Embracing the Challenge

A Committed Constructionist's Reflections on Strategies for Fostering an Engaging Learning Community

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Abstract

The UniTrento FabLab, located within the Department of Computer Science and Engineering at the University of Trento, serves as a vital educational hub for a broader constructionist community in the local area. By connecting university departments, local schools, cultural associations, and other stakeholders, the FabLab promotes free exploration, hands-on experimentation, and social interaction, ultimately fostering an inclusive and innovative learning environment. However, building such a community has not been without its challenges, many of which are still not completely solved. In this paper, we reflect on the history and organization of the UniTrento FabLab, examining both its successes and failures. We aim to provide both a starting point and a cautionary tale for those embarking on a similar journey from the point of view of an organization that recently started. While we acknowledge that many questions remain unanswered, we hope to initiate a debate on the most effective methods for promoting constructionist approaches, particularly within one's local community. Overall, our goal is not to evaluate the efficacy of the constructionist methodology but rather to encourage discussion and reflection on the best strategies to foster it.

Introduction

In Italy, university FabLabs are typically established within design, architecture, and art faculties. They provide students with access to digital fabrication tools that enhance their technical skills and stimulate their creativity (Blikstein, 2013). Alternatively, they can be found within civil and industrial engineering departments, giving technical students the opportunity to rapidly prototype their designs before moving them to production (Martin, 2015). These FabLabs promote the maker approach, which is based on hands-on and project-based learning methodologies, within the universities.

The FabLab at the University of Trento, on the other hand, has a unique story. The UniTrento FabLab was created within the Department of Computer Science and Engineering with a distinct aspiration: to serve as the "educational hub" for a broader constructionist community, connecting all university departments and potentially reaching all the educational stakeholders in the local area, such as schools, cultural associations, and museums.

Although some may find it surprising that an initiative like this originates from a computer science department, it is, in fact, a natural fit (Papert, 1980). Our primary aim is to promote the constructionist philosophy, which emphasizes free exploration, hands-on experimentation, and social interaction, by exploiting the protean ability of computers to embrace and facilitate learning across all the STEAM disciplines, ultimately fostering an inclusive and innovative learning environment (Resnick, 2017).

UniTrento FabLab is thus more than just a FabLab: it is a learning center, a professional development facility for teachers, and a place where university professors can meet to discuss innovative approaches to their teaching. It also serves as

a social club where students can hang out, freely explore, and connect their ideas. Instead of merely "being present" and hoping that its physical existence alone would facilitate the sharing of ideas, the UniTrento FabLab actively fosters a blending of ideas and skills. It facilitates projects, connects students, and promotes design events both within and beyond the university. In doing so, it exports the skills and enthusiasm of its students throughout the region and realizes the university's third mission toward society.

To achieve this goal, the UniTrento FabLab has established an external "arm," namely a cultural association called Glow. Its objective is to showcase the innovations and designs developed within the academy, by connecting with people and communities that are typically beyond the reach of an university, such as youth organizations, town squares, mountain villages, and more. Glow plays a crucial role in our design: not only does it implement projects funded by charitable and non-profit foundations, but it also brings together volunteers and enthusiasts who believe in constructionist ideas and might not otherwise be affiliated with the university.

The process of creating such an environment is ongoing. Although we only started recently (2019) and were hit by the COVID emergence like everyone else, the growth we are experiencing now is astounding. This is the time to reflect on the results achieved so far and to consider the challenges that lie ahead of us.

Building a thriving constructionist community is no easy task; it requires constant effort, adaptation, and collaboration among various stakeholders. Some of the key challenges we face include cultivating a sense of belonging and shared values among community members, while respecting and celebrating the diversity of backgrounds, disciplines, and expertise they bring to the table; establishing channels for effective communication and collaboration within the community, fostering an atmosphere of openness, trust and mutual respect; develop and maintaining partnerships with external organizations and institutions to expand the reach and impact of our initiatives; continuously assessing and refining our strategies and practices to ensure that we are effectively responding to the evolving needs and aspirations of our community members.

