Circuit Game

A Craft-based Electronic Building Practice

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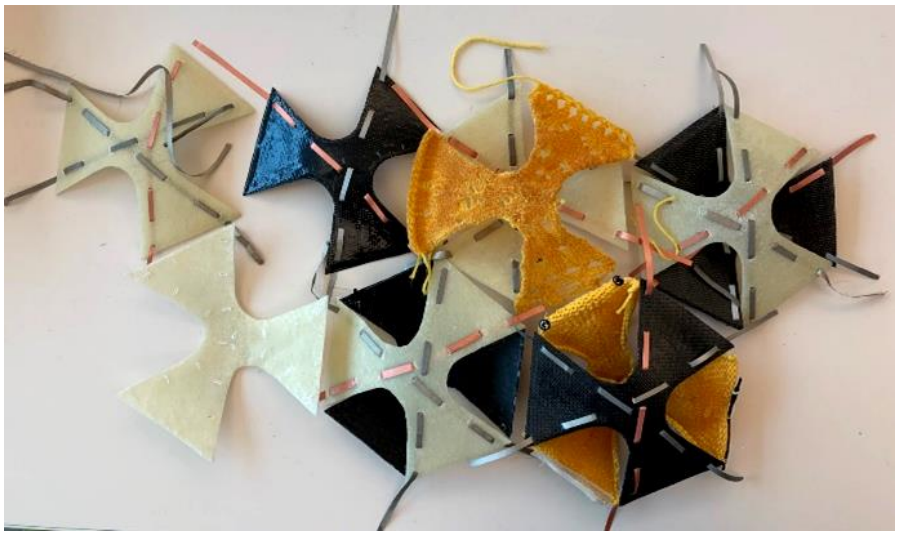

Abstract. In this research, through a project named Circuit Game, a conceptual framework has been developed by which new processes of integrating craft and technology for educating electrical concepts are explored. The framework incorporates Do It Yourself (DIY) methods through making and assembly procedures. The intention is to engage architecture students in the process of crafting a new technological artifact while understanding difficult concepts related to electronics. Buechley & Hill define HCI as the development of new interfaces for interaction between people and technology (Leah Buechley & Hill, 2010). The authors seek to discover how a composite textile interface can invite people into thinking about electronics, materials, and design processes and eventually engage them in the process of designing circuits through crafting. Base materials, DIY making, and DIY assembly processes are three interwoven components of the circuit game. The role of these elements in the learning process are investigated through the development of a circuit game.

Keywords: Game, Circuit, Composite Textiles, Craft-based Game, Interaction

1 Background Research

In the last decades, HCI has been researched from different perspectives. This part explores literature studies mostly related to the gaming, integration of electronics and craft, as well as educating through materiality.

1.1 Educating through Materiality:

Base materials that are the interest of this research include crafts, Arduino boards, and computers that enable the craft to play as the interface for interaction with a human. Based on a discussion by (Wiberg et al., 2013) a material perspective offers very different implications of HCI practice and a new way of seeing. In addition, a good material understanding helps to expand the boundaries of HCI. Therefore, materiality is one of the main elements of HCI and its role should be explored through the experience. This section investigates how the material has been defined in HCI research practices

Based on (Davis, 2017), Papert, Eisenberg, Buechley, Elumeze, and MacFerrin are some researchers that represent computers as material. Papert introduces computers as "an object to think with" (Papert, 1980), play and experiment with (Davis, 2017). His approach requires human participation and interaction with computers to enhance the learning process. Eisenberg goes further and looks at computing as an act of bringing things to life by making them do things (Davis, 2017).

Redstrom and Maze identify computational materials and assert that temporal form is the main difference between these materials and the conventional materials. In their research, they focus on the shift from form to experience. The temporal form that they refer to will be apparent when they are used by people to create new expressions. (Mazé & Redström, 2005). In this regard, Davis declares that to make, invent, combine, select and recycle a material indicate where a person is in relationship with the material and determine the degree of completeness, openness, and lifespan of that material (Davis, 2017).

