



Now That's What I Call A Robot(ics Educational Kit)!

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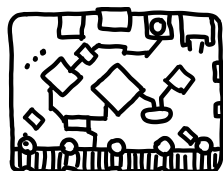
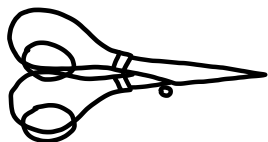
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ABSTRACT



STEM education is an important component of broadening participation in computational fields, and robotics-inspired kits are a common avenue for teaching youth computational concepts. In this pictorial, we contrast widely used kits (i.e., Lego Mindstorms, Sphero, and DASH) with a kit we created in the form of a module embedded in a summer camp, that takes an alternative approach. Most existing kits are designed with clear-cut, narrowly defined end goals for learners to accomplish. The lessons typically do not include



CCS Concepts: • Human-centered computing → Collaborative and social computing; Collaborative and social computing devices.

Additional Key Words and Phrases: robotics, education, edu-larp, design-based approach, social wearables, STEAM, eTextiles

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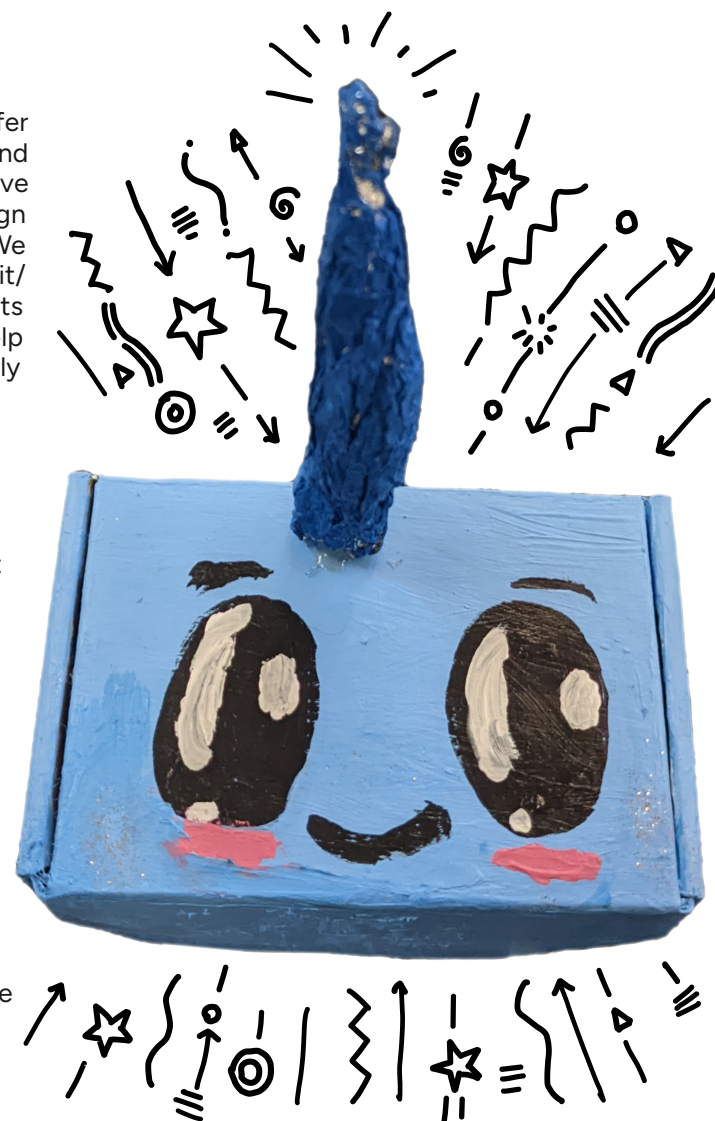
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teaching design concepts, and do not offer opportunities for crafting, personalization, and storytelling. We offer a more flexible and creative kit design; integrating concepts such as design thinking, iterative design, and collaboration. We illustrate our design process used to craft the kit/module, along with artifacts collected from its use, and discuss how this approach might help support a broader range of groups—particularly those that are underrepresented in STEM.

INTRODUCTION



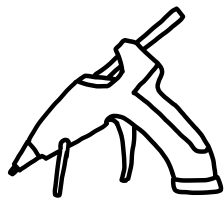
STEM education has long been an important way to broaden participation in computational fields and develop relevant core skills such as computational thinking [41]. In particular, middle school is known to be a key time to intervene and provide this education, encouraging interest at a time when many girls in particular declare they are less interested in STEM fields [11]. Supporting the STEM career pipeline to include women and other underrepresented groups is a challenge, especially because much of the industry is still less inclusive to these groups [3]. Despite awareness that middle school is a critical period for supporting girls' interest in computing, there



is comparatively been little research on developing interventions that circumvent these obstacles [11]. Therefore, it is of utmost importance to design STEM education interventions specifically to engage underrepresented groups and assess their potential impact.