During the process of building our community, we found immense value in the extensive literature available on constructionism and its effect on learning in formal and informal settings (Papert, 1980; Martinez, 2013; Resnick, 2017). However, we observed a scarcity of research and reports addressing the broader objective for a university to create a constructionist community both within and outside its walls, ensuring its sustainability and growth (Taylor, 2016). While this paper may not have all the answers, we hope it offers valuable insights into the success we achieved and the challenges we encountered, and inspires other communities to embark on similar endeavors. By shedding light on the many open questions we continue to grapple with, we aim to foster a discussion not only on the most effective approaches to promote constructionist methodologies, inside and outside the university, but also on the process required to establish a thriving constructionist community.

The Context and a Brief History

The University of Trento is a medium-sized, generalist university with 16,000 students located in the alpine region of Italy. Trento is an autonomous province, enjoying a certain degree of political and administrative autonomy from the central government of Italy. This autonomy allows the province to manage its own affairs in areas such as education, healthcare, transportation, and local administration. It also enables the province to make decisions and policies that cater more effectively to the specific needs and interests of its citizens while preserving and promoting its unique cultural and linguistic heritage. As a result, a strong sense of community is present in the region. The University of Trento is the sole academic institution in the area, fostering strong ties between the university and the local community.

The University offers a variety of degrees in numerous fields, including science, engineering, humanities, law, business, social sciences, psychology, and more recently, medicine. Arts and design programs are absent, except for a blended

engineering and architecture degree with strong roots in the Department of Civil Engineering. Very recently, the university established a Teaching and Learning Center, trying to innovate its pedagogy, and started to participate into European networks where challenge-based learning is studied and encouraged.

In 2019, the Department of Computer Science and Engineering established a FabLab, which, after a period of reduced activity due to the pandemic, became fully operational in 2021. This FabLab opened its doors to students from all departments, both scientific and otherwise, as well as to students of the local schools, and, although less frequently so far, to the general public. The creation of the FabLab marks the culmination of several initiatives the department has launched over the past decade, with goals as varied as providing extracurricular activities for students and forging strong connections with the local community. Over the years, these goals have evolved into the broader ambition of innovating education across all disciplines and educational levels through the integration of constructionist theories and methodologies.

Next to the Fablab, Glow has been created, a cultural promotion association" (one of the legal forms of the third sector in Italy). Its mission is to broaden the reach of the constructionist community beyond the university walls and to disseminate the scientific achievements attained by the Fablab.

Figure 1 shows a diagram of our model. In input, there are the skills provided by the various departments that make up the university, embodied by our students, and a set of cultural associations that collaborate with us, some of which were founded by former students. At the center is the Fablab-Glow duo, operating in synergy as if it were a single entity. In output, there are our areas of intervention, not only within the university but especially in the world of education and the local community.

