# An E-Textiles Workshop for Undergraduate Learning

Ethan R. Behrendt[1], Hunter M. McDaniel[2], and Emily M. Hastings[2]
[1]Department of English
[2]Department of Computer Science
University of Wisconsin - Eau Claire
Eau Claire, WI 54701
[behrener4392, mcdanihm4137, hastinem] @uwec.edu

**Abstract**

E-textiles integrate various materials such as sensors and power sources directly into fabrics to enable detection and transmission of data. During our study, we conducted an interactive workshop with 12 participants designed to teach circuit design and sewing skills to undergraduates and increase their interest in these topics. Our participants were led through an activity where they used conductive thread and mechanical components to modify a regular fabric glove into an e-textile. During our study, students reported high interest in e-textiles and received high scores on a circuit design and sewing quiz after the activity. We found statistically significant increases in several measures, including participants' self-reported knowledge and enjoyment of circuit design and enjoyment of sewing. Using the data collected from our study, we plan to design a teaching module that could be deployed and evaluated in a classroom or extra-curricular setting to teach introductory electronics at an undergraduate level.

# 1 Introduction

Electronic textiles (e-textiles) are textiles that combine technology with fabric based materials. The applications of e-textiles are vast and can be used in many fields such as theater, wearable computing, healthcare, and education. Our project focuses mainly on the use of e-textiles in educational settings, where their integration displays a unique bond between technology and learning. E-textiles are especially useful for teaching related concepts through the use of hands-on learning. Educational theory such as embodied learning [12] and constructionist learning [5] suggests that by allowing students to explore coding and design in a physical way, rather than through lecture, they will be able to learn easier and retain the information for longer periods afterwards.

During our previous literature review [1], we found that educational e-textile activities have mainly been employed in classrooms with younger students. The exact age of the students varies, but is often around the middle school level. We noticed that there was a relative lack of information regarding e-textiles for education in undergraduate settings, and therefore decided to conduct an undergraduate-level workshop and evaluate its effectiveness. During our workshop, the 12 participants were tasked with designing an interactive e-textile glove that performs a certain function. Participants were allowed to choose the desired function of their gloves from several options including lights or vibration. To create their e-textiles, the participants sewed conductive thread along the fingers and thumb of the glove. Once the finger and thumb are touched together in an "O" shape, the glove's chosen function will activate (see Figure 1 for an example). This allows for a rudimentary and interactive example of a circuit.

Participants reported being interested in e-textiles projects like the one completed during the workshop (median=6 on a scale of 1 to 7) and greatly enjoyed taking part in activity (median=7). They also believed that it could be promising to incorporate into a course such as Introduction to Computer Science (median=5.5). Our analysis supports this idea, as we found that students received high scores on a circuit design and sewing knowledge quiz after the activity. We additionally observed a statistically significant increase in several areas measured by our pre- and post-surveys, including participants' self-reported knowledge and enjoyment of circuit design and enjoyment of sewing. Participants' interest in e-textiles, quiz scores, and self-reported sewing knowledge also increased slightly pre- and post-activity; however, these differences did not achieve statistical significance. Several participants from unrelated fields and demographics not typically associated with computer science showed particularly interesting increases in several measures, suggesting opportunities for e-textile activities to improve experiences for non-standard CS students.

Using these results, we aim to design and evaluate a more streamlined e-textiles module to be deployed for classroom use to teach introductory circuit design at an undergraduate level.

