Soft Circuits for Livelihood and Education in India

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ABSTRACT
A workshop on the design of soft circuits in the contexts of undergraduate engineering education and empowerment of rural, economically disadvantaged women in India was conducted at Amrita University in Kerala, India. We report that the soft-circuit workshop complemented existing undergraduate engineering education with increased expressivity, initiative, improvisational engineering skills, and integration of hardware and software skills. The workshop participants also explored the viability of the soft-circuit experience as a source of livelihood and technical education for rural women, and developed a Livelihood-Education plan that will be piloted with rural women who are in vocational training, over 60% of whom have dropped out of formal schooling before completing 9th grade. We highlight aspects of our workshop and the resulting economic and educational empowerment plan that are particular to cultural contexts of women in India, to vocational training of underserved populations in India, and to undergraduate engineering education in India.

Categories and Subject Descriptors
K.3.0 [Computers and Education]: General; H.5.2 [Information Interfaces and Presentation]: User Interfaces;

General Terms
Design, Experimentation, Human Factors.

Keywords
Soft circuits, education, vocational training, e-textiles, hands-on engineering, paper craft, creativity, informal learning

1. INTRODUCTION

1.1 Context: Vocational Education and Empowerment of Women through Computer-Based learning

Economic development efforts in developing nations can be better addressed by increased participation of women in education and employment. Women who are educated and are employed also raise healthier, better-educated children. Ammachi Labs' SAVE[1] and WE[2] projects for computer-based vocational training have provided education and potential for livelihood to over 2500 women in rural and tribal India through vocational courses [1]. Sixty two percent of the women who have benefitted from the training have dropped out of formal education before tenth grade; none of them have gone to post-secondary education.

Fig. 1. Soft-circuit workshop participant discusses electronics and marketing with recent graduates of vocational fabric painting course

The women use computer-based multimodal interfaces, including haptic interfaces, during their training [2]. In addition to the content of the vocational programs themselves, this empowers them in increased social status due to their familiarity with computer technology, as documented in the experience of women trained in certified plumbing repair, and in training for construction trades [3].

In rural India, arts and crafts play an important part in people's lives [4][5]. Ammachi Labs' computerized vocational education and training includes craft production such as fabric painting, ornamental jewelry making, soap making and flower arrangement as well as technical courses such as plumbing, motorcycle repair, and carpentry [6]. Cultivating technical knowledge empowers women to work in all these vocational areas.

1.2 Soft Circuits Workshop

A soft circuit design workshop at Ammachi Labs was initially conceived as an opportunity for recent engineering graduates to

FabLearn 2013, October 27-28, 2013, Stanford, California, United States.

[1] Sakshat Amrita Vocational Education is an Amrita University initiative.
[2] The Women Empowerment is a project of Amrita University supported by grants from the United Nations Democracy Fund.

learn skills in constructing simple circuits and Arduino controllers on textiles, to reflect on their own learning, to demonstrate e-textile embellishment in the context of Indian traditional clothing, and to report on the feasibility and applicability of craft-based electronics projects in vocational training.

Four recent graduates from undergraduate EE and CS programs participated for three weeks. The plan presented to them was to design increasingly complex circuits on textiles using conductive thread, electronic components, and Arduino control programming, with a final project to wire a decorative sari with lights and possibly movement sensors.

We provided textiles, conductive threads, a limited selection of conductive paints and foils, conventional electronic components, and some LilyPad components [7]. Participants used Arduino and LilyPad Arduino controllers for some of the projects.

We depended on information and techniques for textiles and paper soft-circuits from websites and publications from the soft circuit and maker communities, particularly Jie Qi's paper craft and workshop experience [8][9], Hannah Perner-Wilson's e-textiles experience and soft-circuit resources [10][11][12], Kobakant collective's projects and resources [13[14], Leah Buechley's work [15][16], and MIT's High-Low Tech Group [17].

The goals of the workshop were:

• To explore whether soft-circuit engineering could complement the training of recent undergraduate engineers and add to their skills, design inspiration, and enhance their abilities to contribute to research projects as research staff members.

• To explore whether soft-circuit, crafts-based projects could become a component of vocational training for rural, economically disadvantaged women in India.

