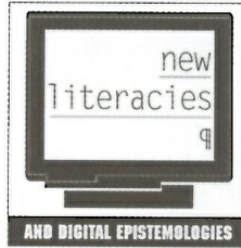# TEXTILE MESSAGES

Dispatches From the World of E-Textiles and Education

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Chapter 11

LilyPad in the Wild: Technology DIY, E-Textiles, and Gender

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Textiles and Electronics DIY

The last decade has seen a resurgence in vibrant Do-It-Yourself (DIY) communities in a range of disciplines including textiles and electronics. Groups of hobbyists, artisans, educators, and youth of all ages are building artifacts and congregating in both physical and virtual spaces to share projects, designs, and techniques (Kuznetsov and Paulos 2010; Levine and Heimerl 2008; Frauenfelder 2010). In the textile realm, a handful of websites stand out as emblems of these crafts' re-popularization. Ravelry, a site that enables people to share knitting patterns and projects, is visited by over 700,000 unique individuals each month.[1] Burda Style, a similar site that allows people to share and remix sewing patterns is accessed by around 350,000. In a slightly different vein, DIY fashion sites are enabling novices to act as models, magazine editors, and stylists. For example, Lookbook.nu, a site where users share photos of themselves dressed in their favorite outfits, draws over 800,000 visitors a month. Women make up the majority of participants in each of these communities; Quantcast estimates that 73% of Ravelry's visitors, 77% of Burda Style's and 68% of Lookbook.nu's are women.

Technology DIY communities meanwhile are flourishing in different spaces and attracting different participants. Electronics makers congregate in forums hosted by electronics retailers like Adafruit and SparkFun and tool-makers like Arduino. Traffic estimates for these sites are not available, however Adafruit's forum has over 41,000

members, SparkFun's over 25,000 and Arduino's over 68,000. Electronics builders also vie for recognition for their projects on popular blogs like Hack-a-day, with over 700,000 unique visitors per month, Gizmodo, with approximately 5.8 million visitors, and MAKE, with over 100,000. It should come as little surprise that these communities are predominantly male; according to Quantcast, 83% of Hack-a-day's visitors, 70% of Gizmodo's and 63% of MAKE's are men.

While these are just a small sampling of online gathering spaces, they generally demonstrate that the electronics and textile DIY communities employ very different toolsets and consist of very different people. In particular, their gender compositions are starkly contrasting; textile crafts are dominated by women and electronics by men.

The LilyPad Arduino kit that we introduced in Chapter 1 and was employed in most of the educational initiatives discussed in the last section, is positioned at the intersection of these two fields. One of our central motivations in designing the kit was juxtaposing and blending textile and electronics cultures and disrupting traditional gender patterns within them. We were also interested in creating a tool that would engage more women in electronics and computing—fields in which they have historically been underrepresented. When the LilyPad was commercially released in 2007 and people in the real world began to use it, we were given the opportunity to investigate if and how these cultural shifts were taking place. The remainder of this chapter presents three different studies that document disruptions in gender perceptions and practices that have arisen from the kit's adoption.

Arduino

To contextualize our studies of the LilyPad Arduino, we compared its users with those of a more traditional electronics toolkit, the original Arduino (the platform the LilyPad is based on). In the last few years Arduino has become the tool of choice for electronics DIYers. It is an inexpensive, open source computing and electronics platform that was developed by educators and students at the Ivrea Interaction Design Institute in 2005 (Joliffe 2006; Banzi 2008; http://en.wikipedia.org/wiki/Arduino ND.) It consists of a programmable circuit board and accompanying programming software. The Arduino developers design and manufacture boards, but they also openly publish the designs for their boards, release their software and hardware under open source licenses, and make their software freely available online. No other electronics platform is as useable, affordable, and "hackable"—by which we mean easy to modify and customize.

