Beyond Game Design for Broadening Participation: Building New Clubhouses of Computing for Girls

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ABSTRACT
The absence of women in IT has been a vexing issue for over two decades. Most attempts to broaden participation in computing have focused on "unlocking the clubhouse" to a more diverse group of participants. One popular approach has been to ask girls to program games, which developed into the Game Design Movement, a series of studies and tools to help develop and empower females as designers of interactive digital media. This paper examines the rationales and successes behind the Game Design Movement in order to outline new strategies for broadening participation in computing. Rather than simply "unlocking the clubhouses" through expanded game-making activities, we argue here that educators and researchers should devote themselves to "building new clubhouses" altogether by focusing on using new programmable materials, interactive activities, and both in-person and online communities that leverage the traditions of girls' play worlds and the cultural practices of women's crafting communities.

Author Keywords
Gender, computing electronic textiles, games

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K.3.2. **[Computers and Education]** Computers and Information Science Education – *pedagogical approaches and gender*

INTRODUCTION
In mid-November 2013, a company uploaded a video to promote GoldiBlox, their new set of engineering toys for girls. It features three young girls sitting on a living room floor and watching with bored expressions a TV show of themselves as girls, dressed in pink, dancing and singing, "Girls, girls, girls, what do they want?" As the camera switches to a toy disk player, the tunes of the ever-popular 1986 Beastie Boy song "Girls" start up. The girls grab an engineer tool belt, put on safety glasses and a hard hat. The rooms in the house transform with Rube Goldberg-like contraptions of spinning salad bowls and wagons pushing aside a pink tea service while overlaying the original Beastie Boy song with new lyrics: "Girls—to build the spaceship / Girls—to code the new app / Girls—to grow up knowing / That they can engineer that / Girls. That's all we really need is girls." The owner of the company, herself an engineer with a degree from Stanford, made the case that the GoldieBlox toys were aimed "to inspire girls the way Legos and Erector sets have inspired boys, for over 100 years, to develop an early interest and skill set in engineering. It's time to motivate our girls to help build our future." An earlier successful KickStarter campaign also sold t-shirts with "More than just a Princess" available in kids and adult sizes, The video, watched over 8 million times within its first week, clearly aimed at providing a fresh perspective of the otherwise heavily stereotyped toys and advertising for girls in the upcoming holiday season.

The GolidieBlox video surely captured the frustrations that many have felt around the absence of girls and women in fields of computing, engineering and gaming over the last twenty years. Coding [26, 27] but also gaming [8] communities have a long history for not effectively engaging and encouraging girls in the fields and the reasons for this are multiple: on one hand, there is the lack of initial interest, compounded by a lack of direct experience and consequently skill from females; though, on the other hand there is the persistent stereotyping of women in these same three areas, exacerbated also by a lack of female role models. To address these diversity and equity issues in computing and gaming, programming (rather than just playing) games has been seen as a possible remedy [19]. Over the years, numerous studies, that collectively can be called the Game Design Movement, have demonstrated that girls can potentially be more engaged by and learn more about computing, content, and design skills by effectively making their own video games [16].

While the Game Design Movement has been successful in engaging girls, one underlying question has never been truly addressed: why did girls have to design games in order to become more tech-savvy? Why, that is, had this become the perceived "necessary" pathway to get females more

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involved with computing? Even the feminist side who mightily (and justifiably) lamented about the reification of stereotypes in commercial game play [9] has not dealt with this issue. One of the concerns is that the communities and productions of gaming have been reluctant to open up to women, a situation that has remain unchanged for the last twenty years. An additional concern is that game design itself might not prove to be the enticing road into computing as a recent study by Robertson [32] illustrated. While making games provided girls technical expertise, it didn't necessarily sway female participants into becoming more interested in pursuing computing careers. These concerns cast a noticeable shadow on the popular Game Design Movement as an outreach effort and suggest that we need consider new activities, materials and communities.

In this paper, we argue that by understanding what initiated the launch of the Game Design Movement and its follow-up developments, we can better understand how to design new directions for materials, activities, and communities that can introduce and promote computing to girls. Several new material developments in form of electronic textiles and online communities will serve as examples. This approach leverages the same motivations behind the development of GoldieBlox toys and tools to have girls see and experience themselves as budding engineers. The push towards developing new directions of activities and materials in computing reaches far beyond what GoldieBlox and game making has offered so far. As important it is to open the doors to the existing clubhouses of computing, as it is to build new clubhouses that envision different educational opportunities in computing. It is connecting back to history of computing but also forward to new communities.

