From Textiles to Soft Robotics and the Emergent Approaches in STEAM and Textile Labs

Adrina Cabrera Galindez, Pistofidou Anastasia

Matrix gmbh & co kg, Germany
Fabricademy, textile and technology academy, Spain

Abstract

At the intersection of art, technology, biology and science, the emergent field of Soft Robotics can be a beneficial and engaging topic for designers, artists, and educators, who want to implement transversal and innovative projects. Moreover, it enables inclusive learning about robotics and materials applying digital fabrication and biology, offering an explorative space for makers and professionals. This paper discusses the challenges of actuated materials and Soft Robotics inside the transdisciplinary program Fabricademy[1] and envision informal educational activities in shemakes.eu[2].
Fabricademy explores further the practices of wearable technology and the application of Soft Robotics in a distributed educational format, while shemakes.eu project engages participants from girls in STEAM to women innovators, introducing inclusive practices and digital skills during learning paths. Both aim to bring this complex knowledge into a hands-on approach in the labs, experimenting with different challenges from the concept of Soft Robotics, actuated materials, and bio-based composites from a variety of applications. This paper will describe some of the practices that participants and lecturers face during the workshops and lectures. Further, it presents the reflection to the research questions Interaction, Fabrication, Inclusion, and gender gap, illustrating the different paths that describe future practices from performative arts to healthcare solutions, reflecting a more comprehensive range of implications in sustainability, Industry 4.0 and innovation narratives. The goal of this paper is to highlight how the field of Soft Robotics is connected to the changes in the uses of materials such as soft goods and textiles in Education. Consequently, we want to envision how the field of Soft Robotics and actuated materials can (re)shape the implications and applications of wearable technology in education and (re)define emergent approaches in the textile and clothing industry.

Keywords: *Programmable Materials, Soft Robotics, Fabrication, Bio-inspired design, Learning by doing, wearables, FabLabs, Digital fabrication, Material driven Innovation, Interaction Design,*

1. Introduction

By definition, Soft Robotics is a broad field that uses the softness of an object, a piece of material or a system for building a robot satisfying a required softness to both its environment and its reception [3]. Soft robotic fabrication explore textiles and materials also can be a smart materials themselves [4]. Developments in Soft Robotics continue to explore the gap between machines and people [5],and is a key research theme in the development of biomimetic robots, which describe with examples from nature, to reproduce and simulate them and form shapes that fit living organisms, particularly human beings [6][7]. Recently, the exploration of robotics has been oriented towards HCI research and developments in other educational contexts outside the classroom, in learning practices between technology and the arts and in particular crafting[8] and biology.
This field has more recently further explored applications in wearables, textiles, and soft materials[9]. These experimentations, which are often carried out in labs, are becoming more and more attractive in connection with different actors involving universities, research institutions, schools, accelerator centers, and promoting cross-disciplinary knowledge as it is generated in FabLabs, where learning by doing takes place[10]. Furthermore, this approach starting from the experimentation of materials in conjunction with digital fabrication technologies allows interaction of different audiences in the concept of Soft Robotics.

2. Framework

In the following framework, we will then look at the development of Soft Robotics practices generated around Fabricademy from its inception in 2017 to 2021 and the relationship with the FabLabs ecosystem in activities in different contexts (schools, universities, laboratories), as well as the participation of diverse public and a large female audience.
This evaluation began by looking at the Soft Robotics lecture[11] at the Fabricademy advanced postgraduate program, which is held at 45 locations and had a total participation of 116 women and 29 men from 35 different nationalities ranging in age from 17 to 65 years old[12], Particularly, in the final Projects (Figure1).

The second analysis was done through activities and workshops, such as the international conferences of the FabLabs, activities in universities and accelerators, in which the concept of Soft Robotics was introduced and worked from 2 hours to 5-day hands-on workshops, with an audience from a variety of nationalities and ages.