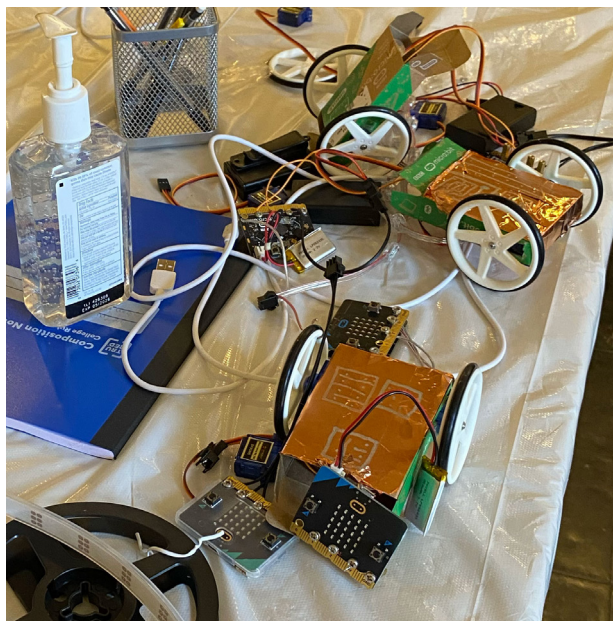
Robotic kits, in particular, have been gaining increased attention as a tool for providing STEM education [34]. This is, in part, because robotic kits facilitate computational thinking development through the tradition of tangible hands-on learning [14]. Off-the-shelf kits such as Lego Mindstorms¹, Sphero², and DASH³ are designed to teach STEM topics to youth, allowing them to design, build, and program a robot. These widely used robotics-inspired education kits emphasize tangible problem-solving (such as navigating a maze or collecting scientific data), and provide step-by-step instructions for achieving these aims. While some aspects of crafting and design might be included in these kits, it is not their primary focus, as these robots are made up of prefabricated parts. These well-regarded kits do appeal to and support many learners, but they may not support the broadest range of learners [24]. We argue that further progress needs to be made in developing

robotics kits that appeal to a wide range of learners who tend to leave the STEM career pipeline.



Numerous researchers have found that girls' computational interest

1. <https://www.lego.com/en-se/themes/mindstorms>
2. <https://sphero.com/>
3. <https://www.makewonder.com/robots/dash/>



Pictured here are the Critters having their code downloaded by staff. These were intended to be props for the campers to interact with but not to alter.

increases when they can use crafting skills as a part of their technical learning and experimentation [7,24,27,30]. To address this gap, a few scholars and designers have integrated crafting materials with electronics, resulting in new types of toolkits and activities such as paper computing (using paper, conductive paint, and electronics [29]), squishy circuits (using conductive Play-Doh and electronics) [15], and e-textiles (fabrics with embedded computers and electronics) [5,8,18,26,27]. Some have explored developing construction kits that allow children to create wearables using a tangible, modular method, e.g. [17]. However, often, these kits are not widely distributed and are not evaluated in practice from the perspective of drawing interest from

underrepresented groups in STEM education.

In this pictorial, we present a novel approach to kits that support inclusive STEM education. As part of a broader project to design and develop an educational live-action roleplay camp experience (Edu-Larp), we created a robotics focused module that makes use of off the shelf commercial components. Our goal was to make an educational module/kit that teaches STEM-related skills such as collaboration and design that are often underemphasized in other state-of-the-art kits. The module is embedded in a larger multi-day experience, but in this pictorial we focus on the module itself as an open-ended and flexible kit design aimed at making a more inclusive experience for a more diverse set of learners. This module was iterated over four deployments of our in-person camp for middle school girls. In the early stages of the camp, the design of the robot 'creature' was more similar to the widely used robotics education kits mentioned above. However, over the course of the four camps, through our design process and feedback provided from the campers, the robot creatures' design and role in the experience became more flexible and open-ended, and supportive of teaching creative and designerly skills. We argue that a more flexible, design-based approach to educational robotics kits could help engage a wider audience, thus broadening participation in STEM fields.

BACKGROUND



Most of the popular robotic-based education kits for youth (e.g., Wonder Workshop's Dash, Lego Mindstorms) focus on developing programming skills and computational thinking through task based challenges with a prefabricated, though

sometimes modifiable, robot platform. However, there are quite a few barriers to entry for these kits depending on kids' socioeconomic status [20,34], gender identity [2,28,37,38], and the tasks/ curriculum paradigms employed [2,38]. From a practical standpoint, cost of robotic education kits, direct and indirect, bars many children from access. Robotic kits are generally marketed, and priced, as high-end STEM toys, costing several hundred dollars per unit and often require access to smartphones or tablets with WiFi capabilities, putting them well out of the reach of lower-income families and schools. Beyond issues of material, skill, and usage access gaps [4] students from lower socioeconomic groups often report lower interest and engagement with STEM and robotics education [4,20,34]. This is likely due to a culmination of lack of experience, and/ or different experience, with technology resulting in an exorbitant emotional cost of access wherein youth from a lower socioeconomic class feels anxiety, stress, and fear around their place interacting with technology which may then ultimately lead to a rejection of interest in STEM related tasks/education [4].