EXAMINING THE EXISTING CLUBHOUSES

The Game Design Movement draws from two separate but interrelated developments that both hinged on the lack of girls' presence, interest and participation in computing and gaming. Numerous studies have documented girls' lack of interest in and experiences with computing inside and outside of schools (for overviews, see [41]). To address these disparities, research has focused on "unlocking the clubhouse" [26] by demystifying the 'geek mythology' and accompanying sense of exclusivity that surrounds STEM cultures. Likewise, many studies documented girls' lack of interest and experiences in gaming communities [8]. One of the reasons why these two developments became intertwined is that they supported the technology "pipeline" argument—namely that kids needed to have opportunities to interact with technologies early on if they were to choose and pursue later technical careers. As a case in point, many argued that boys' early access to video games and communities of fellow game-enthusiasts provided them with exactly this type of "home advantage" in getting experience and familiarity with digital media [15]. Consequently, increasing girls and women's participation in gaming has been charged as one essential way to address the overall lack of women's involvement in computing. It's for these reasons that a study [18] of elementary school children's learning while making games conducted in the early 90's received such widespread attention and became a role model for promoting programming games for learning inside and outside of school.

Game Design Projects

The original game design project was launched with the intention to provide a socially and personally meaningful context for learning programming, but the project took on a life on its own when it demonstrated that not only could girls be interested in making game but also could effectively learn programming skills. It followed an approach to coding that had learners design educational software to teach fractions rather than learning programing just for the sake of learning programming [14]. A class of sixteen 10-year-old students was asked to design and program their own educational fraction games. The students met every day over a period of three months to design educational games by creating their own characters, story lines, game themes, and interactions for younger students in their school [18].

The game making study was remarkable for several reasons. For one, it disbanded the conventional wisdom at the time that girls couldn't be interested in programming and be interested in gaming. On the contrary, they very much could be interested in both intertwining domains if they were only given the opportunity to be able *to make* their own. All the students who participated in the project significantly increased their programming skills in writing and debugging code, especially when compared to students who had learned programming the traditional way, which typically was once a week in a computer lab for a hour working on small pieces of code rather than an extensive project. Even those students who had daily access to computers did not fare as well in their learning of programming. Furthermore, none of the analyses revealed any significant gender differences, demonstrating that girls could be as good programmers as boys. Designing games was successful in engaging all students in learning programming and in computing culture.

But there was one important difference in how boys and girls approached and realized their game designs. Most of the boys' designs featured violent feedback and were situated in fantasy settings that featured male players and combatants; meanwhile, most of the girls' designs were games with no violent feedback and featured realistic settings rather than fantasy realms. Most female designs also made provisions for players of different gender, whether it be giving players a choice of multiple avatars or populating the game with both male and female characters [19]. An alternative interpretation of these findings would propose that the boys positioned themselves in their games as savvy game players by choosing established conventions that reaffirmed their gender while the girls did the same with their choices [29]. In their choices of game themes and their programming of animation and interactions, the boys and girls offered a glimpse into what they found appealing and unappealing in the digital games and stories they experience in other media. Making a game and its rules allowed the game designers to be in charge and to determine the player's place and role in a virtual world, with all the consequences. A later study [20], in which students were asked to design and implement astronomy games, found no differences in game designs— suggesting that context—or in this case, giving kids a specific context in which to design their games—plays an important role in how students position themselves in relation to each other and particular subject matters.

While the number of participants in this study was small and not replicable given that only few students in the 90's had daily access to computers in their schools, the study's findings had larger impact because they provided a compelling illustration that girls could be interested in computers and games. The findings from this research spoke to both gaming and computing communities because they aligned well with then-popular discourses about gender differences in interest and performance in technology; however, rather than reinforcing the common discourse, the study's results also potentially offered a constructive way out: let girls make, rather than play, digital games. This project became the launch pad for the Game Design Movement, a collection of studies and tools developments to promote making games for learning on a larger scale.

