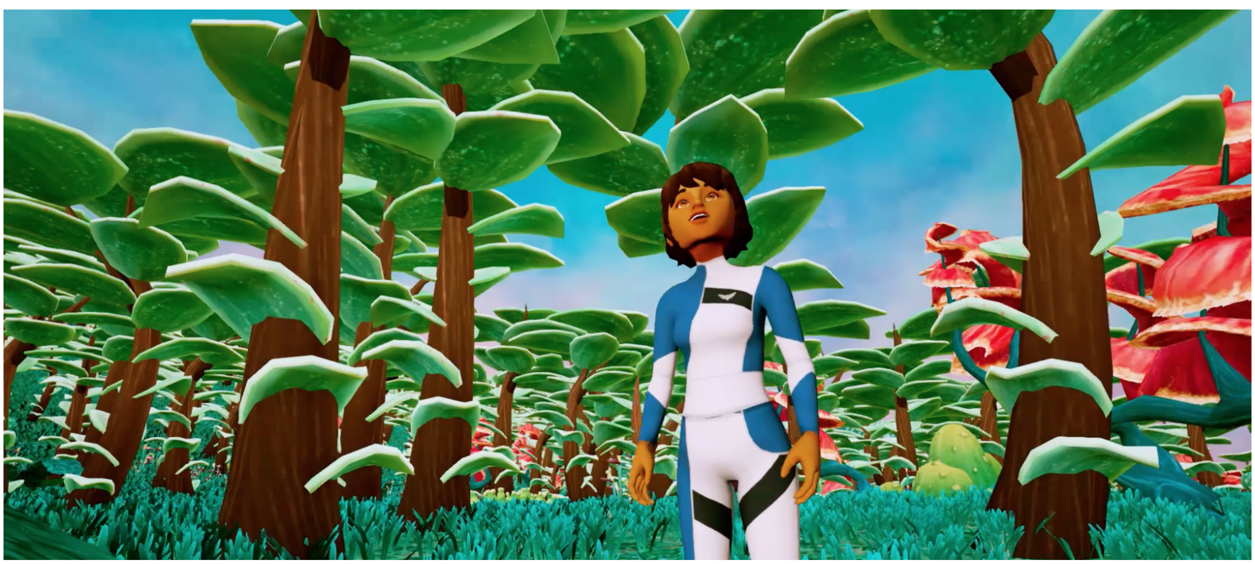
Executive Summary

We're creating a video game as an experiential learning platform to inspire young women by the impact of STEM careers, to reach the goal of doubling the number of young women majoring in STEM.

Our proposed video game, *Tyto Online*, provides an opportunity for girls to engage directly in STEM by collaboratively solving problems like working with a botanist to solve a food shortage. The product:

1. fights stereotypes without being pink-washed, shows how STEM careers are creative and collaborative, and has diverse role models;
2. shows the social relevance and impact of STEM careers;
3. helps develop a sense of belonging in an online, cooperative community;
4. uses a video game to increase spatial skills;
5. is created as a platform with a set of authoring tools so that we can work with partners to vastly expand content, age group, reach, and local contexts.

Initially, the *Tyto Online* team will develop our own science content and reach girls through classrooms. In 2-3 years, we'll begin scaling content with our first beta partners and into informal learning contexts. In 3-5 years, we'll open the platform to approved partners to expand to additional ages and reach their networks of students. In 6 years, we'll open up the platform for anyone to add content, exponentially increasing content and adding free levels of access for high levels of adoption penetration.



Proposal

The Problem

Women are highly underrepresented in STEM careers. While 60% of college attendees are women, only 35% of STEM graduates are women[1]. Similarly, although women make up half the labor force, they only account for 25% of STEM jobs[2]. Improving this gap is essential for the United States' growth, and in achieving equity and growing a broadly scientifically literate public[3].

While this proposal focuses on young women's entrance into STEM, it's also important to note the intersectional nature of this problem: many of the same factors impacting women also reduce the participation of underrepresented minorities. Disadvantaged groups, like Black and Latinx students, are also less likely to have *access* to advanced math and science high school courses[4].