Perhaps more compelling than Arduino's individual success is the way that it has inspired—and, by being open source, actively facilitated—a number of extensions and variations. For example, the "Boarduino" is identical to the Arduino except for the fact that it fits onto a standard breadboard, the "Arduino Mega" is similar to the Arduino but uses a faster, larger, and more powerful processer, and the "Funnel

I/O" is an Arduino with built-in wireless networking capabilities. Each of these variations can be programmed with the open source Arduino software, and draws upon and adds to a shared body of knowledge and documentation that has grown up around the tool. The LilyPad Arduino is another Arduino variant, electronically identical to the traditional Arduino, but with a shape that was optimized for e-textile construction.

LilyPad and Arduino Communities in the Wild

In 2010 we conducted two studies that compared the LilyPad and the traditional Arduino adopter communities (Buechley and Hill 2010). We defined the LilyPad and Arduino adopter communities as the people who were buying kits and building things with them. For these studies, we collected and analyzed two sets of data: (1) LilyPad and Arduino sales records from SparkFun Electronics, and (2) project documentation—in the form of photos, videos, and text—that community members produced and posted online. We used this information to document the similarities and differences between the two groups. In 2011, against the backdrop of the fields growing popularity, we initiated a small study of the responses of SparkFun Electronics' customers and other community members to e-textile blog posts.

Fig 66 LilyPad Arduino and traditional Arduino board

Study 1: Customers

Our first study investigated customers of the electronics website SparkFun Electronics, the manufacturer of the LilyPad Arduino. Spark-Fun is a young but growing supplier of electronic parts and tools to hobbyists, engineers, and students. In addition to selling merchandise the site showcases technology projects on a blog, publishes tutorials for working with electronics, and hosts a forum where people can ask and answer questions about technology projects. In short, it functions as a community gathering place as well as a retailer. The site is well known inside technology and electronics DIY circles, but (as would be expected) mostly obscure outside of these niches.

For our study, we obtained records from SparkFun for all LilyPad Arduino and traditional Arduino (Figure 66) sales between October 1, 2007 (when the LilyPad was first commercially released) and November 30, 2009—13,603 records in total. Each
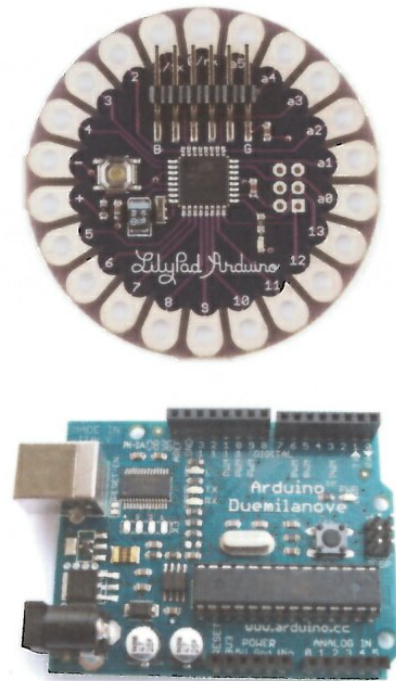
record contained the customer's first name, country of residence, a unique customer identification number, information on whether the customer was a reseller, information on the item purchased, and the date of sale. We aggregated this data by customer to obtain sales histories for 11,335 unique buyers.[2]

It is worth noting that SparkFun is the sole manufacturer and primary distributor of the LilyPad, but only a reseller of the Arduino, which is manufactured by an Italian company. Thus, while the LilyPad sales data in our sample are comprehensive, the Arduino data are not. However, our data do account for a significant amount of total Arduino sales (approximately 30%) and a large percentage of US sales. Due to Spark-Fun's size and importance, we argue that trends in its customer base are likely to be indicative of trends in the larger community.

To obtain gender information for these customers, we hand-coded each record using first names. Thus "Michaels" were identified as male and "Jennifers" as female. Because some customers were identified only as institutions and some names were gender ambiguous (i.e., Chinese names written in the English alphabet, the names "Alex" and "Chris," etc.) we were only able to classify 87% of customers by gender.