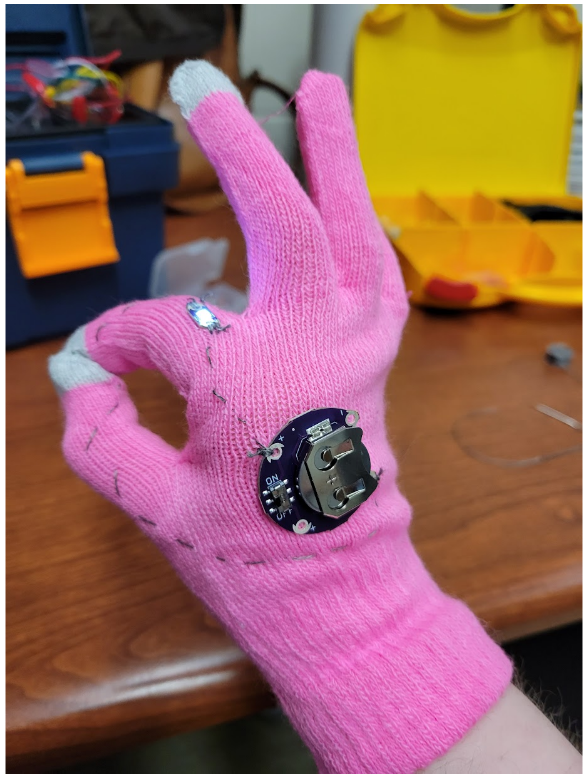

Figure 1: E-textile glove created by the authors and shown to participants during the workshop as an example.

## 2 Related Work

This paper contributes to the literature on e-textiles, particularly in educational contexts.

### 2.1 Educational Benefits of E-Textiles

Electronic textiles have applications in many fields but show high capacity for future use in medical and educational areas. The first patented e-textile was created in 1910 for an electronically heated glove [8]. Since then, the field has exploded in complexity, allowing for more intricate designs and creations. Although there are near endless applications of e-textiles, our project is focusing on the educational benefits.

The educational uses of e-textiles provide many advantages as opposed to traditional teaching methods, inspired by theories such as embodied learning [12] and constructionist learning [5]. By using a tactile hands-on learning approach, students are able to better understand the connections between computer hardware, and the code that allows it to run [9]. Physically showing the connections between coding and hardware can show students exactly how the concepts they learn apply to real life. This is especially important in our current time where generative AI use is rapidly expanding into every facet of educational lifestyles (e.g., [13]). Students are often tempted to outsource tedious thought processes to a large language model, preventing them from learning the material they are supposed to understand and potentially leading to skill atrophy (e.g., [2, 10]). E-textiles have the potential to keep students more engaged and support ownership of their work, which has been shown to have positive educational outcomes (e.g., [4, 3]).

### 2.2 Examples of E-Textiles in Education

Prior work has studied applications of e-textiles in education and has been described in papers such as the recent literature review by Behrendt and Hastings [1]. These studies focused on using e-textile workshops to teach students of ages that ranged from elementary school through high school. Each workshop was different from one another, but their objective was to test the effectiveness of e-textiles as learning tools.

One study, conducted by Hébert and Jenson [6], deployed two different workshops in an elementary school aged setting. One workshop was to be offered during an in school unit, and the other workshop took place in an after school makerspace. The idea was to see which workshop setting would be more effective at teaching the children. While taking part in the workshops, the students were tasked with using electronic components to create their own e-textile hat across 12 sessions. Although both settings were effective at teaching the children, the after school workshop proved to be more impactful for the children. By using post-project questionnaires, the researchers discovered that the students in the after school workshop increased their knowledge by 11.63% (2.76 points) whereas the students from the in school section increased their knowledge by only 7.69% (1.76). Researchers also noted that student interest in coding nearly doubled after the workshop.

In another study, researchers Hughes and Morrison [7] used an e-textiles workshop to include students who may have been under-represented in opportunities for extra curricular growth. Their group was made up of 5 students who were to design an e-textile bookmark. One participant was legally blind, another participant was diagnosed with attention defecit disorder (ADD) and a third student was part of an Individualized Education Program (IEP). The rest of the students were considered "mainstream" students. Despite the fact that some students had mental health concerns or learning disabilities, all of the students were able to complete the workshop and learn from it. Similarly, another study used e-textiles as a way to support children who were diagnosed with ASD (Autism Spectrum Disorder) [11]. The researchers planned to assist children in creating their own e-textile toys that provide haptic feedback when played with. They hoped that the use of these toys would help target issues related to sensory oversimulation and allow children with ASD to better express themselves emotionally and creatively. Five children with ASD (alongside their caretakers) participated in the study, and were given materials as well as instruction from the researchers. They would be designing a stuffed toy that incorporated electronic components that would allow it to vibrate when played with. The children were given a large amount of freedom in the creation of their toys. Researchers provided them with many different materials, different vibration patterns, and the ability to draw faces on their toys. During the workshop, the children showed a great interest, and appeared very engaged with their projects. The findings of this study show that e-textiles are also beneficial to under-represented groups.