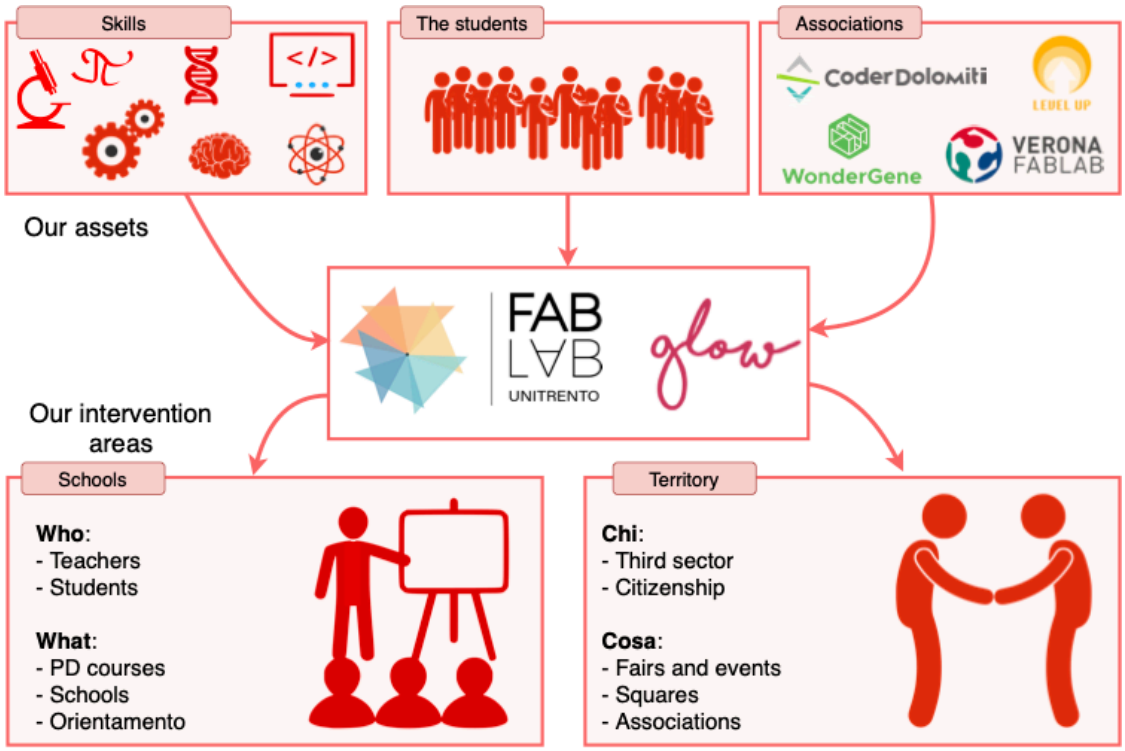

Figure 1 – Overall picture of the UniTrento Fablab ecosystem.

The FabLab UniTrento is coordinated by the two authors and is equipped with a technical staff unit to ensure the

operation of the devices; additionally, the second author is also the founder and president of Glow. The rest of the staff is hired on a project basis, according to the competitive calls won.

The Areas of Intervention

The FabLab's initiatives can be broadly categorized into three main areas: supporting university students, engaging with schools, and connecting with the local community.

Supporting University Students

Papert's constructionist vision, Resnick's creative learning approach, and the free access to new technologies provided by the maker movement are concepts that are seldom encountered in Italy's schools, particularly at higher levels. As students grow, they increasingly find themselves confined within individual disciplines, with limited opportunities for both interdisciplinarity and free experimentation. Consequently, they are forced into rigid learning patterns, becoming focused on obtaining grades and credits.

When students enter university, their experience often remains unchanged: they find themselves caught in a continuous cycle of lectures, studying, and exams, with little to no room for curiosity, serendipity, and personal exploration. This holds true even for courses employing innovative educational approaches, such as problem- and project-based methodologies (Barron, 1998). The UniTrento FabLab's primary objective is to break this cycle by providing students with a unique space in which they can develop their ideas, passions, and skills within a highly interdisciplinary context. Interdisciplinarity here means the collaboration between different academic disciplines and fields, fostering an environment where students from various backgrounds can merge their unique perspectives, knowledge, and skills to explore complex problems and create innovative solutions. It encourages creative thinking, enriches the learning experience, and allows students to see beyond the confines of their particular study area.

The UniTrento FabLab grants free access to students from all departments and offers basic skills training for those without technical backgrounds. To guarantee a truly authentic learning experience, the authors strongly believe that all activities offered by the FabLab should be extracurricular, not carry any credits, and be completely disconnected from any form of summative assessment (Hattie, 2007).

Faced with this newfound freedom, students often struggle to adapt – after years of indoctrination by schools, they seem to be always waiting for someone to tell them what to do (Kirschner, 2006). It is essential to provide them with the right prompts and create a community that can offer examples, fostering an exchange of ideas that enables a creative spark in students (Schunk, 2011). We offer a variety of initiatives to foster learning and growth among students:

- *Introductory workshops*: We regularly organize introductory workshops to help students acquire knowledge and skills related to machine usage; examples of topics include 3D printing, parametric 3D design, laser and vinyl cutting, CNC milling and engraving. The laboratory is more than just a Fablab, however; it can take the form of a hackerspace, and meetings related to software tools have been organized as well; Flutter, OpenStreetMap, and LaTeX are just a few examples.
- *Resident students*: We encourage university students to live in our spaces and enhance their functionality. They often take an active role, such as welcoming newcomers and providing explanations on how the laboratory works, driven by the enthusiasm of being part of a community. When they are particularly proactive and enthusiastic, they are promoted to the role of resident students; they can access the laboratory even in the absence of staff and

provide an essential contribution to the functioning of the laboratory.