Using forgotten histories as the material and practice of innovation for reconfiguring the present as well as creating and visualizing our relationship to the design in the future is proposed by (Rosner, 2018).

1.2 Integration of Craft and Technology- Educating through DIY Making Process:

(Leah Buechley, Eisenberg, Catchen, & Crockett, 2008) introduce three approaches toward technology and these are technology as automation, entertainment and expanding human expression. While the first two aim to ease the learning and improve the productivity and human condition, the latter focuses on whether the human can do things or express things that are beyond their capacities. One way that people can challenge themselves for their potentials is engaging in Do It Yourself activities. In general, DIY comprises modification through creative activities to make new things and it can be an important alternative for design practices (Leah Buechley, Rosner, Paulos, & Williams,

2009) which requires the active participation of people in making and assembly processes.

Craft has been incorporated in research practices as a material for educating people in electronic concepts. for example, the implementation of printed circuit boards (PCB) in crafts using techniques like sewing, carving, and painting is the focus of research by (Leah Buechley & Perner-Wilson, 2012). Integrating craft materials like sequins and buttons as part of the circuit device engages the users and makers of the device due to the familiarity with the materials (Leah Buechley & Eisenberg, 2007).

Regarding the integration of textile and electronics, in their book "Textile messages", the authors point out that e-textiles use the materials and practices that were traditionally the domain of women as pathways into engineering for the women and under-represented groups through a playfully combining of electronics with textile, crafts, clothing, and jewelry (L. Buechley, Peppler, Eisenberg, & Kafai, 2013). This act of piecing together "help establish design as a site to invite more intimate and longstanding relationship with technological things" (Rosner, 2018). Overall, the makers are designers of the devices, who will learn something new through playful making processes and integrating familiar craft-based materials and electronics.

1.3 Game Practices- Educating through DIY Assembly Process:

The other approach is educating through assembly and game strategies. Based on (Björk, 2008), there are three interwoven area in gamed-based design:

- Codes or the systems that embed the process in themselves (game)
- People who are doing the game practices (gamers)
- The type of interaction that people have with the game (gaming)

Each of the elements of the game differently affects the educating process. Papert suggests that games like LOGO, as a tool for education, should be easily accessible to get into it but should not be a toy. The game language should also be accessible but challenging enough to help users make progress in learning new things (Papert, 1980). Researchers and hobby designers are exploring the methods of embedding technology into toys for the educational purposes (Leah Buechley & Hill, 2010), (Salgado, Soares, Leão, Matos, & Carvalho, 2017). Buechley and Perner-Wilson point out that education researchers like Eisenberg and Kafai investigate the role of combining art and technology in hand-on projects to enrich the quality of learning. In their study, the methods by which technology can be augmented through developing hybrid crafts integrated with electronics is presented (Leah Buechley & Perner-Wilson, 2012). (Kafai & Vasudevan, 2015) recognizes games as models of richer and collaborative learning environments and board game design as a computational thinking activity. In their approach, combinatorial interactive games will be developed by combining physical and digital or low-high interfaces through the integration of craft boards (crafting) and digital screens (coding).

(Rosner, 2018) refers to Critical fabulations as ways of storytelling that evoke how things that we design come into being and what they do in the world. This approach is related to what (Mazé & Redström, 2005) argue about temporal forms. these forms will

emerge according to the ways that people use an open-ended design to explore more and understand better. In fact, based on different assembly strategies, there can be different ways of storytelling and developing temporal forms. Allowing users to manipulate the configuration of the pieces enables them to tell their own stories or tell the same story in a preferred way.

Related to the type of interaction that people might have (Giles & van der Linden, 2014) incorporated non-visual effects in quilt electronics as an output to the interactions, where senses go beyond the appearance of the device and give the semantic meaning to the material such as recalling childhood memories by touching the material.