3. Opportunities and Discussion:

Soft Robotics in Educational Practices at Fabricademy and Labs: We start by introducing the topic of Soft Robotics with a look at scientific documentation and research approaches towards a second aspect of how to adapt these hands-on practices in different formats.
The aim is to grasp the concept of how the intersection of biology adapts to the "making" in the labs, exploring the principle of softness from soft wearables for inclusive design [13], fashion and art to large scale explorations. Below we will highlight some of the essential topics in the lecture on Soft Robotics by introducing the key challenges.

Bio-inspired Design: Soft Robotics within the field of Biomimetics focuses on taking information from nature, for example, changes and movement, and interpreting it into flexible and conformable shapes that can be reproduced in a range of configurations. Exploration of this comes through making and manufacturing of components and materials. Ideation for bio-inspired design uses natures materials, processes, or structures as sources. Biomimetics explores the embodiment of function over mechanism but often the two are combined in soft robotics. As well as this, biologically informed design has the potential to enable a circular, sustainable and renewable design practice from the beginning of the development process.

Learning by doing: Involving the hands-on approach to understand what kind of methods and strategies in CAD and CAM can be applied in the development of Soft Robotics, and previously in what we call: *Soft prototyping* [30] [31], which refers to the making, hacking, and fabrication of projects that demand flexibility, allowing for an innovative form of communication and interaction. Digital manufacturing has been pushing the boundaries of how we manufacture, working on a small scale but with a high level of complexity. This development includes not only the use of machines but also an in-depth study of materials such as paper, textiles, biomaterials, electronics, and their applications, which can be explored in the FabLab.

Material driven design: As mentioned above, material experimentation has a significant role in applying textiles and soft materials, particularly by using biological strategies to generate intelligent materials or bio-composites. Fabrics and materials with a history and identity apart from their appearance and functionality also reflect circular design principles[14].

Wearables in bridging the gender gap: Given the increased explorations of wearables in makerspaces and especially the use of open-source, Soft Robotics enables a space where there can be different responses to wearables that converge in practices that facilitate constructive learning, allowing a safe space for experimentation. It is the authors opinion that actuated and/or stimulus responsive materials such as those used in Soft Robotics worn on the human body provides an immediate, individual and immersive experience with technology which could offer new insight into Science and Engineering principles. Furthermore, the importance of combining the skills of textile craftsmanship, such as sewing, embroidery, knitting and weaving, with embedded electronics provides an inclusive understanding to other fields such as engineering and computer science. In recent years, women's participation in STEAM (Science, Technology, Engineering, Arts and Mathematics), biotechnology and textiles have increased thanks to a more diverse offer with programmes such as Fabricademy, Poderosas[14], Fabrication for Care[15]. They have promoted diversity and the engagement of women interested in the creative areas of design and fashion and the implementation of new digital fabrication technologies[12].

4. Conclusion:

Soft Robotics enables a safe environment and invites exploration without certainty of what the end result will be, no right or wrong. But with an ultimate purpose or a goal. It is the authors finding that in the workshops, the individuals experience, understanding the principles of actuation and reaction in Soft Robotics, engages the user in an immediate interaction with the material and the important critical reviewing functions as bending and strain mechanisms. In the meanwhile, this practice enable the exploration of cognitive and emotional features in prototyping for different disciplines.
Soft Robotics allows the exploration of narratives of nature and the gap between electronics, technology, and science. The topic brought the attention of different audiences regardless of gender and age and invited the participation of all levels of knowledge. While in the workshops, most of the audience is mixed, a bias can be noted that the majority of participants who choose soft robotics as their final topic are women. This indicates empathy with the topic and a preference to develop the challenges of interaction applying soft robotics and actuated materials.

We see the application of the values that promote the gender vision brought by shemakes.eu (equality, collaboration, welcoming differences, empowerment, and inspiration), showing its application and dissemination in the final projects and workshops, framing the practices generated around Soft Robotics as a driver to bridge the gender gap. Soft Robotics is also a practical example to illustrate how to promote activities around the empowerment of the use of technology, learning by doing and innovating in the intersection of technology, science, and art.
Their development in the fashion sector can be very attractive and demonstrates the migration and influence from science to prototyping development and commercialization of Soft Robotics products. Therefore, it becomes more relevant to facilitate access to manufacturing tools through laboratories and educational practices such as the Fabricademy program and future activities in this field.

