Design and Storyboards

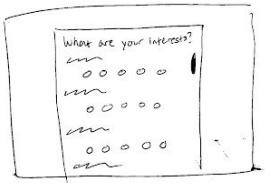
Our prototype began with screen storyboards to explore how a student might progress through the game:



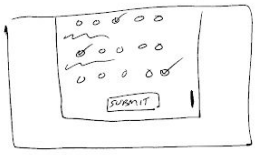
Student presses start on the home page



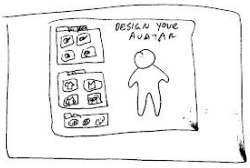
Student enters their name on the intake form



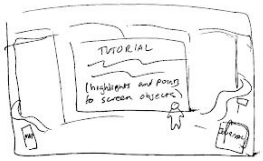
Students answer survey on their interests



Students submit survey



Students design their avatar

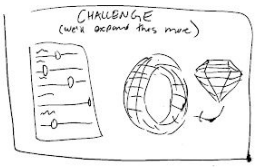


Students get a quick tutorial on the mechanics of the game

Students see the map and are given suggestions for where they should star

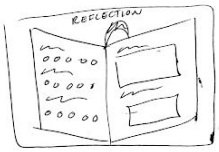
Students are allowed to wander around the town and enter buildings

Once in a building, a mentor greets the student and explains their job and the challenge

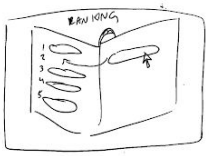


The student completes the challenge, tailored to the mentor's job

The mentor tells the students what skills they improved in



The student answers quick reflection questions about the challenge and the job



The student ranks the challenge compared to other ones they completed

The mentor offers students ways to learn more, or lets them go back to exploring

The student is back in the town, ready to learn more

Learning Principles Description

The mission of our game is to educate and inspire creative middle schoolers to pursue higher-level STEAM coursework toward a fulfilling career they never thought possible. We hope to broaden the players' perception of who and which skills are valued in STEM. We also hope to improve the players' beliefs around self-efficacy in STEM subjects.

We are using various learning principles in support of these goals. These principles are central to the player experience and desired transformation:

- **Segmentation and scaffolding:** "Challenges" assigned to players by mentors will begin with a breakdown of the necessary skills to complete the task. This simplifies the task, as well as highlights critical features of completion. Challenges are then separated into learner-paced segments, and complete with a review of the skills players used/built throughout the challenge.
- **Narrative, personalization and scaffolding:** Mentors recruit players' interests through compelling personal stories and interesting careers/challenges. Mentors talk directly to students in a conversational tone. They also motivate students through vicarious experiences, as mentors will be diverse, interesting, and nontraditional. Their introductions and deeper biographies (an optional exploration feature) will show students that STEAM is accessible for nontraditional candidates like them.
- **Metacognitive knowledge and reflection:** Completing challenges and logging in their explorer's journal will help players reflect on the skills they liked using, what was exciting about the challenge, and what wasn't a great fit. Like mentors, this helps players create new stories about what they can accomplish and envision who they might become if they follow this path.

We are also drawing from learning science best practices to make our game effective in more subtle ways:

- **Pretraining:** As students begin to explore challenges, the mentor will highlight and explain three skills necessary to success in the career. Activities in the challenge will also introduce students to the concepts before they apply them.
- **Secondary reinforcers** (badges) - As the students complete various challenges, they receive money and badges. They are also able to gain various titles. For example, if the student does all of the art-related challenges, they may receive the title of "master artist". We are also considering how we can implement the

concept of leveling up, and whether we want the challenges to have different difficulty levels the students can progress through.

- **Multimedia principle** - The game relies heavily on pictures and video, not just text. We are planning to use drawings instead of photos to achieve the aesthetic we would like.
- **Choice/customization -** We hope to engage students by offering them multiple ways to customize their game. At the beginning, they can design their avatar. After completing various challenges, they earn money that they can use to buy their avatar clothes. They can choose what challenges to do and what order to them, customizing their path through the game. They can also choose whether to read additional information based on their interests and time commitment.

Technology Prototype

The concept video is available here. All assets and content are original, excluding footage of CAD from 2:07-3:09. This was drawn from a public YouTube video and was used purely to convey the concept of CAD within the challenge for user testing.

The video shows a typical Sparkville experience. The student presses Play Now, enters their name and age, then chooses their interests. They are then dropped in the part of town that corresponds to their interests. If they want to explore another part of town, they can move their avatar to the road or choose it from the map. If they want to go inside a building, they move their avatar to that door.

Once inside, a mentor introduces themselves and explains what their job is. They talk about their interests and why that relates to that job. The student is then allowed to interact with the mentor's workspace. They can click on one object to learn more about various topics in the career. For example, the concept video explores a jewelry maker, and the first object informs the student about Moh's hardness and why jewelers pick the gems they do.

After they are done learning about the topic, they can begin the challenge. There may be an explanation before this challenge as well, but the majority is interactive. In the concept video, the activity was creating your own ring, even though we weren't able to include a mockup of the activity itself.