2 Understanding the Critical Parts of the Circuit Game

If we consider the circuit game in the center, Material, DIY making process, and DIY assembly process are the main components of this game (Fig. 1). These game elements are distinct but have overlapped at some points and can assist the learning process in different ways. The remainder of the paper discusses these elements came together in Circuit Game to satisfy the objective of this research.

The overall structure of the game is inspired by interwoven sculptural structures designed by Erwin Hauer to weave all three components of the game.

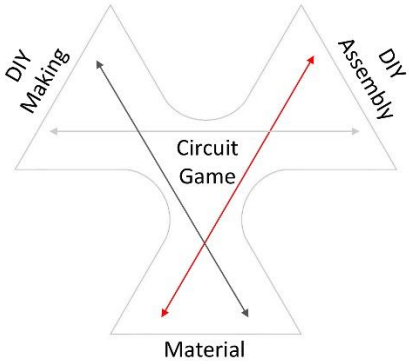

Fig. 1. Three main elements of the Circuit Game and their relationship (Material, DIY making, DIY assembly).

2.1 Base materials in circuit game:

This research was part of a practice related to the "Responsive Architectural Fiber Composites" course that required students to work with composite textiles. Therefore, composite textiles made of woven glass fiber, carbon fiber, felt and cotton knitted textiles with distinct patterns are selected to develop the game pieces (Fig. 2, Fig. 3). Flexible and shapeless textiles have been impregnated with resin to procure the fixed complex shapes. The textile-based composite material with the LED lights integrated into the pieces perform as an interface for the circuit game. The LEDs respond to the stimuli,

which is the accurate assembly of pieces, by blinking. For the sake of simplicity, the response is limited to the blinking LEDs, however, other types of responses such as playing a piece of music, change of color, vibration will make the game more interactive and interesting to play with.

Any circuit has four parts: the energy source that provides the voltage, conductor which is the wiring system of the circuit, switch for controlling and the load that is the amount of energy source used by device to complete its task[1]. Additionally, to design any electronic integrated craft the main parts are inputs (sensor), connector (wires) and outputs (actuators) (Leah Buechley & Perner-Wilson, 2012).

In general, to make the whole structure there are two approaches: seamless and aggregation method. Since it is a game-based project, therefore, it is required to have separate pieces to explore different combination strategies. In addition, the interwoven geometry of the structure does not allow it to make one continuous piece. Therefore, the aggregation method is chosen and the pieces are made accordingly.

Fig. 2. Pieces made of different types of fabrics. Black pieces are Carbon Fiber, semi-transparent pieces are Glass Fiber and the samples in the bottom are Felt.

[1] https://www.hunker.com/12003706/the-four-and-more-basic-parts-of-an-electrical-circuit

Fig. 3. Knitted samples with different patterns are knitted and the shape is fixated through impregnation with resin. The knitted patters are modified by adding holes in their structure to add conductive fibers.

2.2 Circuit Game and DIY Making Process:

The next step is making the pieces of the circuit game using the composite textile materials as the base and to bring the pieces to life as Eisenberg calls it (Davis, 2017), other materials are integrated into the pieces and these are conductive materials, LEDs, Arduino boards, and craft joinery materials. Making the main part of the electronic circuit from the craft materials, a research study revealed that most students participated enthusiastically in the projects of making functional electronic-based artifacts. In addition, the result of their study shows that different crafts can engage people with a distinct background in race, ethnicity, and socioeconomics differently (Leah Buechley & Perner-Wilson, 2012).

Conductive fibers have close characteristics to the textiles and can substitute the wires as well as connect the game pieces. Additionally, to be reliable as a connector the material should have low resistance (Leah Buechley & Perner-Wilson, 2012). Conductive fibers used here are in three different colors which means having different levels of resistance, however, the resistance of all the colors is suitable enough to flow the current. The integration of conductive fibers and the composite textiles is in the way that fibers are not connected directly in one piece to avoid the short circuits. Different joinery details are developed based on the joint location using knotting technique, sewing, metal snap buttons, and earring post pins (Fig. 4).