We observed that most studies target younger audiences ranging from elementary to high school, rather than the undergraduate level. We plan to address this research gap by conducting our e-textiles workshop in an undergraduate setting and evaluating its effectiveness.

## 3 Research Questions

The study we conducted was designed with the following research questions in mind:

**RQ1:** How does taking part in an e-textiles workshop impact students' perceptions of circuit design and sewing?

**RQ2:** How does taking part in an e-textiles workshop impact students' knowledge of circuit design and sewing?

**RQ3:** What opportunities does taking part in an e-textiles workshop provide for students historically underrepresented in the field of computer science?

Our goal in posing and answering these questions was to measure the effectiveness of the workshop and assess the potential of including a similar activity in a classroom setting.

## 4 Method

To answer our research questions, we conducted an experiment which included a two-hour workshop event tasking a group of undergraduate college students with creating their own electronic textile glove as a way of learning concepts related to its construction. The experiment was approved by the IRB at our university.

Participants were recruited via an email advertisement sent to majors and minors in the following departments and programs at our university: Computer Science (CS), Software Engineering, Artificial Intelligence, Materials Science and Biomedical Engineering, Physics and Astronomy, Pre-Engineering, Art & Design, Theatre, and Entrepreneurship. The event was also shared with relevant student organizations (the Student Association for Computing Machinery and Fashion Club) via reaching out to members of their leadership teams,

| Major | Year | Gender | Race/ Ethnicity | Circuit Exper. | Sewing Exper. |
|---|---|---|---|---|---|
| CS | Junior (3) | Male | White | Yes | No |
| CS | Junior (3) | Male | White | No | No |
| CS | Sophomore (2) | Male | White | No | Yes |
| Info-systems | Senior (4+) | Male | Black | Yes | No |
| - | - | Male | White | No | No |
| CS | First year | Male | White | No | No |
| Journalism | Junior (3) | Female | White | No | No |
| CS | Junior (3) | Male | White | No | No |
| CS | Junior (3) | Male | White | Yes | No |
| CS | Sophomore (2) | Male | White | Yes | No |
| Geography | Junior (3) | Male | White | Yes | No |
| CS | Junior (3) | Male | Asian/Pac. Isl. | No | Yes |

Table 1: Demographic information about the workshop participants collected from the post-survey. Empty cells were left blank by students on the survey.

and several fliers were posted on bulletin boards around campus. These recruitment efforts resulted in 12 participants who attended the workshop event, which was held in our university's Makerspace on a weekday evening. See Table 4 for demographic information about the participants.

To collect the required data for analysis, we provided students with pre- and post-surveys to complete to show their knowledge and perceptions of circuit design and construction in addition to sewing. On the pre-survey, participants completed a consent form and then were asked to rate their perceived knowledge of and interest in the concepts on a scale of 1-7, and given 10 multiple-choice questions to more objectively assess their knowledge of the related material. For example, students were asked questions like, "What does LED stand for?" and "What is a short circuit?", and similar level questions about sewing such as "What is the line called where two pieces of fabric are held together by thread?". Some of the question topics were explicitly addressed over the course of the workshop, and some were left for them to discover on their own during the activity. For example, short circuits were not mentioned at the onset of the activity, but were expected to be encountered by participants as they created their projects.

After participants completed the pre-survey, the main workshop began with an introductory presentation about e-textiles and their potential uses and then transitioned into the hands-on activity where participants would build their projects. They had the option to select a colorful knit glove, battery and battery holder, and other electronic components to add functions to their glove. Options included LED lights in various colors and vibration boards. Participants then sewed conductive thread in a path along the fingers and thumb of the glove, setting up a circuit which would be completed when the finger and thumb are touched together in an "O" shape, which would activate the glove's chosen function. See Figure 1 for the example glove which was created by the authors to use as a demonstration for the workshop. Participants were given written and verbal instructions for the completing the project at the beginning of the workshop, and the authors were available to answer questions and assist throughout the activity.