Both customer groups had similar geographic demographics—over 90% of people in both were from North America or Europe—but they had very different gender profiles. Figure 67 shows the results of our analysis of customers by gender. The percentage of the 11,335 customers who purchased each board is shown on the x-axis—88% purchased Arduinos, 9% purchased LilyPads and 3% p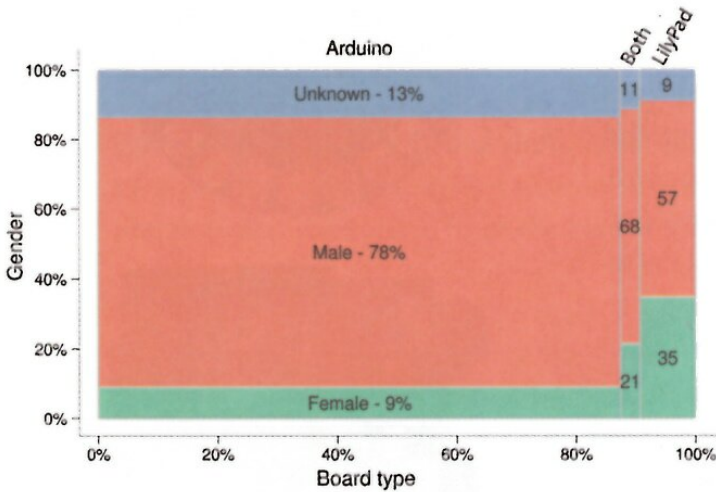urchased both. Gender is coded by color. Of the people who purchased Arduinos, 78% were male and 9% were female. In contrast, 57% of LilyPad customers were male and 35% were female. The gender balance of the group who purchased both boards was somewhere in between: 68% male and 21% female. These differences were highly statistically significant ($\chi2(4, N = 11,335) = 644$, $p<0.001$).

Fig 67 Mosaic plot of LilyPad/Arduino customers by gender and board type (N = 11,335)

LilyPad boards were approximately three times more likely to be purchased by women than Arduino boards. Keep in mind that the context for these data is an electronics hobbyist website—a space that is already male dominated. (Quantcast esti-

mates that 72% of visitors to the site are male.) Imagine what records might look like if the two kits were sold in a venue like a toy store, a museum gift shop, or an art supply store—contexts where we would expect many more women to spontaneously encounter a product.

Study 2: Builders

Many LilyPad and Arduino users employ the internet to document and showcase their work. They publish videos and photos of their projects, along with reflections on their construction processes, on personal webpages, blogs, and media-sharing sites. These postings provide a window onto the practices and demographics of a highly engaged subset of customers. Our second study focused on understanding these builder-documenters.

To obtain a sample from the pool of online postings, we employed a group of anonymous workers through Amazon's Mechanical Turk (Kittur, Chi, and Suh 2008) to find LilyPad and Arduino projects that were documented online. Mechanical "Turkers" were blind to the goals of this study and knew no details about the research. We posted eight "HITs" (Human Intelligence Tasks) on Mechanical Turk, asking people to find projects documented on Flickr, YouTube, Vimeo, and other sites. Each HIT asked people to supply the URL of the project and the creator's gender, age, and country of residence. (More information about our methodology can be found in Buechley and Hill ([2010]). Our HITs collected 175 LilyPad submissions and 202 Arduino submissions over seven days.

The data submitted by Turkers was double-checked and, in a number of cases, corrected after being examined by our research team. In particular, we eliminated inappropriate submissions (i.e., submissions of irrelevant websites) and duplicates, eliminated our own projects, and corrected errors. These included erroneous submission of gender, age, or country information when such information was not readily avail-
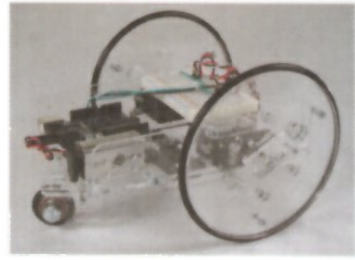

Fig 68 Projects made with LilyPad (top two images) and Arduino (bottom two)

able from the creator's profile or website and misidentification of age or gender when such information was available. After making these adjustments we were left with 114 unique Arduino projects and 57 unique LilyPad projects, 88% of whose creators we were able to classify by gender.

