

# A Review of E-Textiles in Learning Environments

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## ABSTRACT

The field of electronic textiles (e-textiles) combines digital technology with textile objects, and has applications in fields such as wearable computing, theatrical design, and medicine. Prior work has examined deploying this technology in educational settings, to teach such skills as circuit design, computer programming, and iterative design. However, e-textile-based learning materials are still not commonly used, and more validated examples of such interventions would be valuable. The aim of this project is to investigate the state of the art in e-textile technology, especially in educational contexts, and to develop and evaluate an e-textiles intervention which could be deployed in a classroom or extra-curricular setting to teach introductory programming skills. So far, we have conducted a literature review examining applications of e-textiles in learning environments. For example, in one study [1], the researchers provided a safe environment for children with ASD (Autism Spectrum Disorder) to create their own sensory haptic toy. We found that many of the studies targeted middle and high school age children as a way to gauge and increase their knowledge of electricity and sewing techniques, but not many examined undergraduates. Therefore, in future work, we plan to conduct an experiment investigating the effectiveness of e-textiles in undergraduate learning.

## BACKGROUND

E-textiles, or electronic textiles, represent a fusion of fabric and technology that allows for a greater range of use than ever before. E-textiles integrate various materials such as sensors, wires, and power sources directly into fabrics to enable detection and transmission of various forms of data (see Figure 1).

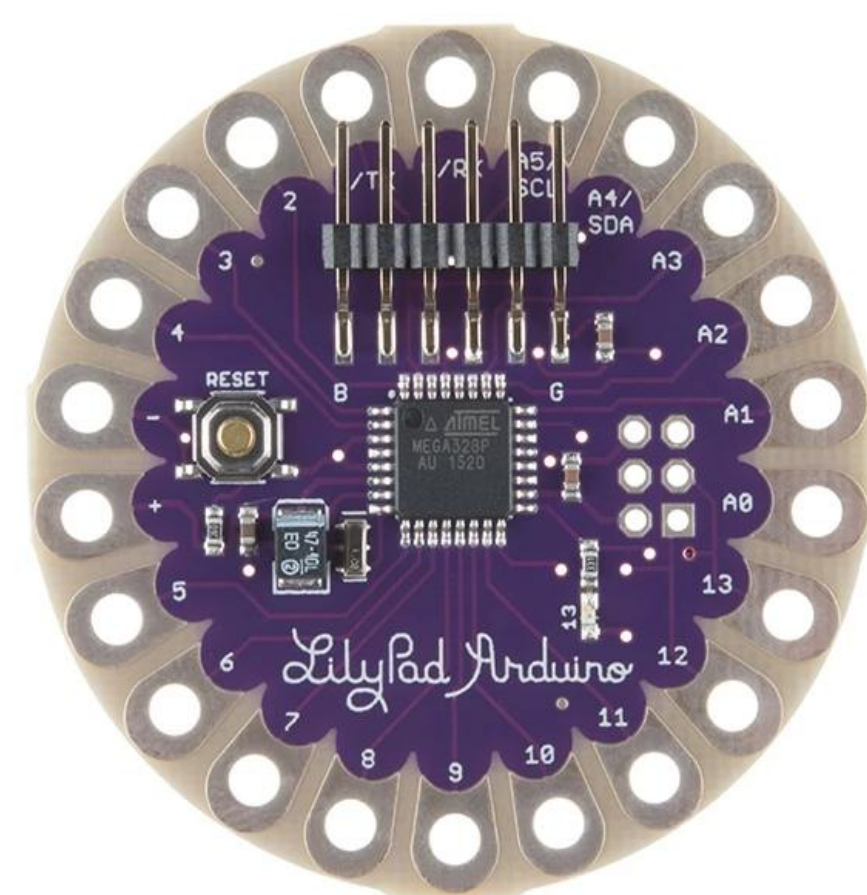


Figure 1: Lilypad Arduino, a circuit board created specifically for use in e-textiles  
(Image from <https://www.sparkfun.com/lilypad-arduino-328-main-board.html>)

## SCOPE AND METHODOLOGY

In this review, we survey the existing literature to understand current applications of e-textiles in education, specifically focusing on attributes such as contexts of use (e.g., classroom vs. extra-curricular activities, grade level), learning objectives (e.g., teaching circuit design, programming with variables/conditionals, etc.), measures studied (e.g., student learning, satisfaction), and the exact design of the e-textile interventions.