What causes the STEM gap? It is not due to ability: girls and boys perform equally well in math and science during school[5]. However, from age 11 to 15, girls lose interest in STEM[6]. There are complex social factors, but two of the primary are stereotypes and misconceptions about STEM careers.

(1) Stereotypes and stereotype threat. Due to stereotypes around STEM careers being masculine, girls often experience stereotype threat, the phenomenon where stereotyped groups actually do worse on tasks when reminded of the negative stereotypes[7].

Girls report lower self-efficacy in STEM despite performing as well as or better than boys, internalizing the stereotype that girls are not as capable in STEM[8]. Further, the chance of leaving a STEM major is increased when women are exposed to stereotypes that STEM is masculine[9]. These stereotypes begin early: by second grade, when asked to draw a picture of a scientist, students tend to draw a white man; if they draw a woman, she looks unhappy[10].

(2) Misconceptions about STEM careers. Some factors that contribute to women's' lack of entrance into STEM include the perception of STEM careers as a solitary profession, women in computer science being presented as "weird," and presenting the activities as machine-focused rather than being focused on people or social issues[11].

While fifth grade girls often say they want to help people for their career, they dismiss engineering as boring[12]. In one study, only 17% of girls ranked engineering as a very good career (½ the rate of boys' rating). But then when asked if it would be appealing to protect rainforests by developing new ways to farm, use DNA to solve crimes, or build cars that run on alternative fuels, they were 2.5-3x more likely to say they were interested[13]. There is a lack of information communicated to students about what STEM can accomplish, and the impact the careers have, which are important factors in girls' decisions to pursue STEM careers[1].

Existing Solutions' Approaches

Promising research shows that this divide can be closed through efforts to develop spatial skills in girls through training, providing more information about STEM careers, making connections to how STEM careers benefit society, providing positive role models, and demonstrating what scientists actually do and how their work benefits society[4].

There are a variety of organizations with outreach efforts designed to increase girls' participation. However, scaling can be an issue with many of these in-person, volunteer-driven organizations. For example, Girls Who Code, a fantastic non-profit providing clubs, camps, and resources, has existed for seven years and has reached 185,000 girls… less than 1% of girls in United States schools[14].

PBS's SciGirls produces a TV show, has a website with games and activities, as well as profiles and challenges for girls to share, and does outreach through in-person clubs focused on girls ages 8-13. SciGirls has reached 14 million girls over 9 years, which they state is the most widely accessed girls' STEM program in the United States[15].

We know that current solutions are not working at scale despite the promising efforts. Some recent data even suggests that girls' interest in STEM careers has declined -- Junior Achievement conducted a survey which shows only 9% of 13-17 year old girls were interested in a STEM career in 2019, down from 11% in 2018; during this same time period, boys' interest increased from 24% to 27%[16].