Figure 68 shows some of these projects. Some of the LilyPad projects we collected are also showcased as vignettes in this volume, including the LilyPad Embroidery project by Becky Stern and the crocheted robot by Osamu Iwasaki. The different affordances of the tools are immediately apparent in the two sets of projects. Most of the LilyPad projects are textiles, many of them are wearable, and several have a design or artistic focus. They include dance costumes that record dancers' movements, interactive textile wall-hangings, and light-up cycling gear. The Arduino projects meanwhile look and feel like more traditional electronics: robots, specialized audio equipment, alarm systems, and modified consumer electronics.

The project images also begin to hint at the ways in which the two communities are different, but let's first examine their similarities. Over 75% of all documenter-builders were from North America or Europe.[3] We were able to obtain (self-published) age information for 40% of them, and within this subset, the median age for Arduino builder-documenters was 27 (mean 30) and the median for LilyPad builder-documenters was 25 (mean 26). However, mirroring what we saw with the customers, the two communities had very different gender profiles.

Figure 69 shows the results of our gender analysis. 86% of the Arduino projects we collected were done by males. Only 2% of the Arduino projects were built by females. In contrast, 65% of LilyPad projects were constructed by females and 25% by males. These differences were highly statistically significant ($\chi 2(2, N = 171) = 88$, p<0.001).

Fig 69 LilyPad and Arduino projects by gender (Arduino N = 114, LilyPad N = 57)

To give these numbers additional context, we remind the reader of some of the statistics we cited in Chapter 1. Women make up small minorities of students in Electrical Engineering, Computer Science, and Computer Engineering departments
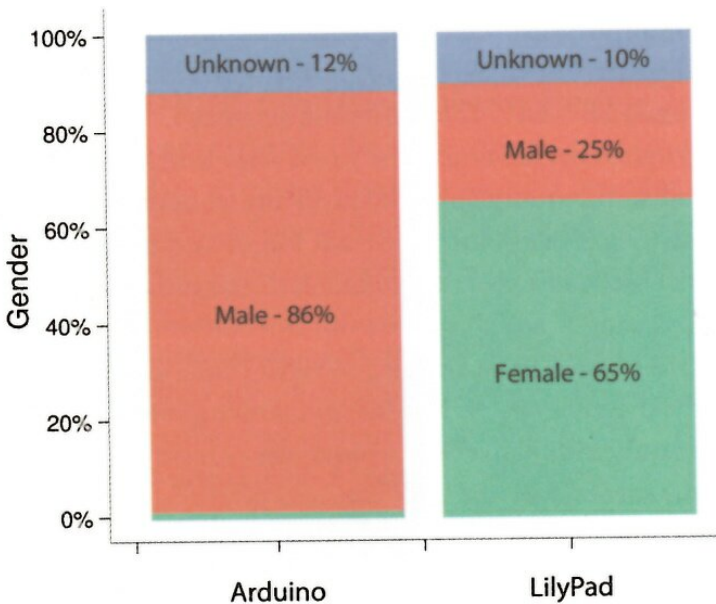
(generally 10%–20%) (American Society for Engineering Education 2010; Gurer and Camp 2002) and even smaller minorities in technical hobbyist communities (often <10%) (Feller et al. 2007). Given how persistent and seemingly intractable the gender imbalances have been in technology communities, we believe the LilyPad example illuminates a powerful strategy for diversifying these fields: integrate technology into activities and contexts that different kinds of people are intrinsically motivated to participate in.

It is interesting that the percentage of female builder-documenters is different from the percentage of female purchasers for both LilyPad (65% versus 35%) and Arduino (2% versus 9%). Women customers seem to be overrepresented in the LilyPad builder community and underrepresented in the Arduino community. What are we to make of this? One possible explanation is that women and men are constructing projects in proportion to their purchases but documenting them differently. That is, women are less likely to document their Arduino projects, and men are less likely to document their LilyPad projects (and vice versa). Alternatively, it may be that people are purchasing tools that they never use; men purchase LilyPads that collect dust and women do the same with Arduinos. Whatever the reason, we believe that the builder-documenter percentages tell us more about the communities that are forming around the tools than the customer data.