When the student finishes the challenge, they click done. The mentor then summarizes their experience. The students can reflect about the challenge in their journal, and they

learn what skills the challenges increased. Once the student is finished reflecting, they can choose to learn more about the mentor, learn more about the career, or go back to exploring the town center.

The concept video also shows a few other features in the game. The student can customize their avatar, changing the color and form of their outfit, body, and hair. They can also earn new outfits if they do very well on certain skills. For example, if they can complete all the art-related challenges, they can earn a paint-splattered artist outfit. Students can also rank their list of careers in their journal. This allows them to go back later and remember what they like best. It is also a good resource for teachers or parents to look at.

There are some features that weren't included in the final concept video. After students choose their interests, a journal page appears with a list of the suggested jobs to explore. They can also connect with other people in the game to talk about the challenges and different careers. Additionally, If a student clicks on the symbol above each building, they can read a description of what career it represents. We also didn't show the map of the entire town, which would ideally contain thirty buildings or more. And of course, there are many more careers than just jewelry designer. Students could explore video game design, landscape architecture, 3D animation, technical writing, science journalism, industrial design, and more.

Formative Assessment

GOALS OF USER TESTING

After creating a concept video for Sparkville, we arranged to show the video to several Pittsburgh middle schoolers to receive feedback. Our formative assessment goals included:

- Did watching the concept video of the jewelry design challenge broaden students' perception of STEM skills' value to creative jobs?
- Did watching the concept video expose students to new career paths and the skills needed?
- Did students show improved self-efficacy scores in STEAM subjects before vs. after watching the concept video?

- Did students exhibit curiosity and motivation to pursue STEAM subjects after watching the concept video?
- Was the game age-appropriate and interesting?

ASSUMPTIONS

Going into testing we assumed that students would have experience with computer games. Based on the profile of the middle school where we conducted testing, we assumed that they came from middle-class and above families. Finally, we assumed that students would have varying interests and proficiencies in STEAM subjects.

POPULATION

We met with four middle schoolers from the Kentucky Avenue School, a small constructivist K-8 school in the Shadyside neighborhood of Pittsburgh. We conducted user testing with two girls, age 11, and two boys, age 12. The principal chose them from their class based on our criteria: creative students who are either interested in math, science or software, or who have been discouraged in these subjects in the past.

PROCEDURE

The facilitator cleared the procedure with principal and supervisor Aimee Defoe before beginning the session (signed consent form at end of this document). The facilitator

welcomed students and introduced the session. Students took a one-page pre-survey, watched the five-minute concept video, took a one-page post-survey, and participated in a followup discussion led by the facilitator.

The survey asked students questions related to their declarative knowledge within the challenge domain (natural sciences and design software), as well as attitudinal questions about the relevance of STEAM topics to the featured career (jewelry design).

The pre and post-surveys were identical, and included two to five-point Likert scale questions:

Designers must be good at art:	○ Disagree	○	○ Neutral	○	○ Agree
Designers need to know science:	○ Disagree	○	○ Neutral	○	○ Agree
Designers need to know math:	○ Disagree	○	○ Neutral	○	○ Agree
Designers need computer skills:	○ Disagree	○	○ Neutral	○	○ Agree
I know that 3D modeling software exists:	○ Disagree				○ Agree
I could see myself using 3D modeling software:	○ Disagree	○	○ Neutral	○	○ Agree
I am familiar with the properties of stones and minerals:	○ Disagree				○ Agree
I could see myself working with stones and minerals:	○ Disagree	○	○ Neutral	○	○ Agree
With training, I could be a designer:	○ Disagree	○	○ Neutral	○	○ Agree

The semi-structured interview was guided by the following questions:

1. Would you want to play this game to learn more about different careers?

2. Did this challenge helping a jewelry designer seem interesting to you? was this job inspiring? why or why not?
3. What about this game would you change?
4. Do real-world examples of the things you're learning in school motivate you to learn more? Can you give examples?
5. Do you think about careers? Is it important to you?

FINDINGS

1. **Participants were universally excited by the game.** Unprompted, the girls noted that **they would pay for it.**

   “Is this a real game? If this is ever published I would love to get it. I would pay money for it.”

   “I would beg my mom to get it. Even if it cost money on the app store.”

Participants commented or exclaimed aloud during parts of the concept video. Both boys and girls were very intrigued by the “select your interests” screen in the beginning, as well as the flashes of other challenges at the end.

2. Participants were particularly drawn by the ability to **choose a multitude of categories of interest** before entering the game, especially ones **outside of traditional school subjects**.

   “I like how it's not subjects in school [“yeah!” other student exclaims] - *it had elements of subjects in school but it was specific.”*

When asked if real-world applications of school subjects motivated them to learn more, the girls said that they enjoyed field trips. One girl qualified, “I'm more motivated by things *outside* of school, like wildfires.” The other said, “sometimes I see things outside of school that motivate me for a while and then I just give up, but [playing] this might help me [keep going].”