Game Design Movement

Numerous studies have been conducted to document the multiple benefits of making games inside and outside of schools, to connect it to new literacies in media studies, and even to support the development of new learning environments. A review of the existing research literature [16] identified four different learning goals in the Game Design Movement. The first one, learning programming is perhaps the most obvious one, and finds that there are numerous studies that suggest that grounding coding in game play offers children a more effective portal to learn the fundamental concepts of programming while engaged in a hands-on activity [18, 28]. Like in the game design project, the development of an actual "construct" (in this case, a digital game) in either programming language that has personal worth to the user helps demystify the coding process, making it more real and relevant to the learner. The second goal is to make computer programming more palpable to females and underrepresented students in the computer science field, building directly upon the first goal. A growing body of research has demonstrates that students less represented within CS as both a course of study and a career field report to be more engaged and persistent in learning how to code when such activity relates to developing and refining one's own digital games [10, 11].

The third goal focuses on learning content in other academic domains—just as game-making has the potential to make learning programming more palpable, so too does it offer the opportunity to ground more traditional academic subjects in hands-on activity, be it math [18], language arts [6, 33, 43], or history [39]. Finally, the fourth goal is the understanding design concepts—less traditionally academic in nature, this fourth and final goal does not treat digital game-making as a vehicle for learning a related subject (e.g., coding, academic subject content) but as the subject of the learning, in and of itself; a number of studies [1, 13, 30] have conducted qualitative research as to how children learn to create games, talk about games, and advance the game-making process both working individually and collaboratively.

All four of these are certainly valuable learning goals. However, for our purposes here, categorizing the educational affordances of making games as distinctly falling into one of these four categories is difficult, if not impossible, since many approaches often address and reinforce more than one goal. That is, children making games for learning need not just address one of the four categories that Hayes and Games [16] outline in their literature review, but can very well address multiple learning outcomes at once. After all, can a workshop on making basic pong-like video games not only serve as an introduction to computer programming but also be integrated into a core curricula math class focused on the x/y coordinate plane? And why couldn't this same core curricula math course be a classroom of all girls whose own subject based knowledge is supported through modeling and testing their own game designs, opening them up to the potential of computer science as a constructive field? Ultimately, even when educators design video game workshops for a singular purpose, the actual construction of the games themselves often entails multiple and mutually beneficial learning principles.

Another strand of research has focused on making games outside of schools and examined how youth in community technology centers engage in game design and learning programming [24]. A study of over 500 programming projects collected over a two year time period revealed that game designs were by far the most prominent examples found on the clubhouse's server. Most clubhouse members worked only short time periods on their games but some, like Jorge, a 15-year-old Latino male designer, spent the majority of their time working on his own version of a Metal Slug Hell Zone X game, and stretched out over several months [30]. Utilizing the visual programming capabilities of Scratch [31], Jorge animated these images to respond to keystrokes so that the avatar walks effortlessly across the screen or jumps when prompted by control keys. The programming of the game not only incorporated many complex technical features, but also hand drawn sketches based on playing the original videogame, downloaded sample avatars from Internet fan sites, and refined each frame of the movement in the paint editor for smooth stop-action animation. These shifts from creating visual designs to programming animations illustrate Jorge's pathway into computational thinking, which in turn shifted toward computational participation as Jorge tweaked his game to become more user-accessible and more closely resemble the online culture specific to designing and making fan videogames like Metal Slug [17].

More current developments have added a new layer to the potential of making games for learning. Educators, researchers, and general enthusiasts now situate game-making in the field of new media literacies [12, 25], and emphasize benefits such as system-based thinking [36], and critical engagement with media [2, 29]. The push to consider game-making as educationally significant enough to be a "literacy" or one of many "literacies" has proved to be a powerful leverage point in terms of reconsidering what skills and content K-12 schools value and instill in their students. The goal is not necessarily to produce legions of professional game designers but rather give young learners the opportunity to design, develop, and debug their own digital content and, in the process, better grasp the nature of web-based media and the potential to collaborate through such media on project-based assessments. Already alternative schooling models have developed—most notably New York's Quest to Learn School (Q2L)—that incorporate game-making as not some peripheral elective but as core-content subject matter [34, 37]. Now in its fourth year of operation, Q2L continues to grow with the recent addition of a high school, and early exploratory research [38] on the school's model demonstrates its students are making assessable gains not only on state-wide examinations but on what Q2L refers to as "21st century competencies", including systems thinking and effective time management on collaborative projects. Indeed, as Shute and Torres [38] point out in the conclusion of their qualitative study, video games serve as more than just the content of Q2L's curricula but also the pedagogical model of the school itself which too intends to "instantiate learning contexts" and "design rich learning environments and experiences that mirror discourse communities" (p. 113).