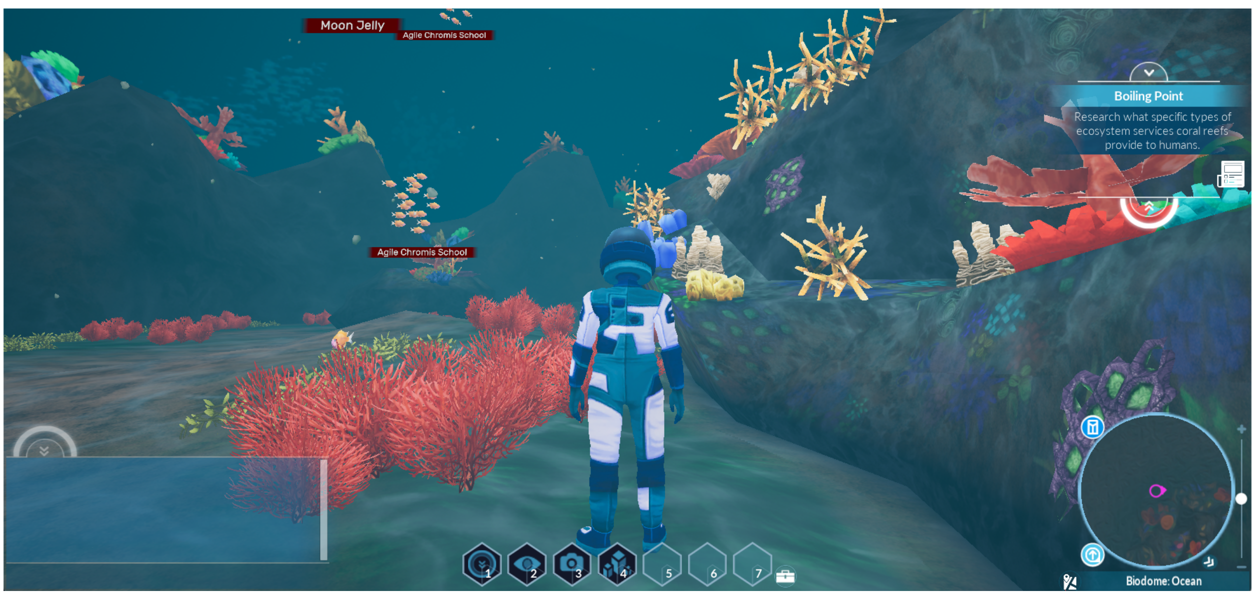
Some researchers suggest that these targeted initiatives may actually "have the unintended effect of signaling to women an inherent lack of fit… [and] send subtle signals to women that lead them to underestimate their success," actually strengthening the associated masculinity of STEM majors[9].

Our Solution

We're creating a video game as a learning platform to inspire young women by the impact of STEM careers.

Based on the research, an ideal solution would empower girls to collaboratively solve problems that have a social impact while building their STEM skills, self-efficacy, and a sense of belonging. For example, students could examine a coral reef that has bleached, using data and performing experiments to build evidence for why the bleaching is happening and how to solve it. Alternatively, they could collaborate to test and iterate on engineering solutions to increase food yield and solve a hunger crisis.

These are both examples that exist in our first version of our solution, *Tyto Online*. We've created an initial version of this learning platform that focuses on STEM for middle school students — the age where girls tend to drop off in STEM interest. We've been supported with over $1 million in grants by the National Science Foundation (NSF) and the Institute of Education Sciences, and have pilots with initial efficacy evidence. Our NSF study showed a 12% increase in science and engineering practices after just one day's experience with our prototype.



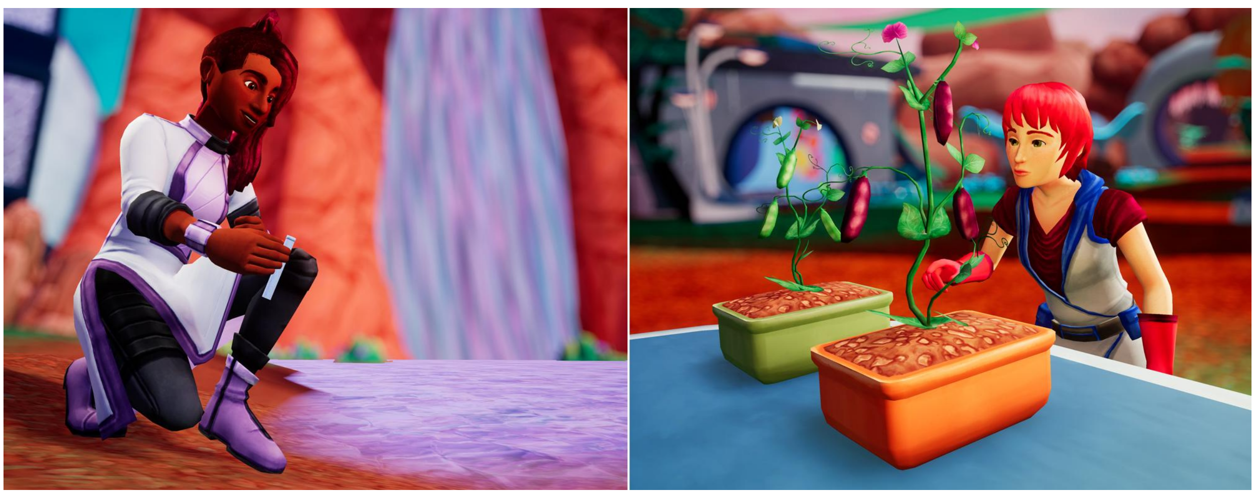
Tyto Online's core learning proposition uses strategies shown to increase girls' STEM interest.