Once the workshop activity was completed, the students filled out the post-survey to re-assess their knowledge and perceptions of the material, to be able to measure growth. Students were allowed to keep their completed gloves to take home with them.

### 4.1 Measures

The questions on the pre- and post-surveys were intended to gauge the following measures:

- Participants' interest in e-textiles projects like the one completed in the workshop event (1 = Not at all interested, 7 = Extremely interested)
- Participants' interest in the project if they were not allowed to keep the glove they made during the event (1 = Not at all interested, 7 = Extremely interested)
- How the prospect of working with circuits impacts participants' interest in the project (1 = Greatly decreases my interest, 7 = Greatly increases my interest)
- How the prospect of working with sewing impacts participants' interest in the project (1 = Greatly decreases my interest, 7 = Greatly increases my interest)
- Participants' self-assessed knowledge of circuits (1 = Complete beginner, 7 = Expert)
- Participants' enjoyment of circuits ("I enjoy working with electronics/circuit design," 1 = Strongly disagree, 7 = Strongly agree)
- Participants' self-assessed knowledge of sewing (1 = Complete beginner, 7 = Expert)
- Participants' enjoyment of sewing ("I enjoy working with sewing/textiles," 1 = Strongly disagree, 7 = Strongly agree)
- Score on knowledge quiz (numeric score from 1-10)
- (Post-survey only) Participants' enjoyment of the workshop (1 = Strongly disagree, 7 = Strongly agree)
- (Post-survey only) Whether participants thought a similar activity should be included in a course at the university (1 = Strongly disagree, 7 = Strongly agree)

We also had free-text questions asking why participants attended the event, what their prior experience with circuit design and sewing was, and if they had any other comments.

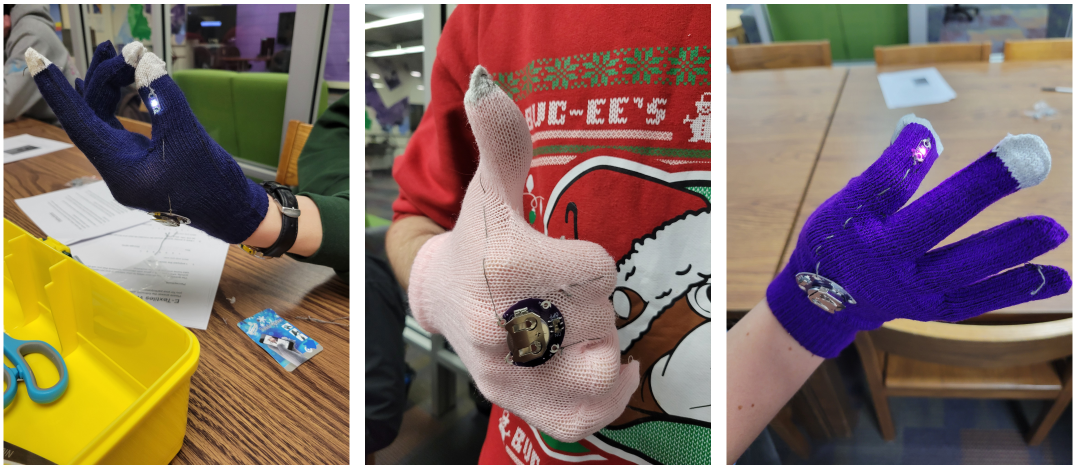


Figure 2: Some of the interactive e-textile gloves created by participants during the workshop.