In regards to gender as a barrier to entry with robot educational kits, the form factors, colors, materials, fictional narratives, and the robot characters themselves are often male-coded (e.g., use of male names/pronouns; male voices; have wheels or weapons; colors associated with male identity). Past work has consistently and repeatedly found that even very slight or subtle design elements can strongly cue people to ascribe gender, as well as gendered traits/ stereotypes relating to social roles, to robots [12,16,22,33]. This strong prescribed gendering of robotic kits for youth that disproportionately represent male identity and associated traits is problematic given that subtle environmental cues



The Lego Mindstorms, Sphero Mini and Dash (pictured above) are examples of commercially available educational robotics kits. In each case, the form factor is pre-defined and does not leave space for personalization by learners.

Images under [CC 2.0](#) : Sphero by GEEK KAZU (<https://www.flickr.com/photos/152342724@N04/38561430566>) | Lego Mindstorms by Eirik Refsdal (https://commons.wikimedia.org/wiki/File:Lego_Mindstorms_Nxt-FLL.jpg_-_background_removed) and DASH by Marco Verch (<https://www.flickr.com/photos/160866001@N07/45304981244>)

are well documented as triggering stereotype threat in groups of people that are socially conditioned not to believe they belong in STEM fields [9,21,37]. Past work has found that girls in particular prefer interacting with a robot who most closely represents their own gender identity [39,43] and that even simple gender expressions (e.g., wearing a bow vs. a necktie) will alter the perceived gender identity of a robot [43]. Moreover, providing female identifying kids with female robot educating partners seems to increase STEM learning outcomes [23,28]. It is also important to note that neutral, non-binary, or fluid conceptions of gender design and robots has only very recently begun to be explored at all [33].

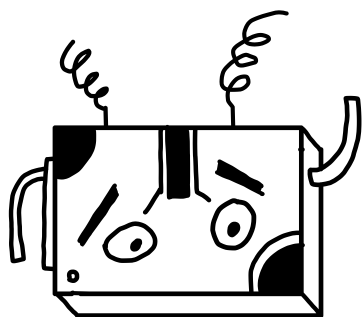
A final concern is the homogeneity of prescribed learning pathways that robotic educational kits tend to employ. In particular, robotic education kits tend to utilize fairly linear "solve-it" tasks (e.g., have the robot perform a specific sequence of movements, attach specific parts in a specific way) which unlocks additional functionality

following success. These are beneficial in that they allow an unsupervised app, or an asynchronous teacher supervising a group, to provide, or attempt to provide, controlled scaffolding as new programming concepts are introduced. However, there is some evidence that female identifying children have worse learning outcomes, compared to male identifying children, with this approach [34,36,38], though the root cause of these differences is still unclear given mixed findings [35,37]. Alternative approaches that are more creative than objective, based and/or collaborative approaches to coding and stem knowledge development have been shown to improve outcomes for girls [2,25,35,41]. Even re-framing the narrative around solve-it tasks, such as building/programming a socially helpful robot, may neutralize previously observed gender differences in solve-it performance [37]. This is particularly interesting given that when robotic education kits employ a narrative to frame programming challenges they often, again, use highly male stereotype coded story devices (e.g., sports, combat, space colonization).

For example, the most commonly researched robotics educational kit is Lego Mindstorms [25]. Mindstorms are primarily built using black, grey and white bricks, with occasional accent colors. The designs also utilize a “Transformers-esque” presentation. One of the Lego Mindstorms kits can be assembled into several different characters, all of which have male-coded morphology [40] and prescribed use cases such as a battle robot, a race-car, and a sports robot [37]. Sphero, another popular robotic STEM toy,

isn’t specifically gendered in name or physical shape, and even supports some colorful accessories. However, most of the activity kits, which all incur additional cost, present Sphero in a sport/

vehicle narrative where customization is generally superficial and non-modifiable. Wonder Workshop’s Dash educational robot has a more playful design, includes narrative-based learning modules, and considerations of gendered design accessibility were included during its development (i.e., wheels were hidden to make Dash look less like a robotic car and thereby make it more inviting to non-male children [1]). However, Dash is still presented as a male character with male-coded features and implicit hierarchical gender roles, as is commonplace in many robotic kits that utilize fictional characters[40]. Cue, another product by wonder workshop, is presented as the next step to Dash in the complexity of programming going from “Block based code to state machine and text-based programming.” Along with this shift



in complexity in programming comes the added functionality of “Blaster Power Accessory Pack” which adds a foam dart launcher. It paints a line of progression starting with the artistic, narrative, and performance-based, block coding in Dash/ Dot to more serious and real programming with Cue in an increasingly male-coded experience. While many of these kits and instructional materials serve as an excellent introduction to STEM subjects, there is a rigidity to their design that carries through to learner outcomes. It is this gap that we explored when creating the robot module/kit embedded in our social wearables edu-larp camp.