(1) Fighting Stereotypes. In contrast to many efforts, *Tyto Online* does not specifically market to girls or "pink-wash" the product, instead creating an experience that students of any gender can use, while utilizing strategies shown to increase underrepresented groups' interests. This approach is unique compared to most current efforts, and has promise in helping to reduce the spreading of stereotypes that pink-washed efforts can unintentionally spread[9].

Other ways *Tyto Online* can fight stereotypes include:

- showing that STEM careers are creative and collaborative, rather than solitary professions[11], accomplished by having students work together to solve problems in a variety of ways;
- including diverse and non-stereotypical role models within the game[17]; through characters, representing the work of diverse historical figures, and even having live interviews and events with current STEM role models;
- demonstrate what scientists actually do, which we accomplish by having the student directly perform these actions within the game; this focus on *doing* science rather than *being* a scientist is actually shown to increase girls' persistence, likely through also reducing implied stereotype threat[18].

(2) Social Relevance & Impact. The way students interact with problems in the video game focuses on how STEM benefits society, as they solve authentic, impactful problems. *Tyto Online* is used for context to set up these relevant problems in a hands-on way, strategies shown to appeal to girls[19].



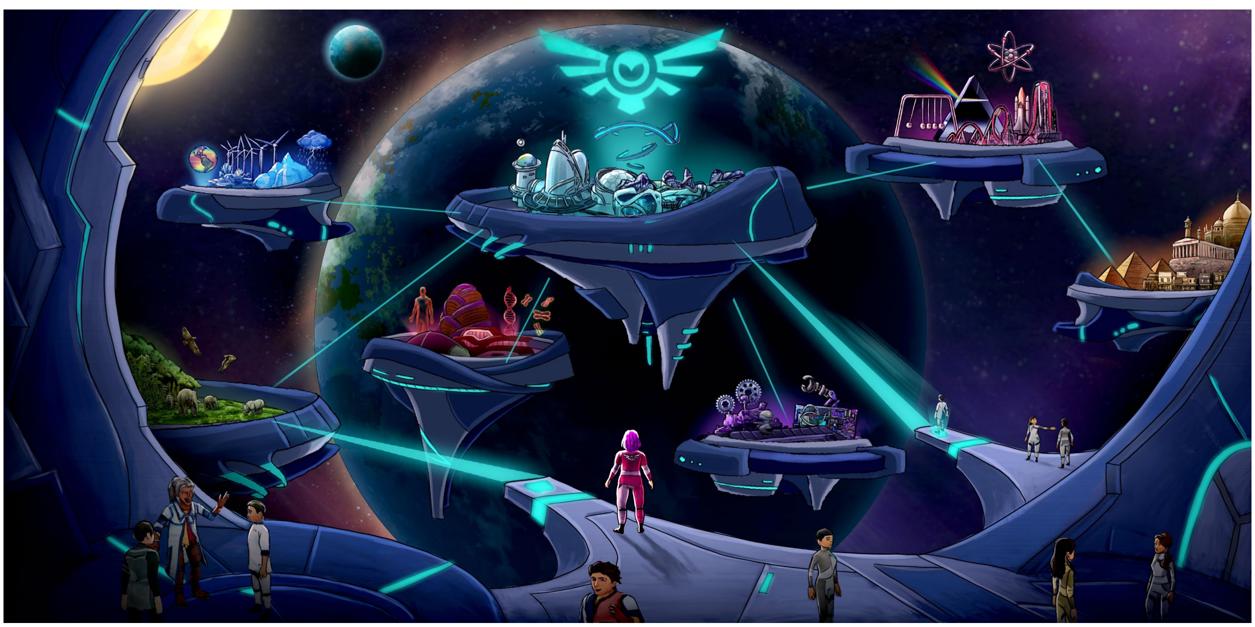
(3) Sense of Belonging. The difference in choosing STEM majors can also be partially explained by *social belongingness,* or teenagers feeling they will fit in better with subjects that have more of their own gender[8]. *Tyto Online* is a virtual world, providing social, cooperative learning experiences to create a pro-social community that girls (and other students) can support each other in, to help young women have more positive expectations of their sense of belonging in STEM careers. Current solutions often fall short here, focusing on individual activities or not designing to promote a broader community of support.