5. ACKNOWLEDGMENTS

This scientific contribution has been funded by the shemakes.eu project that received funding from the European H2020 SWAFS program under the agreement 101006203.
We particularly thank all the partners, makers and guests that have been collaborating in growing the Soft Robotics activities inside the Labs and textiles labs.

References

[1] A. Pistofidou and C. Raspanti, ‘Textile Academy’, Textile Academy, Jun. 01, 2021. http://textile-academy.org/ (accessed May 31, 2021).
[2] ‘Shemakes’, Shemakes. https://shemakes.eu/node (accessed Mar. 06, 2022).
[3] A. Chen, R. Yin, L. Cao, C. Yuan, H. K. Ding, and W. J. Zhang, ‘Soft robotics: Definition and research issues’, in 2017 24th International Conference on Mechatronics and Machine Vision in Practice (M2VIP), Nov. 2017, pp. 366–370. doi: 10.1109/M2VIP.2017.8267170.
[4] Chiyu Fu, Zhigang Xia, Christopher Hurren, Azadeh Nilghaz, Xungai Wang, Textiles in soft robots: Current progress and future trends, Biosensors and Bioelectronics, Volume 196, 2022.
[5] Rus, Daniela, and Michael T. Tolley. “Design, Fabrication and Control of Soft Robots.” Nature 521, no. 7553 (May 27, 2015): 467–475.
[6] D. Trivedi, C. D. Rahn, W. M. Kier, and I. D. Walker, ‘Soft robotics: Biological inspiration, state of the art, and future research’, Appl. Bionics Biomech., vol. 5, no. 3, pp. 99–117, Jan. 2008, doi: 10.1080/11762320802557865.
[7] G. Bao et al., ‘Soft Robotics: Academic Insights and Perspectives Through Bibliometric Analysis’, Soft Robot., vol. 5, no. 3, pp. 229–241, May 2018, doi: 10.1089/soro.2017.0135.

[9] B. Goveia da Rocha and K. Andersen, ‘Becoming Travelers: Enabling the Material Drift’, in Companion Publication of the 2020 ACM Designing Interactive Systems Conference, New York, NY, USA, Jul. 2020, pp. 215–219. doi: 10.1145/3393914.3395881.
[10] A. Brocker, O. K. Afsar, J. A. Barreiros, A. Shtarbanov, K. Gohlke, and S. Schröder, ‘Actuated Materials and Soft Robotics Strategies for Human-Computer Interaction Design’, p. 7, 2022.
[11] F. Academy Textile, Fabricademy 20-21 WEEK 12 - Soft Robotics, (Dec. 08, 2020). Accessed: Mar. 07, 2022. [Online Video]. Available: https://vimeo.com/488618547
[12] A. Cabrera, A. Pistofidou, M. Real, S. Sykes, A. Czeschik, and J. Marsh, ‘Innovation Ecosystem for women makers through textiles labs and the shemakes.eu approach’, in Proceedings of the Fab 16 Research Papers Stream, Rotterdam, The Netherlands, Aug. 08, 2021, pp. 221–239. doi: 10.5281/zenodo.5169852.
[13] Moon NW, Baker PM, Goughnour K. Designing wearable technologies for users with disabilities: Accessibility, usability, and connectivity factors. *Journal of Rehabilitation and Assistive Technologies Engineering*. January 2019.
[14] ‘FabMaterials’, FabLab Kamp-Lintfort, 2018. http://fablab.hochschule-rhein-waal.de/fabmoments/fab-material (accessed Jun. 30, 2018).
[14] N. Robles, ‘Poderosas, FabLab León’, May 31, 2021. https://www.poderosas-tech.es/ (accessed May 31, 2021).