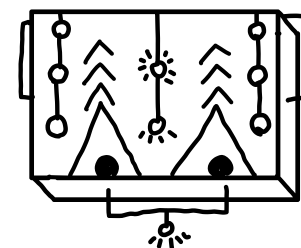
SOCIAL WEARABLES EDU-LARP CAMP



Our robot kit was developed and tested as part of a larger, NSF-funded project [13]. The project is designing a summer camp for middle school girls, which teaches campers how to design social wearable technology (i.e., wearable designs that enhance co-located interaction [19]) by using educational live-action roleplay (edu-larp) as a primary mode of teaching. Edu-larp is a semi-structured role-playing activity, in which campers engage a subject matter by taking on particular roles and enacting situations and scenarios to create immersive learning [6]. In this project we took a design-based research approach [31,32] to teaching, combining larp with the crafting of social wearables that campers could use to enhance their role-play experience. The camp’s design is aimed at middle school girls, as middle school is a time when many girls lose interest and confidence in pursuing technical education and careers [12]. With the design of the camp we also intended to encourage collaboration, teach design-based concepts such as iterative design, and promote more generalized design

thinking skills. Intentionally, we designed the curriculum to be flexible; we designed it to allow campers to alternate between coding, crafting and roleplaying according to their interest, after being given a baseline of coding knowledge. This flexible approach gave the campers agency over their time, allowing them to choose to focus on their interests. In addition, outside of the mission constraints delivered within the live-action roleplay context, we defined no explicit outcomes in regards to what the campers should design and build in the camp. Campers were given a set of design constraints to factor into their creations, but not given an “end goal” to reach with their design. This gave campers creative freedom, with the opportunity to personalize and create expressive designs, which they did. There were loose constraints for campers concerning the robotics-inspired creations (e.g. choosing to include a motor and/ or a light output), but there was no final goal, in terms of the creature’s functionalities. Encouraging and affording this freedom created a sense of ownership over the creations they made and encouraged deeper engagement with the camp’s story and crafting materials. There were four separate deployments of the camp that happened from August 2021 to July 2022 to iterate its design, including the larp narrative, activities, crafting materials, and the camp’s facilitators instruction guidelines. We used observations from each camp to refine and improve the camp design and material in each cycle.

The camp’s larp narrative centers on the “Anywear Academy.” Campers take on the role of agents in training as part of the academy,

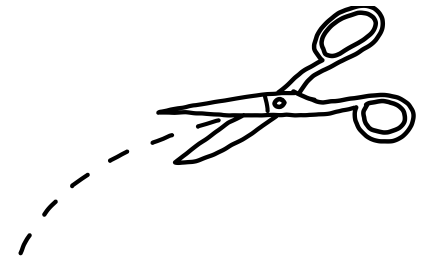


a secret organization tasked with traveling to different dimensions to establish diplomatic ties and right wrongs. Campers use wearable electronics they design and program to accomplish a variety of different “missions” (e.g., going to the fairy dimension to identify poisoned fruit using LEDs, or traveling to a space station to solve an electronics based puzzle which restores power). Campers’ time was split between these missions where they actively role-played, and unstructured activity time where campers were programming or crafting, as well as core classes in which they learned basic programming skills. Campers used the BBC Micro:Bit hardware platform to program a variety of wearable electronics that they would then use when traveling to different dimensions and completing missions in the context of the larp.

DESCRIPTION OF THE FAMILIARS MODULE.

The Familiars module makes use of the framing device of this Anywear Academy camp but can either be run as a module among many others or as an individual activity without the need for the overhead of running the whole camp. This kit/module is comprised of a Micro:bit V2 Go bundle, a strand of Neopixels or WS2812b LEDs, 5V continuous rotation servos, and any number of traditional crafting materials (including but not limited to pipecleaners, craft paper, cottonballs, patterned stickers, markers, and hot glue) and the social framing that the narrative of the Anywear Academy. Campers customize the cardboard box that the Micro:Bit comes in to use as an enclosure for the components while attaching the LEDs and Servos to serve as outputs. The built in sensors, buttons and capacitive touch pads on the

Shown here are a scenes from the different missions of the Anywear Academy



Micro:Bit serve as the inputs for their system. The result is a completely original character built by the camper to serve as a role playing partner that reacts to inputs and communicates state through lights, motion and sounds.

Narratively, Familiars are a badge of office, a mark of mastery, a companion character, and an extension of the player making them. For the student, this can be a strong invitation for further learning and engagement with the technical subject matter behind the design. We found this module so effective as a tool for quickly establishing social motivation and character that it became part of our training material for the adult facilitation staff.