(4) Benefits of a Video Game. Using the medium of a video game also has inherent advantages. Action video games have been shown to increase spatial skills equally to training programs, which generalizes to improving STEM skills[4,20]. Also, girls who spent 9+ hours a week in video games at 13-14 years old are 3x more likely to enter into a physical science, technology, engineering, or math degrees[21].

Scalability. We currently use a content authoring tool to build *Tyto Online's* content, but our plan is to make these available in the future, so that we can become a platform with exponentially growing content made by partners.

Becoming a platform expands the potential of *Tyto Online* for girls.

(1) *Tyto Online* will be able to cover a nearly unlimited set of STEM topics and careers with these hands-on, authentic learning experiences; meaning even more positive information about varied STEM careers and helping develop girls' STEM skills. This potential through the authoring tools will set us further apart from current solutions.
(2) Partners will make customized, local content. This makes learning more relevant, so that we can inspire young women about how they can use STEM as a career to make an impact from their local communities to across the planet.
(3) Partner content expands our age range so that we can reach girls along critical ages and as they make career decisions.



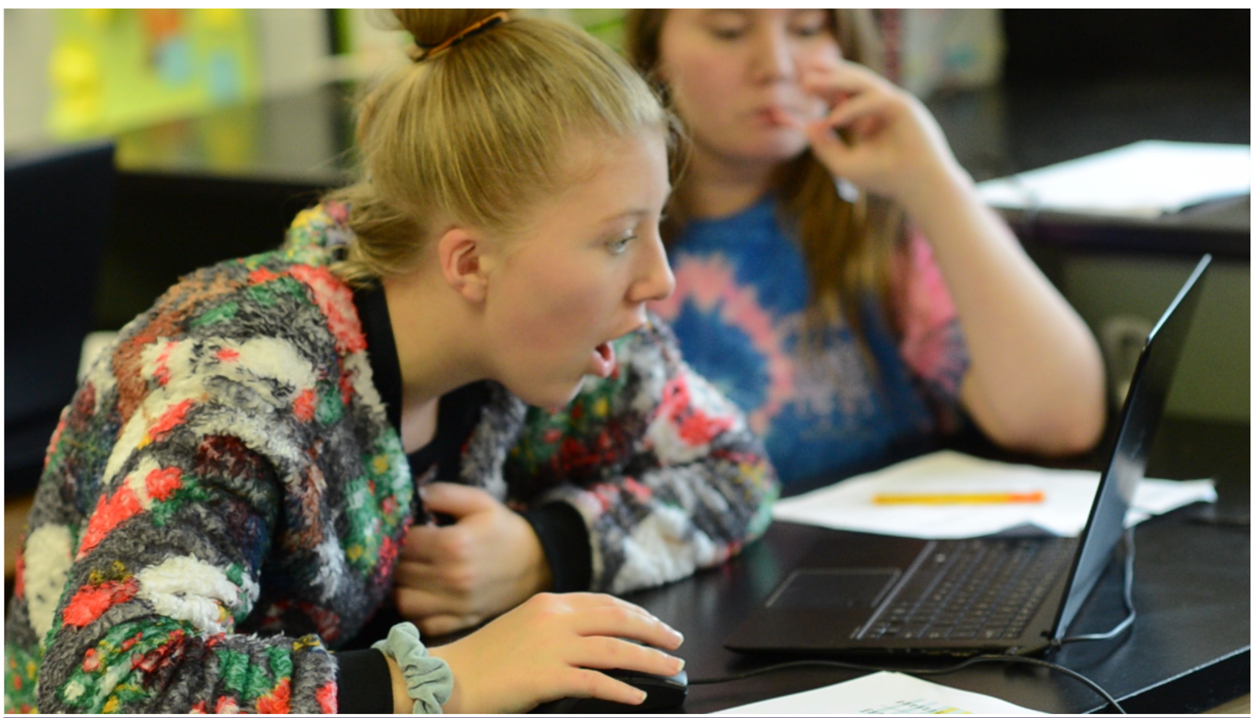
Implementation

Our implementation process is divided into four phases, building out capacity and iterating the solution during and between each phase.

