Make, Wear, Play: Remix Designs of Wearable Controllers for Scratch Games by Middle School Youth

Veena Vasudevan
University of Pennsylvania
3700 Walnut Street
Philadelphia, PA 19104
215-746-3468
veenav@gse.upenn.edu

Yasmin Kafai
University of Pennsylvania
3700 Walnut Street
Philadelphia, PA 19104
215-746-3468
kafai@upenn.edu

Lei Yang
University of Pennsylvania
3700 Walnut Street
Philadelphia, PA 19104
215-746-3468
lei@seas.upenn.edu

ABSTRACT
Most approaches to constructionist gaming—students making their own games for learning —have focused on screen designs. Hybrid crafting approaches that integrate crafts with digital components can extend game making beyond the screen and provide new opportunities for creative expression and learning. In this paper, we report on a workshop with middle school youth (ages 11-13 years) who were using MaKey MaKey, textiles and other conductive materials to sew and glue together wearable game controllers to play their own remixed flappy bird games in Scratch. We examined students' approaches to computing and crafting their onscreen and offscreen designs using Papert's concept of syntonicity that emphasizes resonance across multiple dimensions with children's interests. Finally, we discuss in which ways constructionist gaming can benefit from extending their designs into the physical world.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education – Computer science education; K.8.0 [Computers and Education]: General – Games.

General Terms
Human factors

Keywords
Game Design, Maker Activities, Controllers, MaKey MaKey, Scratch, making, tangible designs

1. INTRODUCTION
Constructionist gaming—making rather than playing your own games for learning [8]—has become a popular approach for introducing youth into programming, system thinking and new literacies [6]. Nearly all of these constructionist game designs have focused on the screen while commercial gaming has long moved beyond the screen into the physical world [19] with new genres of controllers such as the Wii remote for Nintendo games, the drum interface for Rock Band, and the dance mat for Dance Dance Revolution, among others. More recent developments even propose to extend controller designs into costumes and wearables [16]. New construction kits for wearable and physical computing (for overviews see [4] [12]) have made such physical and wearable interface designs accessible to novice designers. These kits facilitate hybrid crafting—those approaches that integrate crafting with digital components to further learning [7] and creative expression [5] but have not extensively been used by young designers.

In this paper, we report on a workshop in which middle school youth designed and made wearable game controllers for their Scratch games to expand constructionist gaming approaches. Integrating these new modalities of interface designs into constructionist gaming not only leverages more authentic connections to commercial gaming but also extends learning opportunities as youth align computing, engineering and interaction design. In a 15-week long workshop (total of 23 hours) students remixed the popular game Flappy Birds in Scratch and made wearable game controllers using MaKey MaKey [15], textiles and other conductive materials. We examined students' approaches to computing, crafting and connecting their onscreen with offscreen designs using Papert's [13] concept of syntonicity that sees great potential in making learning resonate with children's interest. Given the challenges faced by beginning designers, we opted for providing start-up program and wearable designs. We addressed the following two research questions: (1) In which ways do young designers remix their screen and wearable designs? and (2) How do these screen and wearable designs and their remixes relate to students' interests? Finally, we discuss in which ways game making activities for learning can benefit from extending their designs into the physical world.

2. BACKGROUND
The effort to expand constructionist gaming beyond the screen is connected to larger trends to make computing more accessible by providing new materials, settings and displays [3]. The move into wearables expands constructionist gaming even further away from stationary into mobile designs when controller devices can be worn and interacted with on the body as costumes [17]. Our work builds on Millner's research [10] where youth invent and design tangible interfaces which have included projects like designing touch pads and joysticks for Scratch games [9] and game boards augmented with digital dice and displays [18] and even responsive designs [14].