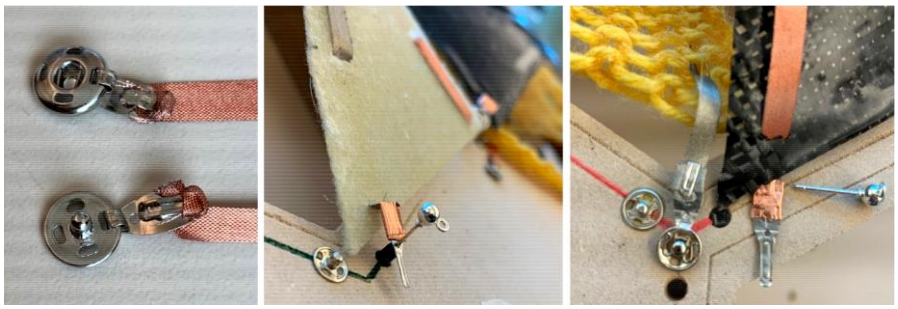

Fig. 4. Details of the joints for connecting pieces. Left: snap buttons for connecting conductive fibers to others and conductive fibers to the middle part of the board. Middle: connecting conductive fibers to the terminal points of the board using ear studs and earring post pins. Right: two types of connections on the board

LEDs are embedded inside the composite pieces and attached to the conductive fibers in a way that red fibers are always positive and dark gray fibers are negative (Fig. 5). The light gray fibers can be positive or negative based on their position and adjacency with dark gray and red fibers respectively (Fig. 6).

Fig. 5. LEDs attached to the conductive fibers

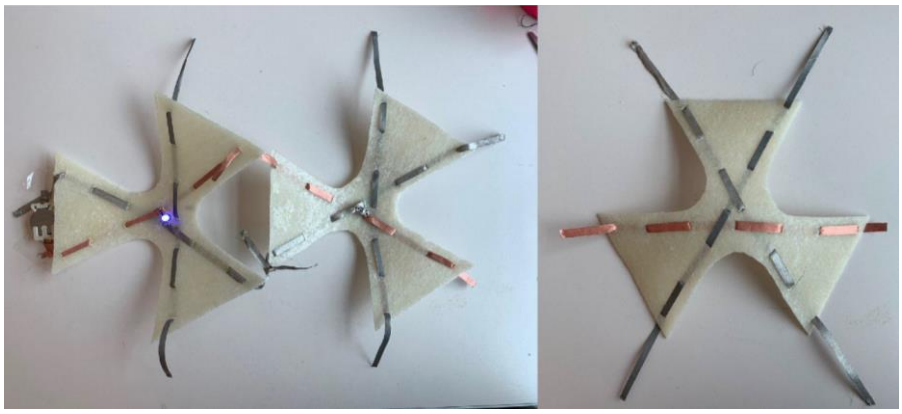

Fig. 6. The structure of conductive fibers is in a way that fibers have no connection with each other, therefore, avoiding the short circuits

2.3 Circuit Game and DIY Assembly Process:

The third step is to assemble the pieces and play the game to complete the circuit. At this step, the application of the game will be tested. Participants will receive the instruction on how to play the game to explore the design alternatives and learn more about the circuits. Through assembly techniques, multiple design alternatives will emerge and each assembly can be a different way of storytelling as Rosner asserts (Rosner, 2018).

There are two strategies for the assembly of the pieces:

1. First is having pieces attached to a board: In this approach, the wires are embedded into the solid board and connected to the Arduino board. Here, the Arduino board and the terminal points are the fixed components. Users attach the pieces together and to the terminal points to get the response. In this approach, because of using the Arduino board it is possible to add other types of responses like plying music, change of color, and kinetic response.
2. The second approach is to have pieces freely attached to other pieces: In this system, there is no need for the baseboard and the game can have any overall form at the end. Some pieces have batteries embedded in them and based on the connection that the player makes between the pieces they will receive the response. Here, the possibility of a connection between the pieces is limited compared to the first approach because the connection of pieces to receive the response is limited to the location of the batteries.