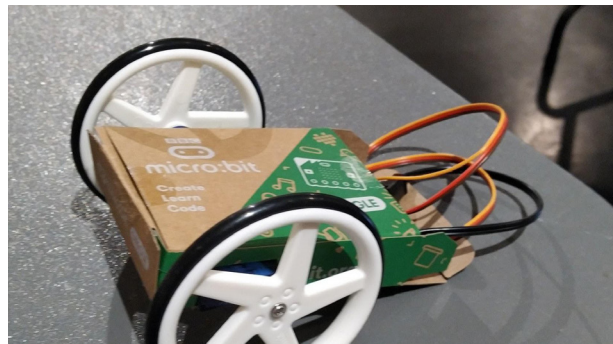
DESIGN ITERATIONS OF KIT



Here, we discuss our design iterations and narrative framing of the small, social, robotics-inspired creatures which we call “Critters” in the first two camp deployments, and “Familiars” in camps 3 and 4. For clarity, we were not initially setting out to create a robotics kit. The Critters were a prop and plot device used as part of a wearables focused experience that drew students attention. Following their interest, we created a series of Familiar activities. Examples of these are shown throughout this section.

In the first iteration of the camp, the “Critters” were two-wheeled remote control robots. These robots had a narrative role, serving as a plot device and prop for campers to interact with as part of the larp. Within that context, the Critters were a set of sensitive probe robots that in the narrative were used to scout new worlds by the

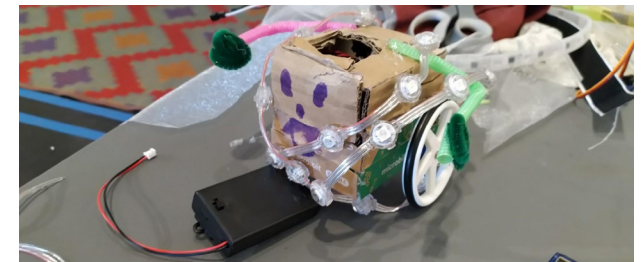
Anywear Academy. When they were introduced to the campers, the larp narrative described them as malfunctioning. Campers were introduced to the challenge of needing to fix them by using wearable technology that they would design collaboratively, to create a rhythmic light display. While this challenge engaged the campers as we hoped, to our surprise a subset of the campers picked up the Critters after the mission, cut their boxes open, and began to re-program and



Starting state of the Critter prop.



Campers continue to alter the Critter.



The completed Critter v2 from the end of the first camp.

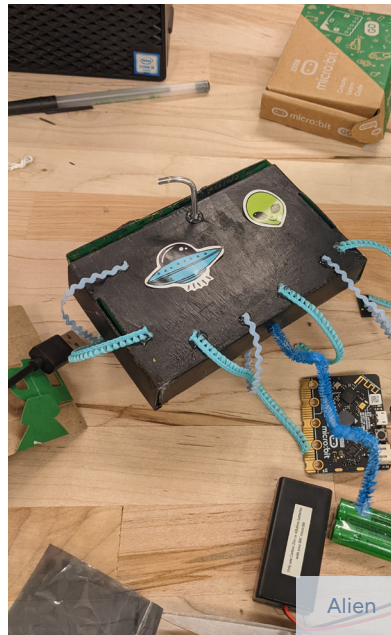


Campers first alterations to the Critter.



The same Critter, repurposed to be a wearable.

redesign them. In the comparison image, you can see how the campers that began working on the Critter modified it to incorporate the LEDs used in the wearable designs as well as using the onboard sensors to take temperature and sense magnetic fields. The Critters' intended design was programmed to roll forward a set number of feet, rotate in a series of quarter turns, record different sensor data each time, then return along the same path back to the user to display the sensor values on the LED screen. From a form factor perspective, this Critter v2 had a modified casing made from spare cardboard to accommodate a larger battery to power both the servos and LED strands. They added character elements like a face and arms made with plastic tubes. This impromptu involvement of some campers in adapting the creatures created a fractured experience for the group, with one of the campers at the end of the camp reporting that they felt they were less able to make use of the computers to reprogram their wearables because they "weren't part of the coding group." This wasn't the intent of the campers that were customizing the robot. In fact, the campers gave the robot to the Anywear Academy at the end of the experience stating that "they wanted the next group to use it for their missions". In the image of the campers working on the Critter v2, you can see the proximity of the coding area to the general crafting area which was intended to create opportunities for open collaboration and knowledge sharing. However, this layout created separation which led to a division forming between the campers modifying the Critter design and the rest of the campers focusing on crafting other wearables. One camper reported in an after camp interview that they felt excluded from those working on the Critters and not in the "coding group," despite the fact that they engaged in coding as part of crafting wearables for their other missions. Even though