IDC '15, June 21 - 25, 2015, Medford, MA, USA
 ACM 978-1-4503-3590-4/15/06…$15.00

In these hybrid crafting projects, students worked alone or in teams using the MaKey MaKey board to expand their game designs into the physical world. Such wearable designs support embodied interactions [1] and connect with what Papert [13] called the syntonic dimensions of learning because it allows learners to identify or align themselves with computational objects in multiple ways:

> "[f]or example, the Turtle circle is body syntonic in that the circle is firmly related to children's sense and knowledge about their own bodies. Or it is ego syntonic in that it is coherent with children's sense of themselves as people with intentions, goals, desires, likes and dislikes … One can also see it as cultural syntonic in that when drawing the circle, the turtle connects the idea of an angle to the idea of navigation which is closely rooted in children's extracurricular experiences." (p. 63-68).

Designing wearable controllers, interfaces and boards where young programmers can manipulate objects not only on the screen but also in the physical world provide a compelling application of syntonic learning. Making such tangible interfaces also can introduce simple and complex circuit designs in conjunction with understanding material features such as conductivity.

These designs are first steps into the world of physical computing that can introduce students to key computational concepts and practices. Such designs make visible or transparent the functioning of computing that is often hidden in commercial applications used by youth [2]. When designing wearable controllers they are writing programs to control activities and interactions on and off the screen. In particularly remixing is of interest here, a practice often used by novice designers to get started. Prior research by Monroy-Hernandez [11] revealed how different levels of screen remixes, ranging from simply copying to more creative variations, could indicate varying levels of computational competency. In this study, we are extending this work by examining youths' crafting and computing of wearable designs.

3. CONTEXT

3.1 Participants

We designed and taught the wearable game controller workshop for 12 middle school youth (7 girls, 5 boys, ages 11-13) situated in a metropolitan city in US northeastern state. Ten (5 boys, 5 girls) of the twelve students consented to participate in the research study. Students joined this workshop as part of their choice elective and met twice a week for 50 minutes over a four-month period for a total of 23 hours. In the workshop, one main instructor (a graduate student) designed and facilitated workshop activities and conducted data collection in partnership with the technology teacher at the school.

3.2 Workshop Design

We designed the workshop to include three phases: (1) remixing Flappy Bird Scratch games, (2) designing wearable controllers and (3) documenting and sharing designs. During the first phase of the workshop, youth learned the basics of Scratch by creating simple designs to get them oriented to the environment. Then, they designed their own games, by creating their own code as well as remixing others' code. In the second part of workshop, youth moved on to design wearable controllers using craft materials, conductive fabric and thread, and MaKey MaKey. Finally, youth documented their projects by recording short reflections about their inspirations for creating their games and we photographed their projects. A week after their last session, youth from the workshop set up and participated in an arcade where younger students came to play their games and give feedback.

3.3 Wearable Prototype Design

Flappy Birds is a popular game that has garnered many remixes in the Scratch community. The game's premise is to keep a bird afloat in the air while dodging a set of scrolling challenges. Traditionally the bird remains at the center of the screen and oscillates based on a user's clicking to keep the character afloat. Given that our students were novice Scratch game designers and had not designed wearable controllers before, we provided a simplified Scratch game code including the scrolling background and the gravity effect (for the bird) for students to remix. For the wearable controller, we started the workshop with an initial prototype; a fingerless glove with conductive fabric on the top (see Figure 1). In this case, to keep the bird afloat, a user would tap the conductive patch on the top of the glove. These patches were then connected to the MaKey MaKey (see figure 1 below). As the workshop evolved, we designed a new prototype that more aptly simulated the action of a bird "flapping." In this prototype when the thumb and the fingers touched, simulating the flapping, the circuit was completed, thus keeping the bird afloat. The second controller influenced several of the youths' designs.

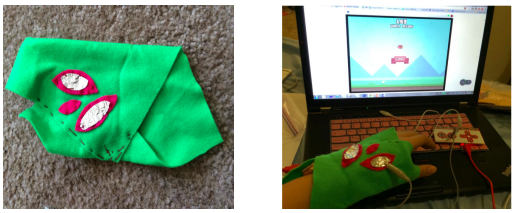

Figure 1. Initial fingerless glove prototype shared with students (left) and glove hooked up to MaKey MaKey and Scratch game (right).