# 5 Results

See Figure 2 for images of some of the projects created by participants during the workshop and Table 5 for a summary of the pre- and post-survey results. Here we present mainly descriptive statistics due to a fairly small sample size (12 participants); however, we did also conduct some inferential analysis in the form of one-tailed paired t-tests comparing the pre- and post-survey responses for our measures to assess the impact of the workshop activity on participants' knowledge and perceptions of e-textiles. Due to the small sample size, we also performed a Wilcoxon signed rank test for the same measures and found results consistent with the t tests, so we omit the details of that analysis here.

## 5.1 Participant Perceptions of Circuit Design and Sewing (RQ1)

Participants were initially moderately interested in e-textile projects like the one completed in the workshop (median=5 on a scale from 1 to 7). They reported attending the workshop for reasons ranging from a prior interest in and desire to learn more about circuits, taking an opportunity to spend time with friends who were attending, wanting to support the authors, and just thinking it sounded "fun" or "cool." We observed an increase in participants' interest in e-textile projects after the workshop (median=6); however, this difference was only marginally statistically significant (t=1.59, p=0.07).

Participants' enjoyment of both circuit-related and sewing-related activities did significantly increase after the workshop. For circuits, this was a change from a median of 5 to 5.5 with a median difference of 0.5 (t=2.24, p=0.02) on the 7-point scale. Participants reported circuits more positively impacting their interest in the activity than prior to the event (median 6.5 to 7, t=1.91, p=0.04). For sewing, the difference was even greater. We

| Measure | Pre-Survey | | Post-Survey | | Change | | | Analysis | |
|---|---|---|---|---|---|---|---|---|---|
| | Avg | St Dev | Avg | St Dev | Mean | Med | St Dev | t | p |
| Interest | 5 | 1.47 | 6 | 1.30 | 0.5 | 0 | 1.09 | 1.59 | 0.07 |
| Interest (no keep) | 5 | 1.00 | 5 | 0.78 | 0.08 | 0 | 1.08 | 0.27 | 0.40 |
| Circuits Impact | 6.5 | 1.53 | 7 | 0.89 | 0.5 | 0 | 0.90 | 1.91 | 0.04* |
| Sewing Impact | 3.5 | 1.82 | 5 | 1.15 | 0.92 | 1 | 1.24 | 2.56 | 0.01* |
| Circuits Knowl. | 2.5 | 1.27 | 3.5 | 1.44 | 1.08 | 1 | 0.79 | 4.73 | 0.00* |
| Circuits Enjoy. | 5 | 1.59 | 5.5 | 1.44 | 0.58 | 0.5 | 0.90 | 2.24 | 0.02* |
| Sewing Knowl. | 2.5 | 1.90 | 3 | 1.67 | 0.33 | 0.5 | 0.98 | 1.17 | 0.13 |
| Sewing Enjoy. | 4 | 1.78 | 5 | 1.67 | 1 | 1 | 1.41 | 2.45 | 0.02* |
| Quiz Score | 7.17 | 0.72 | 7.42 | 1.50 | 0.25 | 0 | 1.42 | 0.61 | 0.28 |
| Enjoyment | - | - | 7 | 1.17 | - | - | - | - | - |
| Have in Class | - | - | 5.5 | 2.04 | - | - | - | - | - |

Table 2: The results of the statistical analysis. Average columns show the median for most measures (Likert items on a scale of 1 to 7) and mean for knowledge quiz score (out of 10). Change shows the mean, median, and standard deviation of the change in scores for each participant between pre- and post-surveys. Analysis describes a one-tailed paired t test. * denotes a significant difference at the level of p=0.05. Note that the questions regarding participant's enjoyment of the workshop and whether a similar activity should be incorporated into a classroom setting only appeared on the post-survey.

observed a change from a median of 4 to 5 (neutral to slight positive) and a median difference of 1 (t=2.45, p=0.02) on the 7-point scale, and the prospect of sewing now increased interest in the activity rather than decreasing it (median 3.5 to 5, t=2.56, p=0.01).

Participants overwhelmingly reported enjoying the workshop (median=7) and had generally positive reactions when asked whether a similar activity should be incorporated into a course such as Introduction to Computer Science at the university, with a median rating of 5.5 on the 7-point scale. Several of the participants also left comments in the post-survey saying that they had fun and enjoyed the activity.