Alien



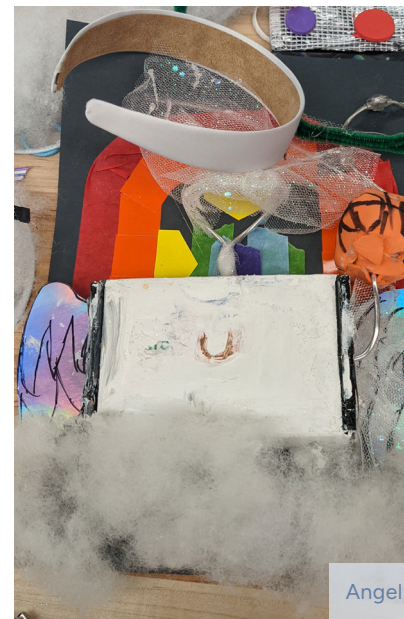
Calculator



Dog



Mossy



Angel

The campers developed their Familiar designs to connect back to the characters they were developing and playing as part of the Anywear Academy. For example, one created their Familiar to be a sci-fi-themed robot to connect to their space suit design (Alien).

Another camper created the Familiar as a gadget to fit their mad scientist superhero character they created for themselves (Calculator).

Other campers even designed their Familiar to connect to their out-of-game interests: one created a Familiar to be a version of their dog (Dog), one camper carried through the visual design of another prop (Mossy) while another created a Familiar to be an angel that can spin a basketball on the top (Angel).



The Robo-Shoe-Flies social wearable design which inspired the development of the "Familiar" concept in the camp design

the goal of the campers working on the Critter were still working to support the collective social experience (they repeatedly said they hoped to create something the others could use on their missions), the lack of structure that facilitated this cooperation led to a division in learning experience.

In the second session of the camp, there were minimal iterations on the camp material. In order to avoid the division amongst the Critter crafts and the rest of the group that occurred in the first camp, the role of the Critters was reinforced as props that were not available as crafting projects.

During the mission in which campers interacted with the Critter props, the facilitators provided a narrative justification to keep the campers from repeating the events that led to the tiered experience of the previous camp. The campers were told that they should leave the props for another academy team to recover and that the

Critters needed more time to rest following the experience that led to their malfunction. However, we had the same phenomenon as the first camp in which a small subset of the campers were looking for a different crafting experience to engage with beyond the ones offered by the structured missions

During this camp iteration, we also began prototyping the concept that would eventually become our Familiar kit/module design. We wanted this to tie back to the wearable, on-body, concept that was key to the camp experience, but also provide campers with the opportunity to engage with more open-ended coding activities if they were feeling too constrained by or disengaged with the other offerings of the camp. Using the same Critter v2 that the campers from the previous camp modified as a base, one of the campers in camp 2 modified it further to act as something like a pirate's parrot or animal companion, as shown by the inclusion

of feathers in the design as shown in the image of the repurposed wearable on page 6. This Critter companion spent much time on the camper's body and was said to communicate danger or opportunity, and detect strong magnetic fields. This interim step in the design of the kit was useful for helping to solidify the design goals for our final robotics module/kit in addition to the overall camp design.

As shown in series of images on page 6, the modifications made to these Critters over time show a shift towards personification and customized element that give these robots. Elements like adding faces or expressive elements were elements we wanted to carry over as we began redesign the camp experience with Familiars rather than Critters.

Inspired both by designs made by campers (the Critter v2 and an anthropomorphic creation termed 'Puffkins' by campers, constructed of pom pom balls) as well as a prototype we had seen of a social wearable robot-inspired creature called Robo-Shoe-Flies [10], in the 3rd and 4th camp deployments, we changed the framing of what we previously called "Critters" to now be wearable, social, robot-inspired creatures that were more open-ended, flexible and fit into the larp narrative more clearly. At this point, they were re-named "Familiars." Within the narrative of the Anywear Academy, the Familiars were framed as companions to graduates of the academy. The Familiars were presented as creatures that need to stay close to the body of their human partner (i.e., wearable), and are intrinsically sensitive—they can be used to detect things that are beyond what humans normally can sense. However, due to their sensitive nature they can also easily become overwhelmed and need support and care from



Camp 3 participants and the familiars they designed.

their human partners (the campers). This meant that the campers, as they were the Familiars' human partners, were asked to help craft and guide their Familiars' development.

To introduce the campers to this concept, we worked with the camp's facilitators during their training session to prepare their own Familiars (the camp's facilitators also participate in the narrative, as they are part of the edu-larp). Then, the Familiars that the facilitators created were used as exemplars for the campers to draw inspiration from. These Familiars were made before the camp session started and helped the facilitators themselves to prepare and establish their characters in the larp. In one of the camp's scripted events, the Familiars of the facilitators were shown to be overstimulated and needed to take time to recover. This scene was created to prompt the campers to begin creating their own Familiars. The idea was that the Familiars' capabilities would be helpful to the campers when they went on the larp narrative missions. The Familiars were intended to be creatures that live close to the body, so worn in some way or held. To program the Familiars, campers were given a bit of starter code. For example, this code included abilities to react to a radio signal broadcast on a pre-decided band. However, the way the campers chose to program the Familiars to react, was up to them to decide: some campers chose to display an icon or text on the Micro:Bit's LED grid, while others chose to play custom audio jingles, or control a servo. Some campers used the LED lights to display an RGB pattern, and others programmed their Familiar to send/receive radio signal waves. To provide the campers freedom to explore and customize their designs to fit their own desire, the design brief for creating the Familiars was intentionally left open.