3.4 Data Collection and Analysis

We documented in field notes and video recordings youths' game design processes, prototyping, and interactions over time. In addition we collected each student's final wearable controller and their final Scratch code. We conducted a descriptive analysis of youths' games and controller designs. We invoked Monroy-Hernandez's [11] categorization and distinguishing between of simple and creative designs to capture students' changes in computational code and graphics. We defined simple remixes as copies with surface modifications whereas creative remixes depart in theme and structure from the original. We used this simplified framework as a lens to think about how youth approached their Scratch game designs. In addition, we used Papert's notions of cultural and body syntonicity as another lens onto youth's wearable controller designs [13].

4. FINDINGS

While all ten youth started with the same Flappy Bird program code in Scratch and controller design, their remixes took them into different directions ranging from simple tweaks to creative redesigns. We saw that personal interests played an important role in the overall design: each game was informed by youth's everyday experiences and affinities related to their digital media experiences. In fact, in each of the five games designed by girls, the theme or main character (sprite) was from popular music or games: *Floaty Cat* inspired by the *Pusheen* cartoon series, *Minion* game inspired by the Disney movie *Despicable Me*, *Michael's*

Trip inspired by Michael, a member of the boy band *Five Seconds of Summer* and Chespin, a popular character from the Pokemon series. In terms of the boys, in four cases, *Spike That Thing*, *Chuck Wild*, *Combat Ninja* and *Color Bear Express*, they seemed to blend a combination of popular game genres with concepts like a psychedelic bear or a one-eyed monster. In the following sections, we examine more closely the remix of screen and controller designs.

4.1 Scratch Designs and Remixes

With the support of the instructors and their peers, youth remixed existing code and developed some of their own code, which was facilitated by the Scratch practice in the early part of the workshop. Seven of the youths' game designs fell into the category of creative remixes, in which youth reinterpreted the original *Flappy Birds* concept where the key character had to avoid a series of scrolling challenges. They opted to transform the original game by making the game personally relevant. To do so, youth updated the aesthetics (e.g., new characters, backgrounds) and sounds (e.g., specific song selection). Within this group, one student added a slight twist by making it possible for the main character to go back and forth using the arrow keys, giving the player more flexibility in maneuvering. Two games, *Chuck Wild* and *Spike that Thing,* altered the scrolling background game by moving their key character to the ground and having obstacles scroll along the ground instead, thus embodying the essence of the design challenge while creatively remixing the concept. One student, *Combat Ninja*, designed a completely different game that did not embrace the *Flappy Birds* theme. As youth continued to develop their code, they wanted more sophisticated functionality for simulating gravity to make their "flappy" character seem more believable, so we borrowed from games available in the Scratch community like *Simple Flappy Birds.*

4.2 Wearable Controllers and Remixes

Youth embraced the challenge of designing wearable controllers for their Flappy Bird remixes using materials like felt, electronic fabric and embellishments like feathers, and sequins. Of the ten youth, eight designed wearable controllers while two designed non-wearables (see Figure 2).

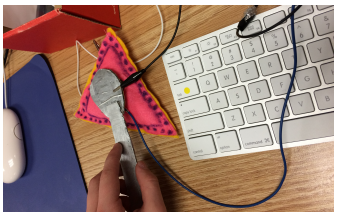

Figure 2: Non-wearable controller: spoon taps the cake, which completes the circuit.

Just as we saw in the Scratch games, youth creatively remixed the original wearable controller by changing how the controller worked and looked. Three of the controllers were what we termed 'simple' remixes and similar to the prototype—mitts that made the character move when the mitt was closed. Each of these controllers for the Flappy Nemo, Michael's Trip, and Chespin games required a user to close their hand, so their fingers and thumb would be touching to close the circuit and keep their characters afloat. When playing, the youth ended up turning their hand up towards the ceiling so the original flapping became more like a tapping gesture (see Figure 3).