## RESEARCH QUESTIONS

1. What contexts of use have prior e-textile studies examined?
2. What learning objectives have prior e-textile studies examined?
3. What measures have prior e-textile studies examined?

## OVERVIEW OF SELECTED LITERATURE

- **Hébert & Jenson (2020)** [2]
  - Workshops delivered both in-class and after school
  - Skills Developed include circuit building, sewing, coding, and problem solving
  - Average Score Increase: 9.74%
- **Seo et al. (2017)** [1]
  - Participants were children with ASD
  - Children showed deep engagement and independence
  - Emotional attachment and pride in creations
- **Hughes & Morrison (2018)** [3]
  - Conducted workshops with diverse demographics of children
  - Inclusive of students with blindness, ADD, and mental health concerns
  - Shows that e-textiles are accessible to all who wish to learn



Figure 2: Dr. Hastings' woven e-textile

## REFERENCES

- [1] Jinsil Hwaryoung Seo, Pavithra Aravindan, and Annie Sungkajun. 2017. 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*. 75–79.
- [2] Cristyne Hébert and Jennifer Jenson. 2020. Making in schools: Student learning through an e-textiles curriculum. *Discourse: Studies in the Cultural Politics of Education* 41, 5 (2020), 740–761.
- [3] Janette Hughes and Laura Morrison. 2018. The use of E-textiles in Ontario education. *Canadian Journal of Education/Revue canadienne de l'éducation* 41, 1 (2018).

## DISCUSSION

To answer our first research question, we searched for information that could tell us where e-textile studies have been conducted in the past. Our review showed us that after school programs and maker spaces provided the best environment for e-textile learning with after school students, showing a greater increase in knowledge versus in school students. For our second research question we examined the learning objectives that prior studies have tested. We found that when using hands-on learning to teach children concepts such as sewing, electrical currents, programming, and problem solving, they are able to experience the information in a way that is personal to each of them. Allowing children to physically interact with the learning material helps them figure out for themselves how each aspect functions and supports the larger project. For our third research question examining measures, we found that some studies used pre- and post-workshop questionnaires to test knowledge related to the projects. Many of the reviewed studies also examined participant enjoyment and satisfaction with the results. While answering our research questions, we noticed that a significant research gap exists in utilizing e-textiles in undergraduate education, where their potential for teaching introductory programming has yet to be fully explored. A key theme we discovered while conducting our research was the emphasis on diversity and inclusion. In the reviewed papers, researchers deliberately chose participants from diverse areas of life and backgrounds to ensure that e-textiles were accessible to all learners. These studies included students from various socio-economic backgrounds, students with cognitive developmental disabilities, and students with behavioral disabilities, providing them with equal opportunities to engage with activities related to STEM. E-textiles proved to be highly accessible to all learners, even including visually impaired persons and children with Autism Spectrum Disorder (ASD). It became clear to us that e-textiles are also more than educational tools. E-textiles can be used to provide other benefits to people such as emotional connections, sensory relief, and improved creativity.

## FUTURE WORK

Based on our results, we will design an educational e-textiles intervention to use either in a course or dedicated extra-curricular event. Currently we are practicing with different materials as can be seen in Figure 2 to the left. These images show a woven e-textile created by Dr. Hastings.

## ACKNOWLEDGEMENTS

Support for this project came from Student Blugold Commitment Differential Tuition funds through the University of Wisconsin-Eau Claire.