The campers inspired each others' creations, and shared knowledge. This led them to develop creative instantiations of the Familiar design. In addition, during the camp, the campers iterated on their designs, each time adapting them further for use in the camp's narrative missions. In some cases, they developed technical design ambitions: for example, one camper wanted to



Cow from camp 4, which was drastically different from the dark, gothic concept the camper was trying to achieve in their prior costuming work.

improve their design so their Familiar, which was a cow with rotating ears, would be able to move its ears in synchrony (a physical computing challenge to coordinate between two servo motor movements that were spinning the "cow's ears"). In other cases, the design inspiration for making the Familiar results from a camper's conversation with their parent: one camper said they discussed the Familiar design with their mother, who suggested their dog's bark as an inspiration for the design.

DISCUSSION



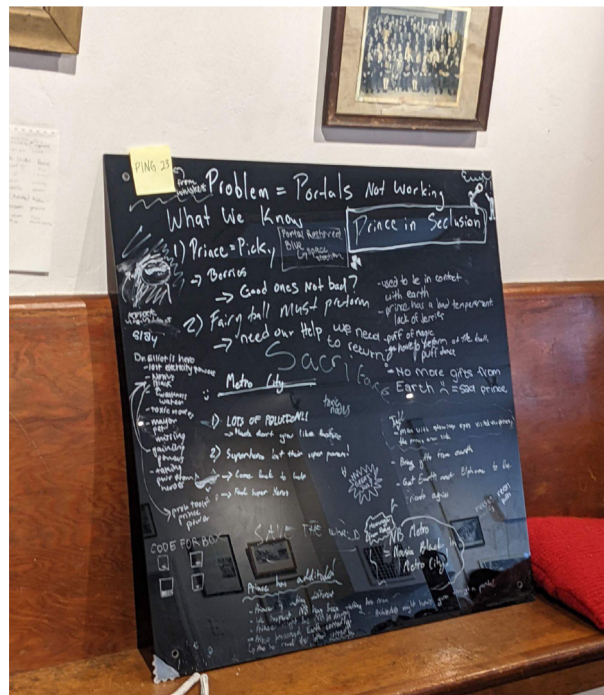
Here we present strengths of our module/kit design in contrast with widely used robotics education kits described earlier, and provide insights gathered from the use of our kit through running the four iterations of the camp. We give suggestions and recommendations for STEM educators to consider when designing or running a program that utilizes a robotics education kit. In the context of our kit design, we had two main goals in support of the informal learning style of teaching in which the camp was grounded. We wanted the kit to a) be open-ended and not have a predefined end goal and b) be in support of teaching design skills to the campers.

In terms of a), it became clear through the iterations of our kit that it was important for the final design to be flexible and personalizable rather than prefabricated. When our robot-creature had a more specific form factor (and was not wearable) in camps 1 and 2, campers were not as collaborative, creative, or as proactive in sharing design knowledge. With the change to Familiars in camps 3 and 4, the kit had no set end goal (open-ended), which helped to encourage collaboration, as campers became inspired by each other's designs and integrated their inspirations back into their designs, following an iterative design process. The flexible nature of the camp also allowed a lot of variety in the designs to emerge, specifically the design of the Familiars. There a few design goals communicated to campers regarding their designs, including that they needed to make their Familiar wearable. The on-body framing of the Familiar might have helped facilitate a personal connection between the Familiar and the camper, as the campers saw it as an extension of themselves. Some campers

designed their Familiars to be tied to the design of their existing costumes/props that they had created until that point in the camp and the narrative of their character (See Mossy and Angel on page 5). Both designs were based on the original character design of the campers. On the other hand, some campers created their Familiars completely detached from previous designs they had made, and started from scratch (The cow from camp 4, which was drastically different from the dark, gothic concept the camper was trying to achieve at first). The design of their Familiar gave campers the space to pivot their design direction, and even retroactively update their character within the larp if they wished. Our kit was also meant to foster collaboration among campers, encouraging them to work together and be inspired by one another's designs. There was a social element of skill sharing, usually initiated by someone asking for help or offering their help on their wearables. Especially in the later days of the camp when campers know each other better, it is a common sight to see multiple campers huddled together to collaborate. Campers who felt finished with their current work announced that they were free to help, campers more experienced at certain skills (e.g. soldering wires, sewing, debugging) directly offered their help to other campers, and campers unsure of how to continue with their design invited others to brainstorm. The effects of campers collaborating and being inspired by another can be seen in the wearables during different camps. For example, in camp 3, one camper painted large eyes on their Familiar which another camper really liked, so the camper painted the same eyes on their Familiar as well. Campers programmed, conceptualized, crafted, iterated and role played throughout the camp.

