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STEAM Toys: Empowering the Next Generation of Women in STEM

By

Grace Newman-Lapinski

A Thesis submitted
in Partial Fulfillment of the Requirements
for the Degree of
Master of Fine Arts in Industrial Design

School of Design
College of Art and Design
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Thesis Committee

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STEAM Toys: Empowering the Next Generation of Women in STEM

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Keywords: STEAM, STEM, toys, design, girls, empowerment, 3D modeling

Abstract:

Even in 2022, STEM (science, technology, engineering, and mathematics) fields continue to be dominated by men. Starting from an early age, women are systematically pushed out of STEM fields. Three main reasons contribute to this – gender bias, lack of role models, and a lack of opportunity for skill building at an early age. This paper proposes that STEAM (STEM + Art) toys are critical to empowering the next generation of women in STEM. By mixing art with STEM, STEAM toys provide kids with the opportunity to explore these complex fields of study in creative ways. By making use of play models that girls are drawn to, STEAM toys can engage girls in STEM activities at an early age, building confidence and concrete skills.

Introduction:

Science, technology, engineering, and mathematics (STEM) jobs are some of the fastest-growing job markets in the United States and around the world. In the US, between 2020 and 2030 STEM occupations are expected to grow by 10.5%, significantly faster than the 7.7% average for all occupations (U.S. Department of Labor Blog, 2022). Despite this growth, the percentage of women in STEM remains stagnant.

Despite a big push in recent years for more women to be educated and employed in STEM fields, women remain highly underrepresented. In 2019, while women made up 48% of the US labor force, only 27% of the STEM workforce were women (US Census Bureau, 2021). There is also a huge disparity within different areas of STEM. Certain fields have higher or similar representation, such as the social sciences where women make up 64% of the workforce, math with 47%, and life and physical sciences with 45%. On the other end of the spectrum are fields such as computer science where women only make up 25% of the workforce and engineering which is at 25% (STEM Women, 2021).

This representation is also reflective within STEM education. While women earn about 57% of all bachelor's degrees in the US, in 2018 they only earned 36% of STEM degrees (STEM Women, 2021). In parallel to the workforce, women have much more representation in biological and life sciences, earning 62% of degrees, while only earning 22% of degrees in engineering and 19% of degrees in computer science (STEM Women, 2021).

Despite popular bias, the reason for this disparity is not a lack of ability. In fact, a 2018 study by the National Assessment of Educational Progress, which tested 15,000 students in the 8th grade throughout the United States on technical and engineering literacy, determined that girls test just as high, if not higher than boys in STEM skills (Young Girls, 2019). Research shows that girls' abilities and interest in STEM can be lowered by negative stereotypes, starting at an early age and continuously decreasing their aspirations for STEM careers over time. One way to start to dispel these negative stereotypes, is by providing girls with role-models of women in STEM fields.

Alongside providing positive role models, building both an interest and concrete skills in STEM fields at an early age is crucial towards empowering the next generation of women in STEM. "While a lifelong passion for science, technology, engineering, or math does not happen overnight, exposure to the possibilities of STEM experiences is a great way to begin planting seeds of interest in an area some [kids] never considered for themselves" (Kinskey 2020). A tool with potential to provide all of the above are STEAM toys.

In short, STEAM is STEM plus Art. The addition of art is crucial, it encourages creative problem-solving and innovation. Toys are a great way to engage kids in learning, because they build skills through encouraging kids to take part in something they love – play. STEAM toys can "establish intrinsic motivation which gets kids involved/passionate about STEAM subjects and leads the way to developing a joyful, healthy relationship towards these disciplines" (Decoding STEM/STEAM).

A successful STEAM toy encourages creativity and hands-on play. It facilitates both curriculum lead and open-ended play. It builds both confidence and skills. And it supports both child-led and parent involved play.

Project Idea:

This project proposes a STEAM toy which provides a positive female role model while building confidence and concrete skills. This toy specifically focuses on building spatial reasoning and 3D modeling skills. This is a skillset that is critical to success in many STEM fields and a skill that most people do not have when they start their STEM educations and careers.

“One of the largest gender differences in cognitive abilities is found in the area of spatial skills, with boys and men consistently outperforming girls and women. Spatial skills are considered by many people to be important for success in engineering and other scientific fields... If girls grow up in an environment that enhances their success in science and math with spatial skills training, they are more likely to develop their skills as well as their confidence and consider a future in a STEM field” (Hill 2010).

This toy will make use of physical blocks and an app to teach the relationship between digital models and the real-world through fun, creative play. The first step in the development of this toy was to identify the ideal blocks to be used to create the real-world models. While this toy could potentially be used to model just about anything – from architecture to scientific equipment to words and more – a theme of animals chosen as the focus of this specific project.

Initial Development:

In order to develop the physical blocks, potential sizes and use were evaluated digitally. First, rapid modeling building took place using Minecraft. Next, models of the final blocks were made in Autodesk Fusion 360 and aligned together to digitally evaluate potential building formations.