1.3 Why Soft-Circuits?

Craft-based techniques for building electronics exist at a nexus of influences which make soft-circuits an appropriate experiment within this laboratory in India.

1.3.1 Learning

Soft-circuit technology research has grown within the intersection of the maker movement and constructionist learning [18]. It combines project-based learning with aesthetic expression by participants. By analogy to Papert's philosophy of bringing big ideas from mathematics and computing to beginning learners through "doing mathematics" rather than "learning mathematics" [19], it is an environment in which one "does engineering" using familiar, everyday objects rather than "learning engineering" with arcane materials and limited-scope problems to solve.

1.3.2 Craft and Decorative Traditions

Textiles, fashion, and papercraft are appealing areas in which to provide learning environments, especially for women, because crafts in general and sewing in particular are associated with women's expertise in many cultures. Many craft traditions involve flexible materials, and often decorative and functional concerns have equal status in the design of artifacts; adding electronics leads to rich challenges and opportunities.

1.4 Livelihood-Education Plan launched for Rural Women and Undergraduates

The results of the workshop were:

• Participants had increased expressivity, initiative, improvisational engineering skills, and integration of hardware and software skills.

• Participants extensively interacted with rural women through a demo, and were able to survey the women's responses as well as have informal discussions with them.

The program was immediately expanded to offer soft-circuit experience to undergraduates.

On the basis of the experiences of the workshop participants and the feedback from rural women, within six months the laboratory developed, and is piloting, a Livelihood-Education plan integrating soft-circuit engineering and electronic crafts-based products directly into its ongoing, proven vocational course model for rural women.

Soft-circuit training will be added to an existing vocational course (jewelry-making). Women in this course will make soft-circuit products for sale through local markets, and also make soft-circuit educational workshop kits that they sell to the university to enable undergraduate workshops. The plan creates a cycle of creative project ideas for the rural women and the undergraduates.

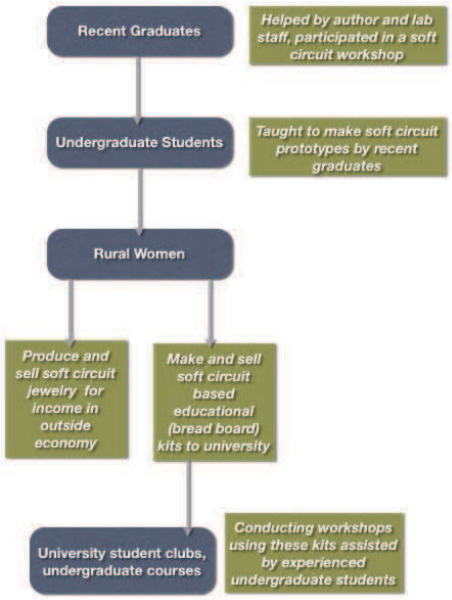

Fig. 2. Flow of empowerment, income, and ideas: Undergraduate Education tied to Rural Women Empowerment

2. CASE STUDY OF PARTICIPANT EXPERIENCE

2.1 Workshop Participants' Initiatives

Within the first two days, participants took initiative to create lighted interactive cards and lighted jewelry in addition to the assigned textile projects. This spontaneous contribution highlights the resonance that craft-based engineering has with promotion of individual initiative and expression [Jie Qi: personal communication]. The participants were able to shift the direction of the workshop by initiating those projects themselves. They made the case that the scale of jewelry and paper, and the potential for creating many different projects in a short time, was more culturally relevant than creating a single elaborate textile worn by only one person at a time.

One of the more elaborate projects was a lighted card (see Figure 3). The participants created and drew a cartoon character; the team members shared duties in designing the layout of the soft-

Fig. 3. Participants making greeting card containing LEDs during the soft circuits workshop

circuit connections, debugging the many electronics, materials and connectivity issues that arose. They iterated through many designs for a switch that would allow the card to light when opened.

While creating this project, the participants pioneered an informal connection between the engineering and the creative/media divisions of the laboratory at a grassroots level: they took initiative to go to the creative/media department (in another area of the building) and ask for materials and help for the card illustration. Although Ammachi Labs integrates the two divisions formally in its vocational-education platform, it was previously unusual for junior staff members to seek informal collaboration and sharing of resources across divisions.