This practice followed the first approach and as it is shown in Fig. 7, a board with the hexagonal openings is selected as a base for embedding wiring and terminal points.

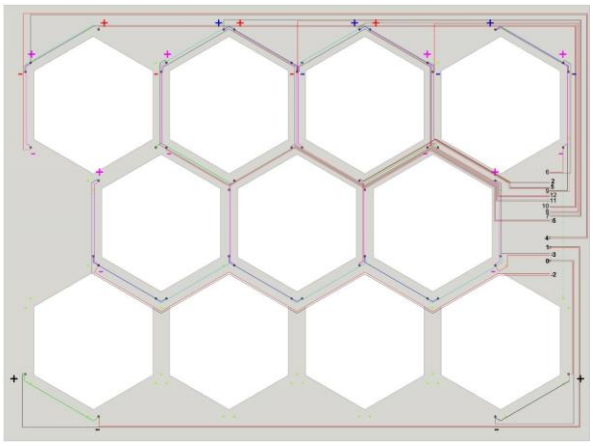

Fig. 7. Baseboard with the hexagonal openings. Terminal points are marked on the board and wiring plan is showed that connect terminal points to the Arduino board

For the game to work according to the goals of this practice, there are some principles:

- The joints for the terminal points and the pieces themselves are distinct, so different design alternatives might be developed considering the joint types.
- Even accurate attachment of one piece to the terminal points will turn the LED embedded in the piece on, however, to get more lights on, the appropriate connections between this piece and other pieces are required.
- Some rules can be defined before starting the game, for example, in this practice one rule was to have at least two pieces joined together with the same color in concave and convex sequence. Although all the conductive fibers flow the current, the other rule was try to connect pieces in a way that conductive fibers attached in sequence have the same color as red (+) and light gray (-) or light gray (+) and dark gray (-).
- Negative and positive terminal points are marked on the board and these are the fixed points.
- Players should attach more pieces with the same color in series as they complete the circuit board.

There are multiple possibilities for completing the circuit game. Fig. 8 shows the base case that authors started the game design with, however, other design alternatives will emerge as different users approach differently to the game (Fig. 9). The main point is having users to discover the circuit logic and learn it through playing the game.

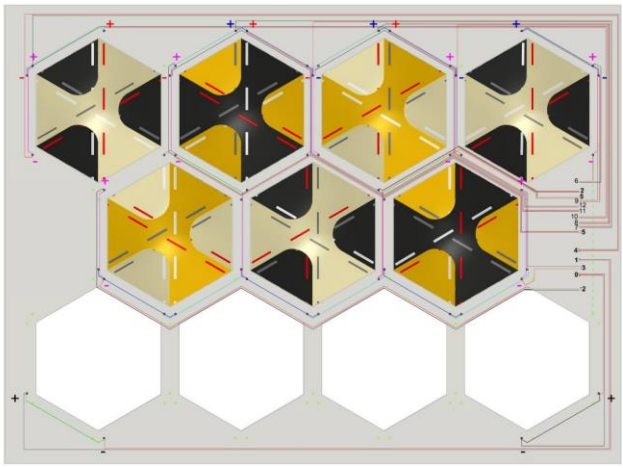

Fig. 8. The baseboard, wiring system, terminal points and the composite textile pieces connected accordingly. These are one of the many aggregation alternatives that authors started to develop the game based on, however, there are other possibilities for aggregating the pieces.