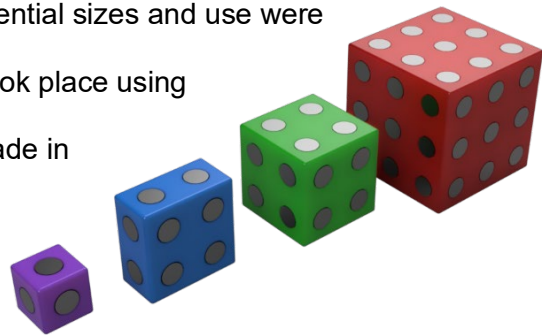


Figure 1. Digital Rendering of Initial Blocks



Figure 2. Initial Physical Blocks Prototypes

Physical models of the chosen sizes were made by 3D printing the blocks and simply gluing in the magnets. These blocks were quick to prototype and could be functionally used for user testing.

User Testing:

User testing took place at the 2021 Rochester Mini Makerfaire. At this event, over 100 children and adults played with and provided feedback on the blocks. The goal of this testing was to evaluate the physical blocks – looking at their potential as a fun and functional modeling tool.



Figure 3. Makerfaire Free Play Model Building

There were 4 key takeaways from this user test. The blocks can successfully be used to model many different things. The blocks are fun and engaging to play with. The magnets fall out and the magnet layout needs to be adjusted. The last two takeaways were addressed in the final model, solving both problems.



Figure 4. Makerfaire Guided Model Building

Final Design:

This toy, titled Voxel Magnet Blocks, forms a collaborative system between physical blocks and an interactive app. The physical magnet blocks are designed to be able to be simple to put together and take apart – rapidly modeling many different things. These magnet blocks have a protective outer casing, safely trapping the magnets inside while still snapping together with optimum connectivity.

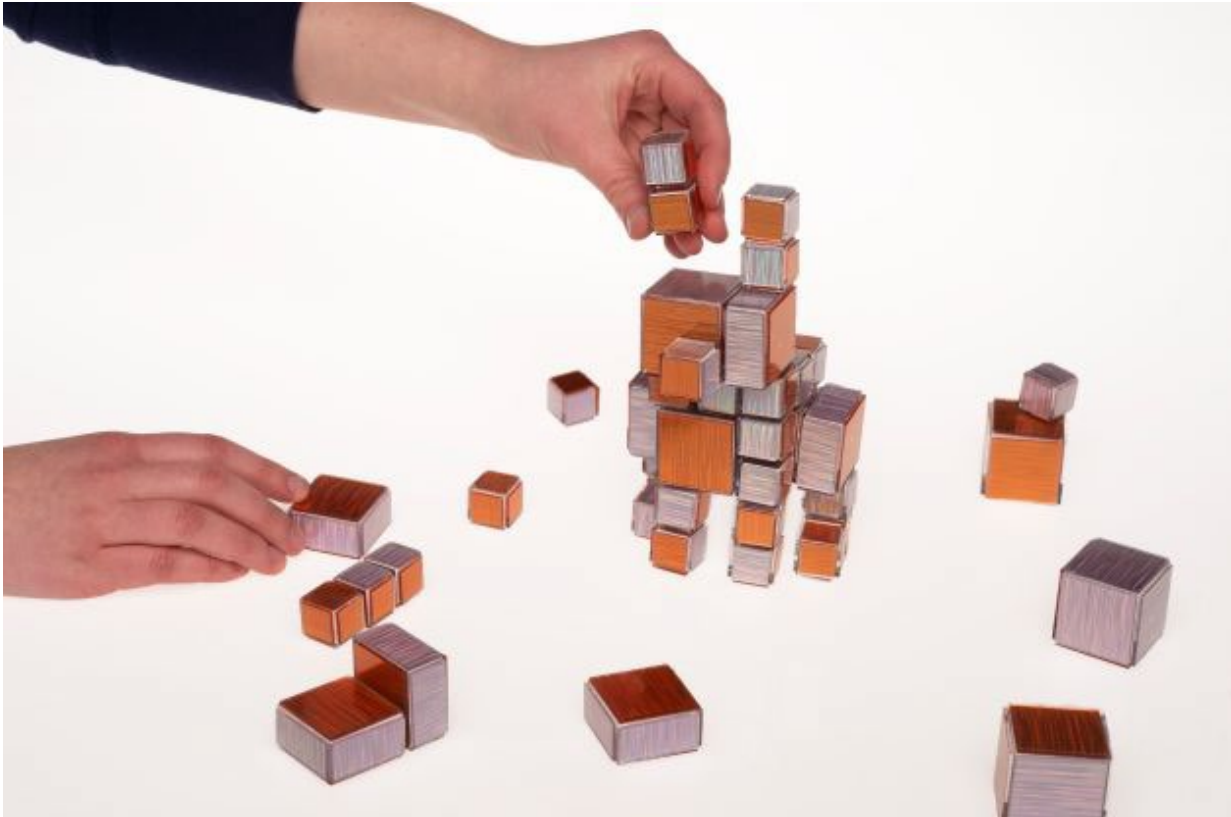


Figure 5. Final Physical Blocks

The overall system of this toy works as follows. The child follows instructions in the app or uses their own imagination to build models using the magnet blocks. The app is used to scan the blocks, creating a digital model of the physical creation. Then the kids can manipulate the digital model. They can recolor the model as well as place it and decorations into various backgrounds. The kids are also able to share their creations, through either images or by exporting their model for 3D printing.