The participants' responses to the proposition that soft-circuit, craft-based engineering would be particularly appealing to women in India were subtle, unexpected, and in contrast with experiences in the USA. Participants were surprised to hear that young women in the USA "drop out" of STEM. They proposed that young university-bound women in India's Kerala state aspire to stay in STEM (especially engineering) and that most universities were gender-balanced in engineering programs. On the other hand, they asserted that women are preferentially and almost universally well-trained in India at a young age in sewing, crafts and drawing, which made the soft-circuits work resonant and engaging for women even at university level. That they could combine craft skills with formal education, particularly engineering education, was unexpected and was a source of creative satisfaction.

Although we changed the workshop focus primarily to paper craft and jewelry areas, we maintained breadth in textiles. India has a rich heritage of textile arts and crafts. Glitter, mirror works, and silver and gold thread on embroidered and woven fabrics are highly developed [20]. We tested the conductivity of metallic threads in fragments of saris and found that many are conductive enough for lighting and sensing circuits. Further work is planned investigating whether longer runs of thread and pads formed by floral designs will allow satisfying incorporation of lighting and other circuits into traditional patterns. We are inspired by related work on incorporating conducting and sensing threads in custom woven [21] and knit [22] fabrics with a combination of aesthetic and electronic purposes.

2.2 Demonstration for Rural Women and Survey of Rural Women

An opportunity to demonstrate the workshop projects to a large group of rural women already participating in vocational education programs capped the workshop experience (Figure 4) (Figure 1). The participants demonstrated their projects to eighteen groups of women, from all areas of Kerala, trained by the SAVE program in fabric painting and in certified plumbing repair. These groups were surveyed with a structured set of questions about their potential personal interest in learning soft circuit technology and crafts, and their economic thoughts about the viability of such crafts as a livelihood enhancement. The venue also provided demo time to groups of the general public.

Preparations for the demo included constructing survey questions in both Malayalam and English, informal commissioning of concept art for wedding jewelry from the creative/media division, practice of setup and repairs of projects, venue preview and lighting adjustment, and preparing a kit of replacement parts and repair tools in order to successfully conduct presentation and data-gathering. The participants gained new engineering and communication skills to prepare an off-site demonstration capable of handling hundreds of visitors during a day.

Fig. 4. Demonstration station. English name translations: for jewelry earring "Beauty", for card "Blissful Light"

The response of rural women to the demonstration and survey was positive and engaged, they asked questions about potential economic viability and expressed desire to learn electronics and how to make the crafts.

2.3 Expansion to Livelihood-Education Plan

During the six months after the workshop and demonstration, participants have continued to teach undergraduate interns at the lab. The participant team and undergraduates have built projects of increasing artistic, hardware, and software complexity including sensor bracelets and beaded lighted necklaces (see Figure 5). One undergraduate created an innovative conductive-thread variable potentiometer inspired by the soft circuit button switch [12] and felt confident to enter it in an Instructables contest [23].

Reflecting on the educational advantages of soft-circuit projects to undergraduate engineering students, as well as goals for rural women (additional sources of livelihood, social status through collaboration with a university education project), the Education-Livelihood Plan was developed (see Figure 4). To implement it, the team is constructing soft-circuit kits on a breadboard philosophy based on work by Leah Buechley [24].

Using these kit materials, the pilot project will run in the jewelry-making vocational training course for rural women. Women will be trained to make both jewelry products and soft-circuit kits. The lighting-embellished jewelry will be sold by the makers locally, and their soft-circuit educational kits will be sold to the university for a planned series of workshops, run by undergraduates, for undergraduate clubs and courses.

Fig. 5 Samples of various soft circuit based products created by participants at Amrita University.

The team trained through our workshop and its extension to undergraduates will encourage the newly involved undergraduates innovate, modify the kits, and give feedback, possibly creating new kit ideas.

ACKNOWLEDGEMENTS

We benefitted substantially from ongoing work by Gayatri S., (CS undergraduate, Amrita U.), discussions with Jie Qi (MIT Media Lab), Ken Salisbury (Stanford U.) and Allison Druin (U. of Maryland), sari material from the Amrita Tailor Shop, enthusiastic project and demo help from Reshma, technical and sourcing help from Deepu S, Unni and Ranjit, and artwork and ideas from artists in the media/creative division of AMMACHI Labs.

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