Phase 1 (Years 0-2)

We are currently in this phase, with the product being used in classrooms by science teachers to support their instruction.

Development. Currently focuses on building our own science content, improving the authoring tools to support strong content, and adding additional cooperative experiences. We will conduct design-based research within schools to drive product improvements, with support from TERC. This involves classroom observation, within-game data collection, teacher and student feedback, and measuring proximal outcomes such as increased interest in STEM careers.



Scaling. Schools and districts are directly adopting the product for their students, which is primarily used within a classroom context. This expands reach and equality of access as usage is not targeted only at students who opt into informal learning opportunities like after school or summer programs (common with existing solutions). Educational Service Agencies (ESAs) are also recommending the product and supporting adoptions through training and support.

Phase 2 (Years 2-3)

Development. Begin scaling content with hand-selected partners, likely nonprofit and University-based who want to engage in STEM outreach with girls. We would work closely and collaboratively with them to create their new content following our established best practice models from Phase 1. These partners would serve as beta platform developers, with their needs driving iteration of our authoring tools and supports in preparation for the next phases. We'd also work with them to test the efficacy and success of this new content with new design-based and efficacy study cycles.

Scaling. We'd continue to grow our work with ESAs, districts, and schools. During Phase 2, we would add informal learning contexts and begin scaling through partners.

For example, the National Girls Collaborative Project (NGCP) is a potential partner that works with 36,400 organizations that serve 29.15 million girls and 9.5 million boys. Due to this network, they have the capacity to help scale efforts. They work through a Train-the-Trainer model, sharing models and resources to their organizations, who then deliver services directly to students. They've written a letter of support to the NSF supporting our work and are interested in partnering to help us scale; we would need a funding partner, which could come in the form of philanthropy that could be donated to NGCP directly, as they have 501(c)(3) status.

Additionally, partners we build content with would help increase our reach through their networks. For example, an ideal content partner would be an organization like the Jane Goodall Institute. We would work with them to feature storylines and challenges based on their work; Jane Goodall and her team could serve as STEM role models in the game, and potentially even join for live events where they talk with students across the world. They would share their new content when it launches to *Tyto Online,* helping to expand adoption of the platform.

Phase 3 (Years 3-5)

Development. Open the authoring tools to approved partners to make their own content independently, expanding our capacity to support increased content. Funding support would no longer need to go only through our organization, as partner organizations could receive funding to develop content using our tools completely independently. With these approved partners, we would continue to collect research and feedback, ensuring the content quality remains high and effective with students when it is created independently from our team.

We'd also expand to support new platforms, adding *Tyto Online*'s availability to mobile phones, which will significantly increase reach for end-users, especially those that come from low socioeconomic backgrounds who are more likely to use a phone for their internet access[22].

Scaling. Partner content will expand age demographics and topics, which expands potential reach beyond the middle school starting point. We also expect a network effect through many partners with their own reach sharing their new content that is available within *Tyto Online.*

Additional goals for expanding reach during Phase 3 would include state-level purchasing so that access would be available for all students, and philanthropic funding through additional nonprofit partners. We will work with these partners to collect distal impact data on our success towards increasing STEM major enrollment, rather than only focusing on shorter-term proximal outcomes.

Phase 4 (Years 6+)

Development. The authoring tools will then be opened up to the general public for adding content to be available through the game. This will result in an exponential amount of content added, so that the product can begin approaching the long-term goal of being able to learn anything along many varied STEM contexts.

Scaling. We'll then expand into a freemium business model so that there is free and paid content available, allowing even wider-scale adoption with students accessing immense amounts of free content.

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