In contrast, most of the existing robotics

education kits have a prefabricated form factor, with a specified end goal of what the robot itself looks like. This explicit form factor might limit interactions with the robot, as it dictates the creation and puts borders around what can be designed with it. While this might be a time-saver for STEM educators trying to teach these concepts as well as appealing to certain youth, this may limit the way in which it is used, which is intentionally addressed by our open-ended and personalizable module/kit design. Our approach does not have a prescribed functional end-goal, which allows campers to have the freedom to explore and allow their designs to guide them.



This blackboard served as a collaborative workspace for campers to gather narrative clues.

Additionally, many of these prefabricated robotics education kits are designed and presented in ways that may perpetuate existing tropes around robotics and STEM.

Our other primary goal was to incorporate developing design skills into the camp experience. Often formal learning experiences are within a school-based setting and built around accomplishing clearly framed tasks, achieving set goals, and so iteration is in service of solving a specific problem [42]. In contrast, our informal approach focuses on camper creation of purpose-built devices to support the overarching



Cat Familiars from Camp 4.

larp narrative, encouraging campers to reflect on and revise their designs to support their own personal storymaking within the larp narrative context. This framing allowed campers the opportunity to customize and create personal stories around their Familiars. Real life animals (cat from Camp 4, multiple dogs from Camp 3 & 4, cow from Camp 4) and mythological creatures (unicorn from Camp 3) were common sources of inspiration for the wearable designs. A possible cause for this could be the way wearables were framed as companions in the camps, and animals seen as natural companions to humans. In addition, the design framing that the Familiars needed to be on-body helped campers take more ownership of the Familiar, making it fit their in-game character's personality and customize it according to their liking. This supports the design goals of the camp itself, helping integrate storytelling with the camper's designs to give some context. Learning programming and hardware skills incrementally over the course of the camp resulted in changing and adjusting designs to make use of freshly learned skills. Instead of trying to reach a "perfect" state in their designs, campers experimented with different design ideas. When one of the campers was done crafting their Familiar, they continued to work on the designs in many ways, such as adding aesthetic details, expanding the ways they could wear their design (e.g. making a wearable attachable via Velcro when it already had an strap to be worn) or making the LED lights/motor perform specific actions. The open nature of the camp seemed to support iterative design and design thinking amongst the campers.

In addition, there is a core story to the role play in the camp, which involves themes of a space agency and portals to different dimensions. However, the role players are free to create their

own characters, come up with unique backstories, and create the aesthetics of their character. The main narrative serves as a tool to help campers create their own unique role play experiences. This makes the design outcomes during the camp in control of the role players and the learning objectives tied to their designs. Thus a learning objective such as coding to change the color of a light, can be applied in wearable designs in a multitude of ways determined by the role player. Connecting the kit into the larger context of the camp narrative has real world applications. One of the benefits of larp is that it can be used to help people situate technology within its context of use in order to help understand its strengths, limitations and use cases, in order to better iterate on the design. The campers were able to do this in the camp, often times coming back from a mission where they used their Familiar and making changes to the designs based on how they wanted to be able to use it in future.

The task of making the Familiar was inherently framed as a collaborative, social challenge. The Familiars were said to help campers understand more about the larp narrative, as they would be reactive to let their wearer know when something about the portal might be dangerous, or when one of the characters in the larp was acting off. The Familiars essentially acted as a sidekick, assisting the campers in their quest to understand more about the narrative.

In terms of application to the broader community, we hope our case study of the Familiars module from our edu-larp camp gives others working with STEM robotics kits inspiration to consider framing learning using role play and social elements, and also, to use crafting and role-play based design goals to allow for greater

personal expression and joyful social iteration of robot designs. Creative customization and crafting gives learners an appealing entry point. Using technology within a social situation helps teach iterative design, as well as to think about the way technology might be used socially and collaboratively with others. This supports learners that may feel more comfortable in a collaborative environment, and encourages them to think more broadly about how their designs might affect a real world context.

CONCLUSION



In this pictorial, we presented a novel approach to inclusive STEM education: a design-focused, flexible robotics-inspired education module/kit that is integrated within the context of an edu-larp. Through running the camp, we iterated the design of this kit toward an open-ended and flexible design process situated within a role play context, allowing campers more opportunities for exploration, collaboration, iterative design, and creativity. Our work may be of value to others teaching coding skills to youth with robotics, and more broadly, to TEI community members interested in supporting STEM education for youth who are not engaged by mainstream engineering culture and approaches.

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