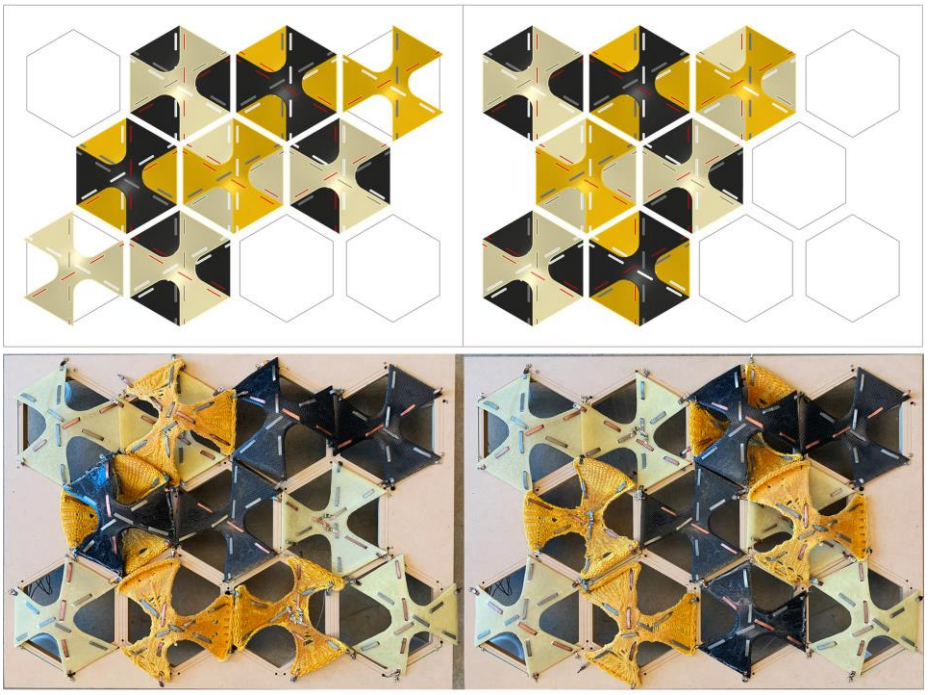

Fig. 9. Other design alternatives

3 News and Future Research Recommendations

Besides developing craft integrated electronics strategies using common toolkits like Arduino and Lilypad, other researchers emphasize on the personal fabrication of electronics instead of using available toolkits bringing novice practitioners closer to commercial electronic products (Mellis, Buechley, Resnick, & Hartmann, 2016). Therefore, the next step would be exploring the potentials of customizing the whole fabricated circuit game from scratch.

In addition, In this practice, two types of joints are designed connecting the pieces together and pieces to the board. It would have given more flexibility to the game if there was only one type of joint with the possibility of converting it to other types using a converter connector. In this way, the players could change the connection joint based on the assembly strategy they choose and explore more assembly alternatives.

It was found that carbon fiber textiles will keep their semi-conductivity even though, they are completely impregnated with resin. In this practice, these pieces were used as fillers. However, based on the type of piece that the player selects to start the game with, different levels of complexity could be defined in advance.

The concept of the game introduced here can be a self-assembled, changeable responsive interior wall or the screen for light filtration. Multiple possibilities of connecting the pieces bring more variability to the design and help to develop more temporal forms.

4 Contribution

Educating through making and assembly processes is central to this study. Based on (Cross, 1982), Peters suggested three principal criteria of education and these are first, valuable knowledge should be transmitted like the art of making, doing, and inventing (DIY Making Process). Second is related to the process of educating and students being aware of what and why they are learning (DIY Assembly process). The third is distinguishing the connection between what students learn and other things (Material selection and material application). Connecting this theory to the study presented here:

- A framework for learning electronics and communicating with DIY making and assembly processes is developed which is relied on the culture of making, sensing, and electronics.
- During the process of assembly, we learned about the circuit logic, the role of material behavior and their conductivity potentials as well as material selection by playing the game and exploring through different assembly strategies.
- Through this game children, architecture students and other groups who are not familiar with the electronic concepts will learn more about circuits through a combination of common craft materials and electronics.

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