Three other controllers for *Minions*, *Spike that Thing* and *Chuck Wild* ventured in their design beyond the prototype and incorporated new elements to close the circuit, one that was wearable and one that was not. For instance, in *Minions*, Ashley designed a wearable mitt, but in order for the circuit to close, the mitt has to touch a small felt banana (simulating the minion eating a banana because they famously love them). In *Spike Jump*, John's controller is comprised of a wearable felt finger rings and an earth connection that a player can hold to help spike jump when the circuit is closed (see Figure 4). Finally, there was a controller, for the game *Chuck Wild*, in which the wearable component goes around a player's foot and when it is tapped against a second component, which is located on the ground below, the circuit is closed and the sprite is able to jump.

Figure 3: **Sara pinching her mitt closed to control screen.**

Figure 4: John's controller including wearable component (left hand) and non-wearable component (right hand).

Two wearable controllers had orientations that did not fit either of these two categories (see Figure 5). The controller for *Color Bear Express* was a wearable headband where the user taps the arrow keys by tapping different patches on their head. When the game is played it looks like someone is tapping their head gently. In contrast, the controller designed for *Combat Ninja* has sleeves for each finger that connected to the arrow keys. Each time a player touched one of their fingers to the associated color-coded felt piece, the character moved right, down, up and left. The hand movement was similar to how one might play the piano.

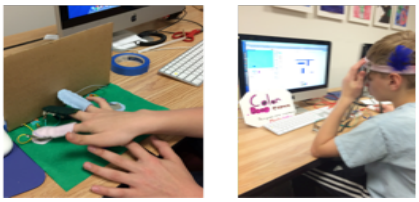

Figure 5: Creative remixes of controller designs: piano-like controller (left), and wearable headband (right).

Finally, there were two controllers that were not wearable. The first, for the game *Flappy Pusheen Cat*, involves two elements, a cardboard spoon and a piece of cake designed from felt. To keep the Pusheen character afloat, the player has to tap the spoon onto the cake. In a second, *Flappy Bat*, the student created two felt patches, that had both be touched to close the circuit and keep the bat afloat.

5. DISCUSSION

In this paper we investigated the potential of expanding constructionist gaming beyond the screen using computational and physical construction kits. Like in many previous constructionist gaming projects, we saw a great deal of personal and creative expression that the novice designers brought to bear in their screen and wearable game designs. We focused on remixing because it offered novice designers a launch pad to develop workable games and controllers within the time constraints of school. The large majority of students went beyond surface changes in remixing code and designs thus supporting it as a valid approach for beginning programmers. This distinction between simple and creative remixes, building on Monroy-Hernandez's [11] categorization of remixes in Scratch community, provides a basic indicator on how we can leverage this practice for assessment purposes though it is also clear that more work is needed to flesh out criteria that capture the multiple dimensions of students' on- and off-screen designs.

The design of wearable controllers also allowed us to re-examine the concept of body syntonicity that Papert [13] introduced with turtle geometry to illustrate how movement of objects on the screen could resonate, or be "syntonic", with students' own movements in the physical world, and vice versa. The design of wearable controllers brings back the body into design and computation. The students' controller designs embraced different kinds of physical movements: the flapping or tapping that was possible with the wearable prototypes we shared, the coordination between two components such that the wearable component needed to touch a non-wearable component to close the circuit, and, in one case, a student designed a wearable that worked by tapping one's foot. Other wearable designs included tapping using multiple fingers and in one case, using one's finger and even the forehead to play a game. Our novice designers here not only experienced but also created syntonicity to direct the objects in games. But beyond the often referenced body or physical dimensions, Papert stressed these personal and cultural dimensions as equally important contributions of syntonicity. Constructionist gaming activities have long used personal interests and informal learning experiences as key motivators for bringing games into school. These findings provide promising indicators that dimensions of syntonic learning can expand constructionist gaming.

6. ACKNOWLEDGMENTS

The research reported in this paper was supported by a grant from the National Science Foundation to Yasmin Kafai (NSF-CDI-1027736). The views expressed are those of the authors and do not necessarily represent the views of the Foundation or the University of Pennsylvania. We would like to thank Peter Endriss for his support.