BUILDING NEW CLUBHOUSES

It is clear that the Game Design Movement has had many successes and reached an impressive dissemination beyond schools and communities. As a starting point for laying the foundations of new clubhouses, it is helpful to examine what worked in using game design for broadening participation in computing. Two aspects stand out: First, the design of applications in learning programming and, second, the provision of an audience for the learning projects. Making games for learning provides compelling illustrations for both. The most important reason for having students design games stood in stark contrast to how most kids learned to program in the 1980s when programming was first introduced on the K-12 level. In its initial foray into schools, programming largely existed as a stand-alone activity in which students would participate once or twice a week for an hour at a time. And typically, these isolated moments of coding existed apart from classrooms within the computer lab after which the students were return to their "normal" classes back down the hallway. Learning to program used to be about learning to write code, develop algorithms, and design data and control structures resulting in functional, if not necessarily efficient programs rather than creating meaningful and authentic products such as games and software that are a key part of youth's digital culture.

Game design activities also offer an authentic audience whether just in a local classroom or in online communities. Nowhere is this more evident than in the proliferation of video game-making competitions such as Globaloria's "Globey Awards", Advanced Micro Devices (AMD) "Changing the Game" contest, the Games for Change Awards, as well as the National STEM Video Game Design Challenge co-sponsored by the White House itself [21]. All of these competitions instill a sense of empowerment, both personal and social, that one can make what one uses and is characteristic of the self-reliance and drive of the wider DIY movement that has grown since the advent of Web. 2.0. They all point towards the relevance of communities where ideas and designs can be created and commented on, shared with others, and even remixed–the social contexts and cultural practices will be the focus of next chapters.

Notwithstanding these contributions of the Game Design Movement for broadening participation in computing, there is the larger issue of what girls were being asked to make in order to become tech-savvy. Why did girls have to join the clubhouse of gaming, and not other ones? We know from numerous studies over the last two decades that gaming culture is not a place that girls choose to hang out in due to the topic and interactions of games. There was the equally important issue of stereotyping in games that gave girls few options in terms of female player characters, and even so, with only limited options in terms of avatar looks and gaming potential. Even in the online communities of massive game play with more options of customizations and play, few women would join. While video games are a prominent part of digital culture, they continue to be culture dominated by boys and men. That is true not only of the entertainment culture of gaming but also of the production culture of gaming that with their less than welcoming work place conditions has bereft of female designers and programmers (Kafai et al., 2008). A recent study by Robertson [32] might provide a first glimpse that even girls have questions about game making as a way to engage their interest in computing. While making games provided girls technical expertise, the experience didn't sway female participants into becoming more interested in pursuing computing careers.

The main issue with Game Design Movement is that boys' activities became the benchmark for girls' educational opportunities. The underlying assumption of such benchmarking is that it elevates one group's activities as the norm for others. It also reifies the notion of gender as a biological construct rather than a social construct that is performed [9]. Theorists like Butler [7] have introduced the notion of gender play, meaning that both girls and boys, and men and women, experiment with gendered expressions within different contexts. She conceptualizes gender from a human feminist perspective as "an attribute of a person, who is characterized essentially as a pre-gendered substance, or 'core,' called the person…" (p. 14). Much of the research has focused on where and how society places constraints on gender performances and thus impacts a gendered identity formation. Making games for learning was a first and important step in reconsidering approaches to learning coding by realizing that it could be about real-world designs and audiences that are part of youth culture and instrumental to engaged learning. But there is thankfully more to digital culture than just video games that can lead to building new clubhouses. In the following sections, I outline two developments, electronic textiles and collaborative communities, for broadening participation in computing.

New Materials for Computing: Electronic Textiles

In envisioning new materials and activities, it is fruitful to step back into the past rather than to look to the future of computing. Designs with electronic textiles [4] hark back to the origins of computing. Electronic textiles (or e-textiles) combine traditional aspects of fabric crafts using needles, thread, and cloth with a microcontroller that is both sewable and programmable, various actuators such as LEDs or speakers, and novel materials such as conductive fabrics, paint, tape, and even tinfoil. Such designs draw inspiration from the "Analytical Engine"—a nineteenth century general purpose computer, conceived (but never actually completed) by the mathematician Charles Babbage—was based on the design of the mechanical Jacquard loom, for weaving fashionable complex textiles of the times. It was Ada Lovelace, Babbage's aristocratic colleague, who wrote perhaps the most beautiful sentence ever to link fashion and computing: "We may say most aptly that the Analytical Engine weaves algebraic patterns just as the Jacquard loom weaves flowers and leaves." And yet, this historical and intimate relationship between fashion and computing has largely been forgotten and ignored, even as Lovelace's pioneering spirit lives on today in dresses that change colors, jackets that play music, shoes that light up, and necklaces that display Twitter feeds.