Builder-documenters have taken the time to create and document a project and then post it online. People post projects for different reasons, all of them social: to ask for assistance (documenting and communicating problems they are having); to share construction tips and techniques with other practitioners; and, most often, to proudly exhibit their work. Through these actions they are inviting people to "geek out" around a shared interest (Ito et al. 2009); they are creating and strengthening communities. Builder-documenters are, by an large, deeply invested individuals who are willing to associate their projects with their personal identities. People like this form the core of all creative subcultures.

Our results seem to show that the LilyPad builder community has a female majority, and, conversely, that the Arduino builder community is overwhelmingly male dominated. This paints a portrait of the LilyPad community as one that confounds gender stereotypes and typical demographic patterns in electronics and computing.

There is a long history of systems and curricula designed to attract women to computing. See Rich, Perry, and Guzdial (2004) and Kelleher, Pausch, and Kiesler (2007) for wonderful projects in this arena, but to our knowledge in no instance have researchers documented an autonomous computing community that is dominated by women. Our data seem to indicate that this may be the case for the burgeoning LilyPad community. Women make up a significant percentage of the people who purchase LilyPad kits and seem to make up a majority of the people who construct and document LilyPad projects.

Study 3: Comments on E-Textile Posts

We were encouraged by the results of the 2010 study. It seemed to confirm that a new tool like the LilyPad could engage formerly underrepresented groups in technology construction. Yet as e-textiles became more popular and visible in electronics communities, we began to notice complex and sometimes negative dialogues about gender, technology, and identity taking place in online forums. Here, for example are comments that were posted on SparkFun blog entries that highlighted e-textiles.

> Well, maybe I'm just a dinosaur or something, but I just don't "get" the whole eTextile thing. I've been involved with electronics for a lot of years and this application is among the more (most?) lame that I can recall, IMHO![4]

> Are we really making the 'I don't like it so it's obviously worthless' argument again?...Clothes or robots, enjoy electronics in whatever manner you like.[5]

> I hate e-fashion. It's not electronics. It's crafting and has no place in the electronics hobby. I have been waiting a long time to say that, but this post has set me off like a rocket....It's all too easy and takes away from the real electronics hobby.[6]

To begin to make sense of these conversations, we initiated a small and very preliminary study to analyze the community's response to different topics. Since SparkFun serves as a community gathering place as well as a retail outlet, we elected to survey a collection of SparkFun blog entries and their accompanying comments to try to determine if user comments posted on e-textile entries differed in tone from comments posted on other pages. We used web-scraping techniques to collect 300 blog entries and over 11,000 comments posted from November 2011 through November 2012. We then used sentiment analysis techniques to rate the positive or negative affect of each comment to get a very basic measure of how the community was responding to different topics. We found that the prevailing sentiment of most comments was positive, but that e-textile-related posts received slightly more negative comments than other posts. This trend was replicated when we compared posts associated with LilyPad to those associated with Arduino. Comments on posts related to LilyPad were 35% negative compared to 29% for comments on Arduino-related posts.

Overall, the sentiment analysis indicates that the SparkFun community is supportive of and positive towards DIY electronics of all varieties. It is reasonable to assume this positive response contributes to a welcoming environment for newcomers, including e-textile builders. Although the sentiment evaluation indicates slightly higher levels of negativity for content regarding e-textiles, the difference

is not extreme enough to conclude that there is general negative sentiment against the medium.