### 5.2 Participant Knowledge of Circuit Design and Sewing (RQ2)

Participants' self-reported knowledge of circuit design significantly increased after the workshop activity, with a change from a median of 2.5 to 3.5 and a median difference of 1 on the 7-point scale (t=4.73, p=0.00). We also observed slight increases both in participants' self-reported sewing knowledge (median=2.5 to 3, median difference=0.5) and score on the knowledge quiz (mean=7.17 to 7.42, mean difference=0.25), however these differences were not statistically significant (t=1.17, p=0.13; t=0.61, p=0.28 respectively). Note that as shown in Table 4, several participants did have prior experience in either circuit design or sewing, which could have impacted these results.

### 5.3 Opportunities for Underrepresented Students in CS (RQ3)

Although we had a small sample size and therefore cannot comment on generalizable trends, we did have a few participants from outside the demographics typical to CS courses who may provide some insights.

One such case was our only female participant, a journalism major who originally attended the workshop event as a photographer, but decided to stay and participate because "the glove seem[ed] like a fun activity." After the activity, she showed increases in several measures. Specifically, her self-reported circuit knowledge and enjoyment both went from a rating of 3 to 5. Her sewing knowledge and enjoyment remained high at a 6 and 7, respectively. This section of the survey was rated on a scale from 1 to 7, meaning her reported knowledge of and interest in circuits drastically increased after the workshop.

Another interesting participant we saw was a geography student. Despite reporting very low interest levels overall (finishing with a 3 in circuit enjoyment and 2 in sewing enjoyment) and attending only because he knew one of the researchers, the participant had our largest increase between pre- and post-quiz scores, an increase of 3 points (7 to 10). His interest in e-textiles projects also increased from 2 to 4 after the activity.

## 6 Discussion

The students who participated in the e-textiles workshop showed an increase in knowledge and interest afterwards. This improvement indicates that this activity was useful for teaching and that a later version may be helpful in a classroom setting. Our participants agreed with this possibility, being mostly supportive of the idea of a similar activity being integrated into a course at the university.

Of the participants, almost all were white men who studied computer science. However, some students were in other, less related fields or of demographics typically underrepresented in CS. Despite these differences, these students showed great increases in interest and knowledge that indicate an ease of accessibility for those who are not stereotypical CS students. Even those who did not express great interest in the premise of the activity still showed substantial improvements in quiz scores. These findings suggest that an e-textiles activity could provide an entry point into the field for many other groups that may feel apprehensive about participating in computer science and its related areas of study. By giving students a view into basic concepts that potentially relate to interests or hobbies they already have, they may feel more comfortable with the field as a whole. Our results that participants felt more positively towards sewing after the workshop (a significant increase in their enjoyment of sewing and a more positive impact of sewing on their interest in e-textiles) indicate that such activities could also introduce technically-oriented students to fields they might not otherwise consider pursuing.

### 6.1 Limitations and Future Work

One potential limitation of our study is that the workshop was held as an extracurricular activity that participants chose to attend, which meant that there was a possibility of self selection bias. Participants' interest and skills were already fairly high before the activity, which decreased the room for growth during the workshop. If the workshop were held in a classroom setting, there would be a different baseline in knowledge of and interest in the concepts, which would provide a greater opportunity for learning.

Additionally, future work could explore different ways of assessing the participants' knowledge. Some quiz questions were mentioned explicitly in the pre-presentation for the workshop, but some were left for the students to discover on their own. For example, short circuits were not discussed in the presentation as the students were expected to encounter them during the duration of the workshop. This was done intentionally to test whether participants would still be able to learn related concepts through their own processes. It is possible that had all of the concepts been explicitly addressed, we would have seen greater knowledge increases in participants. Participant comments lend support to this possibility: "I think had this been presented as a step by step walk-through, I would have been able to more confidently answer the post-workshop questions, as opposed to, 'here's the instructions, go.'"

Future work might also consider using interviews to assess the students' knowledge of the material and gain more insight into their perceptions of the activity's strengths and weaknesses.