There are now numerous examples of how such soft computing that incorporates sensors and actuators into e-textiles can be a personally meaningful and rich learning activity for crafts, engineering, and computing that spans the K-16 spectrum [3]. More importantly, there is evidence that different communities of computing develop around working with LilyPad, an e-textile construction kit, than with the functionally equivalent Arduino, a micro-controller. In a study of LilyPad Arduino users (hobbyists) and their projects, Buechley and Hill [5] found that significantly more women use the LilyPad Arduino (57% male, 35% female) than the technologically identical Arduino (78% male, 9% female). These findings suggest that indeed cultural packaging can attract different groups while still engaging them in the same complexities of computing. It is particularly relevant since the LilyPad Arduino is rooted in a tradition of tangible computational construction kits such as LEGO Mindstorms [35], but extends activities that have been focused on programming and engineering to include sewing, textiles, and crafts. Efforts to broaden participation in computing can be integrated into designing interactive wearables rather than robotic constructions and reigniting historical connections.

New Communities for Computing: Crafting Circles

We also need to re-envision communities of computing that focus more on collaboration and less on competition. It is widely believed that participating in local and national competitions such as the Google Science Competition, First Robotics, and the Microsoft Imagine, where students prepare, display and share their learning artifacts can be a valuable learning experience. But these online challenges can be as much about collaboration as they currently are about competition. Students can use these challenge competitions as spaces for collaboration with others, and as forums for them to showcase their own creations, including videos, blog posts, fan fiction, video games, and more. Providing online spaces where youth can not only socialize but also develop and share their own digital content can add new dimensions to their online participation in computing. One such proposal connects back to making and sharing collective designs in quilting circles. Such communal circles stand in stark contrast to the more competition-driven workshops of the robotic activities. And yet these quilting circles, while a far cry from the chest thumping of robotics competitions, too have their own (if more staid) competitive edge with members regularly monitoring each others' progress and checking their own skill levels by assessing the skills of those around them. In terms of competition and collaboration, it simply is not an "either-or" scenario, and we, of course, are not arguing here against competitions. They do have an energizing function, providing purpose and audience in a shared event. Our point is about diversifying participation: competitions can't and shouldn't be the only model of how we organize, present, and celebrate computational participation. It suggests that we need to create new communities that unlike the robotics competition provide a collaborative and supportive atmosphere.

As one example are new communal communities and events around computational crafting activities. Called eCrafting Circles [23] they make intentional reference to the quilting bees and sewing circles that used to bring together community members in neighborhoods to collectively produce quilts, clothes and more. Rather than competitions, online crafting circles will be time-sensitive, locally relevant events that allow for sharing and displaying of computational crafts. These are intended to spark increased participation and collaboration in e-textiles, similar to the way First LEGO League competitions have increased participation in robotics, but without the emphasis on competition that is off-putting to significant groups of people. Scalable across regions while adaptable to local needs, eCrafting Circles are intended to provide a forum that allows like-minded and interested participants to share learned insights and provide much needed support for their designs. While much of computational participation has focused on the online world, there is equal benefit to be found in physical construction and local participation. This at least suggests that we might want to revisit what computer labs and classes could look like when crafting and computing provide new materials, activities, and audiences for learning.

In closing, a re-examination of the GoldiBlox commercial leads us to decidedly mixed conclusions. While the commercial (and the product) is to be praised for highlighting the critical role that early introductory toys and tools play in framing children's interests, the two minute advertisement also reinforces the "let us in!" mentality so characteristic of girls trying to gain entry into so-called "men's" activities. There is no question that an engineer's safety glasses, hard hat and tool belt need to become part of girls' play portfolio in addition to the pink dresses, shoes, and handbags needed to accessorize Barbie dolls. But there is also the danger of falling into the same trap as the Game Design Movement, assuming that the engineer's world, as it currently exists, is what girls need to aspire to in order to become interested in engineering and computing. On the contrary, as the popularity of electronic textile kits illustrate, there is no need to step right into a man's world to become interested and engaged in computing and engineering. Instead, we found there are many possibilities to leverage the very same activities that always have been part of girls' play and women's communities in the service of designing and expanding participation to address the vexing issues of gender and IT.

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