These results also indicate that sentiment analysis is too blunt a technique to accurately characterize the community's response. The model is effective at identifying very negative comments, but it does not identify more complex feelings or trends. For example, comments like the following yield insights into how different people within the community think about and relate to e-textiles that are not captured by sentiment analysis:

> I'm not huge on the E-Textiles idea, but my girlfriend loves it, it has given us something to work on together since I know next to nothing of sewing and she knows nothing of electronics....[7]

> It's just you being a man and do not care about clothing at all... It's not just eTextile, but anything for the 'girl's world' will be a bit nonsense for us...but there are people who like it, so if that's what they like about electronics... it's just fine[8]

It is clear that e-textiles are sparking passionate and nuanced debates about community, identity, and gender in electronics DIY forums. It is also clear that we need to employ more sophisticated and qualitative ways to explore these conversations to identify meaningful patterns.

Future Research

The studies we have just described are, we hope, illuminating, but they raise as many questions as they answer. We are especially interested in understanding how and why novices decide to attempt a new potentially challenging activity and how existing communities respond and change when new members join.

To assess the first question, we plan to undertake a follow-up study similar to the 2010 investigation to explore how and why LilyPad adopters came to use the toolkit. We would like to understand more about: their previous experience with both textile crafts and electronics, their local situation, and their peer network. We are especially interested in knowing how many new LilyPad adopters are electronics novices. In other words, is the e-textile field (and the LilyPad kit) truly engaging a new group of people and giving rise to a new community of electronics designers? To the extent that this is the case, what can we do to grow the community?

To explore the second set of questions, we plan to continue our collection and investigation of online discussions. We also plan to interview LilyPad adopters to learn more about their experiences in interacting with and joining existing textiles and electronics communities. Did they feel comfortable and encouraged or isolated and lost? What can we do to create welcoming spaces and experiences for people from different backgrounds?

Conclusion

Margolis and Fisher's groundbreaking study on gender in computer science was titled "Unlocking the Clubhouse" (Margolis and Fisher 2001; Fisher and Margolis 2002). This phrase provides a good description of the path that most projects aimed at broadening participation in engineering take. The story behind the research goes something like this: traditional engineering culture is a boys' club that is unfriendly to women, and we need to find ways to unlock this clubhouse, to make it accessible.

Our experience suggests a different approach, one we call Building New Clubhouses. Instead of trying to fit people into existing cultures, it may be more constructive to try to spark and support new cultures, to build new clubhouses. Our experiences have led us to believe that the problem is not so much that communities are prejudiced or exclusive but that they're limited in breadth—both intellectually and culturally. Some of the most revealing research in diversity has found that women and other minorities don't join communities not because they are intimidated or unqualified but rather because they're simply uninterested (Weinberger 2004).

Through the LilyPad we hope to expand traditional disciplines to make room for diverse interests and passions. To show, for example, that it is possible to build complex, innovative, technological artifacts that are colorful, soft, and beautiful. It is important to note that our studies of the LilyPad adopters also show how boundary crossing tools can encourage men to participate in traditionally female-dominated activities. We are cautiously optimistic that such participation can result in more widespread appreciation for the relevance, complexity, and importance of traditionally female-dominated pursuits.

We want to provide alternative pathways to the rich intellectual possibilities of computation, engineering, craft and design. We believe that the work in this book demonstrates that disciplines can grow both technically and culturally when we re-envision and re-contextualize them. When we build new clubhouses, new, surprising, and valuable things happen.

Endnotes

1. All website traffic and demographics cited are from Quantcast (http://www.quantcast.com) and refer to the most recent data, as of March 2012.
2. 82 of these customers ($< 1\%$) were resellers of the products they purchased.
3. Over 90% of customers from both groups were from the same regions. The discrepancy between customer and builder populations is likely due to the fact that our SparkFun customer data do not include information on many sales made in non-US markets. For example, a Japanese distributor who purchased 500 LilyPads from SparkFun is counted as a single customer in our customer database, but the boards he purchased may be resold and then employed in several Japanese LilyPad projects.

4. From webpage: http://www.sparkfun.com/news/567
5. From webpage: http://www.sparkfun.com/news/608
6. From webpage: http://www.sparkfun.com/news/471
7. From webpage: http://www.sparkfun.com/news/608
8. From webpage: http://www.sparkfun.com/news/567