## 7 Conclusion

We conducted an experiment evaluating the effectiveness of an e-textiles workshop for teaching undergraduate students topics such as circuit design and sewing. We found that students enjoyed the activity, and had significant gains in knowledge and enjoyment of circuits and enjoyment of sewing, as well as smaller gains in sewing knowledge, interest in e-textiles, and quiz scores. We also identified opportunities to support students from underrepresented groups in computer science and provide an entry point into the field. Based on this work, we intend to evaluate a similar activity in an undergraduate classroom setting in future research.

## 8 Acknowledgements

Support for this project came from Student Blugold Commitment Differential Tuition funds through the University of Wisconsin-Eau Claire. We thank the staff of the Office of Research and Sponsored Programs for their valuable feedback during the development of this project. We also thank the UWEC Blugold Makerspace for their cooperation and support during the workshop event and Dr. Kevin Hastings for his valuable advice regarding the statistical analysis.

## References


[1] Ethan Behrendt and Emily M Hastings. A review of e-textiles in learning environments. In *Proceedings of the 2025 Conference on Creativity and Cognition*, pages 508–511, 2025.

[2] Krzysztof Budzyń, Marcin Romańczyk, Diana Kitala, Paweł Kołodziej, Marek Bugajski, Hans O Adami, Johannes Blom, Marek Buszkiewicz, Natalie Halvorsen, Cesare Hassan, et al. Endoscopist deskilling risk after exposure to artificial intelligence in colonoscopy: a multicentre, observational study. *The Lancet Gastroenterology & Hepatology*, 10(10):896–903, 2025.

[3] Paula E. Chan, Kristall J. Graham-Day, Virginia A. Ressa, Mary T. Peters, and Moira Konrad. Beyond involvement: Promoting student ownership of learning in classrooms. *Intervention in School and Clinic*, 50(2):105–113, 2014.

[4] David T Conley and Elizabeth M French. Student ownership of learning as a key component of college readiness. *American Behavioral Scientist*, 58(8):1018–1034, 2014.

[5] Idit Ed Harel and Seymour Ed Papert. *Constructionism.* Ablex Publishing, 1991.

[6] Cristyne Hébert and Jennifer Jenson. Making in schools: Student learning through an e-textiles curriculum. *Discourse: Studies in the Cultural Politics of Education*, 41(5):740–761, 2020.

[7] Janette Hughes and Laura Morrison. The use of e-textiles in ontario education. *Canadian Journal of Education/Revue canadienne de l'éducation*, 41(1), 2018.

[8] Theodore Hughes-Riley, Tilak Dias, and Colin Cork. A historical review of the development of electronic textiles. *Fibers*, 6(2), 2018.

[9] Yasmin B Kafai, Deborah A Fields, and Kristin A Searle. Making technology visible: Connecting the learning of crafts, circuitry and coding in youth e-textile designs. In *Proceedings of the 10th international conference of the learning sciences*, pages 188–195. ICLS, 2012.

[10] Nataliya Kosmyna, Eugene Hauptmann, Ye Tong Yuan, Jessica Situ, Xian-Hao Liao, Ashly Vivian Beresnitzky, Iris Braunstein, and Pattie Maes. Your brain on chatgpt: Accumulation of cognitive debt when using an ai assistant for essay writing task, 2025.

[11] Jinsil Hwaryoung Seo, Pavithra Aravindan, and Annie Sungkajun. Toward creative engagement of soft haptic toys with children with autism spectrum disorder. In *Proceedings of the 2017 ACM SIGCHI Conference on Creativity and Cognition*, pages 75–79, 2017.

[12] Alexander Skulmowski and Günter Daniel Rey. Embodied learning: introducing a taxonomy based on bodily engagement and task integration. *Cognitive research: principles and implications*, 3:1–10, 2018.

[13] Stephanie Tom Tong, Ashley DeTone, Austin Frederick, and Stephen Odebiyi. What are we telling our students about ai? an exploratory analysis of university instructors' generative ai syllabi policies. *Communication Education*, 74(3):261–282, 2025.