Figure 6. Final System – App and Magnet Blocks

Voxel Magnet Blocks are designed to be able to model just about anything. They have potential to work with a variety of different apps with different themes. For this project, one app was prototyped – Staria’s Space Safari.

In Staria’s Space Safari, the kids are guided by Staria and her robot friends as they learn about Earth’s animals and their habitats. Staria is a young girl who lives in a spaceship flown by her mom. She has never been to Earth or seen any of Earth’s animals. Despite this, or perhaps as a result, she loves to learn all about Earth’s different animals and create models of each one that she can play with. Staria guides kids through how to use the app, leading the intro and the guided learning portion of the app.

The app has three main sections – Learn with Staria, Decorate and Play, and Free Play. In Learn with Staria, kids can learn all about different habitats and the animals that live there. They will see a picture of the real animal and learn facts about things like what it likes to eat and do. Staria



Figure 7. App – Learn Facts About Animals

also shares the models she's made of the animals and how the kids can build and customize them. The kids can then place their animal model, along with decorations, into its habitat.

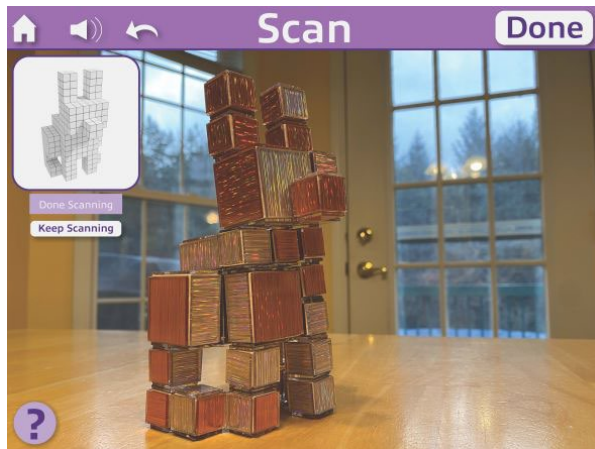


Figure 8. App – Scan Physical Model to Create Digital Model



Figure 9. App – Manipulate and Play with 3D Models

In Decorate and Play, kids can access all the models they've made and decorations they've unlocked by exploring different habitats. They can mix and match the animals, decorations, and habitats, creating their own custom stories. They can also make copies and recolor their animals any way they like.

In Free Play, kids can build anything they want with the blocks and scan them with the app to create a digital model. Then they can color and view their digital model. They can also use their custom models in the Decorate and Play section of the app.

The kids are also able to share their creations. They can share images of their decorated habitats or models. This encourages the kids to share their interests and gain confidence in their own abilities. They can also export a .obj or .stl file of their models for 3D printing. This completed the circle of physical and digital modeling. The kids can see the digital model, make it physically, view and manipulate it digitally, and then get it physically again as a completed form.

To see more of the app and get a better idea of the story, please visit the following link to view a video walkthrough of the intro: <https://youtu.be/vEkkag6puoU>

Overall, this toy engages kids in hands-on, creative play while building skills in spatial reasoning and 3D modeling. It can be used by kids of any gender identity, in fact that is

encouraged, however, by having the guide be a girl, it gives young girls a STEM loving role-model. This toy was designed to bring out the fun in 3D modeling for young girls, building skills that will last them a lifetime.

Conclusion:

The lack of women working in STEM fields is not a problem that can be solved overnight. Many factors contribute to this problem including gender bias, a lack of female role models, and a lack of opportunities to build STEM skills at an early age. It is important to remember that many things need to be done in order to fully mitigate this problem but starting with building self-confidence and skills in girls at an early age is a solid start.

STEAM toys are a critical tool when it comes to empowering the next generation of women in STEM. STEAM toys build solid skills and confidence through fun, creative play. STEAM toys engage kids not only in STEM fields, but also in Art, allowing them to explore their own creativity and innovation.

Voxel Magnet Blocks are a STEAM toy that focuses on building skills in spatial awareness and 3D modeling. This toy has room for improvement, such as increased magnet connection strength and easier manufacturing. There is a lot of room for growth of other potential apps with different themes. Maybe, someday this product will even be available for all girls to get inspired by.

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- Figure 7. “Photo of Arctic Hare.” Photo 88210220 © Sophia Granchinho | Dreamstime.com