3. Kids want games that are **age-appropriate and interesting** but they **need parent approval** to play them. Parents want to limit kids’ screen time and use of non-educational games. Sparkville poses an opportunity to meet the needs of both parties. One student cited a recent experience where her father praised her

for downloading an educational app, saying that he wanted to see her using more like it.

"[This game] is cool because your parents will let you do it. It's still educational but it looks really fun."

"My mom would love this!"

"Most educational games are kid-ish, not very adult-worthy…[not] what you want."

4. Participants universally agreed that **a game about career exploration was relevant, interesting, and important**. Two of four participants already had careers in mind, one noting he wanted to follow either his mother's career path (doctor) or his father's (engineer). The two participants who did not have a career in mind - one boy and one girl - emphasized that it was important to learn about different careers. One mentioned that Sparkville might help him explore and take risks:

   "[When playing this game] I would try out different stuff outside of my comfort zone and see if I might like it."

5. Change between pre- and post-video ratings on survey questions contradicted some of our hypotheses. Overall there was **not a marked increase in students' assessment of the value of STEAM topics** to the jewelry design career, though males' scores showed improvement in the value of art and science.

Females' scores on average actually decreased post-video based on one respondent. It is unclear if this is due to confusion or true attitude change. However, this reveals that the video may have had some impact on attitudinal change, even if not in the direction (positive) that we expected. Based on this finding, combined with students' self-reported awareness of 3D modeling software pre-video, it is possible that these participants already had pre-formed attitudes about design careers. There was also no change in their beliefs about their ability to pursue a career in design.

However, across both males and females, and females especially, they reported **higher attitudinal scores** post-video related to **working within the subject domains** shown in the challenge video ("I could see myself working with" the natural properties

of stones and 3D modeling software). While their awareness of 3D modeling software was not impacted by watching the video, they reported greater awareness of the properties of stones.

SURVEY RESULTS

Type	Question	Δ FEMALE	Δ MALE	Δ ALL	Δ %
attitudinal	*designers must be good at art*	0.0	0.5	0.3	5%
	designers need to know science	-0.8	0.5	-0.1	-3%
	designers need to know mathematics	-0.5	0.0	-0.3	-5%
	designers need computer skills	-1.0	0.0	-0.5	-10%
awareness	*I know that 3D modeling software exists*	0.0	0.0	0.0	0%
attitudinal	*I could see myself using 3D modeling software*	1.3	0.0	0.6	13%
awareness	*I am familiar with the properties of stones and minerals*	4.0	2.0	3.0	60%
attitudinal	*I could see myself working with stones and minerals*	2.0	-0.5	0.8	15%
	With training, I could be a designer	0.0	0.0	0.0	0%

Redesign & Conclusion

Given these findings, in our next iteration of the game we would pursue the following objectives:

1. Given participants' varying attitudinal change on the value of STEAM topics to the featured career, explore more ways to explicitly feature STEAM content in challenges.

Initially we discussed a feature allowing players to explore real-life avenues for practicing the skills featured in challenges. We might consider featuring more STEAM content here, including ties to higher-level coursework that would encourage them to see these linkages. Based on participants' reported disconnect between the subjects they study in school and their fields of interest, this may also require further open-ended user research to understand the best way to design such a feature.

2. Keep this a web-based game so it can be continually updated with new challenges.

Continual updates would reinforce players' excitement about customizing their interests and pursuing different challenges. If possible, we would give players the ability to suggest topics they are interested in for future updates.

3. Expand features on career exploration.

Study participants' excitement for the game concept, and interest in career exploration, makes a great case for our other feature expansion: learning more about mentors' backstories and finding more ways to practice and apply the skills they love in real life. We initially explored the idea of creating mentors from real professionals. This might be more inspiring and tangible for players as they navigate different careers.

We might also explore features to facilitate players' conversations about their ranked career list with adult mentors like guidance counselors or parents.

4. Build out high-fidelity animation with a focus on open-ended exploration.

Participants enjoyed the town layout and opportunity to explore. They cited small details like the building styles as interesting, and one participant noted that he would want the freedom to walk around the town and not just go into buildings. This finding aligns with participants' emphasis that they want interesting and age-appropriate (mature) games.

Sparkville is a game grounded in principles of learning science, with learning goals and features aligned with primary and secondary research in the field. Additionally, overwhelming positive feedback from early user testing indicates that this game is an appealing way for middle schoolers to explore STEAM careers and build intrinsic motivation to pursue higher level learning goals.

Consent Form

Carnegie Mellon University

Human-Computer Interaction Institute

I grant permission for Carnegie Mellon University students to perform an interview session with students at the Kentucky Avenue School.

I understand that the session will be recorded only for the researchers' purposes. The students' names will not be used and the recording will not be distributed, posted or used for any public purpose. I understand that the researcher may take photos of the session but students' likenesses will not be used.

I acknowledge that students' participation in this interview is completely voluntary. The students are free to leave at any time or decline to participate in any part of the interview.

Aimee DeToe

Print Name

Signature

I agree to the terms of this research interview.