7. REFERENCES

[1] Antle, A. (2013). Research opportunities: Embodied child-computer interaction. *International Journal of Child-Computer Interaction, 1*(1), 30-34.

[2] Buechley, L. (2010). Questioning Invisibility. IEEE Computer, 43(4), 84-86.

[3] Buechley, L., and Eisenberg, M. (2008). The LilyPad Arduino: Toward Wearable Engineering for Everyone. Wearable Computing Column in IEEE Pervasive.

[4] Blikstein, P. (2013). The Gears of our childhood: constructionist toolkits, robotics, and physical computing, past and future. In *Proceedings of the 12th International International Conference on Interaction Design and Children* (pp. 173-182). New York, NY: ACM.

[5] Golstejn, C., van den Hoven, E., Frohlich, D., & Sellen, A. (2014). Hybrid crafting: towards an integrated practice of crafting with physical and digital components. *Personal and Ubiquitous Computing, 18*(4), 593-611.

[6] Hayes, E. R., & Games, I. A. (2008). Making computer games and design thinking: A review of current software and strategies. *Games and Culture, 3*(4), 309-322.

[7] Horn, M. S., Crouser, R. J., & Bers, M. U. (2012). Tangible interaction and learning: the case for a hybrid approach. *Personal and Ubiquitous Computing, 16*(4), 379-389.

[8] Kafai, Y. B. (1995). *Minds in Play: Computer Game Design as a Context for Children's Learning*. Mahwah, New Jersey: Lawrence Erlbaum.

[9] Lee, E., Kafai, Y.B. Davis, R.L. & Vasudevan, V. (2014). Playing in the arcade: Designing tangible interfaces with MaKey MaKey for Scratch games. In A. Nijholt (Ed.), *Playful User Interfaces: Interfaces that invite social and physical interaction* (pp. 277 - 292). Singapore: Springer.

[10] Millner, A. (2010). Computer as Chalk. Unpublished Doctoral Dissertation. Cambridge, MA: Massachusetts Institute of Technology.

[11] A. Monroy-Hernandez. (2012). Designing for remixing: Supporting an online community of amateur creators. Unpublished dissertation. Cambridge, Massachusetts: MIT.

[12] Ngai, G, Chan, S. C. F., Leong, H. V., & Ng, V. T. Y. (2013). Designing i*CATch: A Multipurpose, Education-friendly Construction Kit for Physical and Wearable Computing. *ACM Transactions on Computing, 13*(2), DOI: 10.1145/2483710.2483712

[13] Papert, S. (1980). *Mindstorms*. New York, NY: Basic Books.

[14] Richard, G. & Kafai, Y. B. (forthcoming). Responsive Make and Play: Youth Making Physically and digitally Responsive Game Controllers. In A. Nijholt (Ed.), *More Playful User Interfaces: Interfaces that invite social and physical interaction.* Singapore: Springer.

[15] Silver, J., Rosenbaum, E., & Shaw, D. (2012). MaKey MaKey Improvising Tangible and Nature-Based User Interfaces. *In Proceedings of the ACM Tangible Embedded and Embodied Interaction* (pp. 367-370). Kingston, Ontario, Canada: ACM.

[16] Tanenbaum, J. & Bizzochi, J. (2009). Rockband: A Case Study in the design of embodied user interface experience. In *Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games* (pp. 127-134). New York, NY: ACM.

[17] Tanenbaum, J., Tanenbaum, K. & Isbister, K. (2015). Costumes as Game Controllers: An Exploration of Wearables to Suit Social Play. In *Proceedings of the Ninth International Conference on Tangible, Embedded, and Embodied Interaction* (pp. 691-696). New York, NY: ACM.

[18] Vasudevan, V. & Kafai, Y.B. (forthcoming). Bridging Crafting and Coding in Making: Designing Interactive Touchpads and Gameboards with MaKey MaKey in Peppler, K., Halverson, E. & Kafai, Y.B. (Eds.), *Makeology: The Maker Movement and the Future of Learning*. Boston: MIT Press.