- *Events and conferences*: We empower students to share their knowledge and transition from being learners to educators by allowing them to take on active roles in organizing workshops, seminars, and meet-ups on various topics. Some of the workshops listed above have been conducted by students.
- *Hackathons and competitions*: We often organize challenge-based events that enable students to test their skills and collaborate with companies and associations. We participated in several international hackathons and programming competitions, such as DigiEduHack (two of our teams won the last two editions) and Google Hashcode (our hub was ranked second in the world in the last three editions). But more importantly, we support local companies in the organization of small hackathons that are used to get to know our students.

The key to engaging students is helping them understand the significant contrast between the conventional learning methods they are accustomed to and the entirely distinct approach we adopt in the laboratory (Hyun, 2017). Once they grasp this difference, the next step is to engage them in spreading the initiative. They all become ambassadors of the FabLab, sharing their experience and recruiting new members. Moreover, they often become collaborators in activities outside of the lab, such as those described in the Sections titled "Towards Schools" and "Towards the Local Community". Examples are to support younger students in carrying out projects and to assist teachers as they participate in activities promoted by the FabLab.

Towards Schools

An important aspect of the FabLab's mission is its connection with the world of primary and secondary education. The challenges faced in this context are similar to those mentioned previously – constructionist approaches are rarely applied, and teachers often resist change (Le Fevre, 2014). The strategy we are adopting involves gently guiding teachers towards a more constructionist model, without forcing them, and allowing them the necessary time to adapt. We adopt a scaffolding approach, where teachers are first introduced to a well-defined initial environment and provided with teaching materials to start. Then, they are supported by our students in the initial implementation of the activities; finally, this support is gradually withdrawn as the teachers become more independent.

- *Teacher training workshops*: We organize professional development workshops for educators to learn about computational thinking, educational robotics, creative learning, and the maker approach. Our workshops provide teachers with both technical instruction and a space to discuss novel approaches to teaching, enabling them to incorporate hands-on learning and interdisciplinary problem-solving in their classrooms. More than 170 educators participated in the last edition of our main event, called Teacherdojo, which can be more aptly defined as a community of practice (Wenger, 1998), as our trainers are experienced educators themselves who substantiate constructionist theory with real examples of activities that have been successfully implemented in the classroom.
- *Curriculum development*: We partner with schools to create interdisciplinary, project-based curricula that prioritize experiential learning, teamwork, and critical thinking. This is achieved by incorporating FabLab resources and technologies into the educational programs, enabling engaging, hands-on experiences. These collaborations often arise from the workshops previously mentioned. Teachers recognize the potential advantages of these collaborations and seek support to more widely implement the constructionist approach in their teaching practices. For example, we recently developed a curriculum and materials for performing physics experiments that are instrumented with Arduino. By following a constructionist approach, the experimental materials must be assembled by the students. This provides a full and realistic experience that reflects the work of a physicist.
- *After-school programs*: We offer after-school programs for students, where they can engage in constructionist learning activities, learn new skills, and explore their interests. A particularly captivating example is "Matematica in Gioco" (Mathematics in Play), an after-school program in which high-school students from various

backgrounds—including both scientific and artistic specializations—designed and implemented board games inspired by mathematics, with the assistance of university students.

When possible, these programs are co-designed with schools and teachers: the idea is to develop activities that can fit their current curriculum, but providing students time and space for free exploration. For example, we co-designed a bio-informatics activity whose goal was to identify genetic diseases in datasets provided by the Biotechnology department. In the first two years, the activity was promoted by the university and the school. Starting next year, the activity will be guided solely by school's teachers, without our intervention.

Towards The Local Community

An important aspect of the FabLab's mission is its engagement with the local community. By fostering collaborations and organizing public events, the FabLab aims to create a network of individuals and organizations that promote informal learning events in the region. In all the activities listed above, cooperation with Glow is crucial; University bureaucracy would have hindered the completion of most of them.

- *Mobile Lab*: We created a mobile FabLab that brings science and technology to local communities, fostering formal and informal learning processes, creative co-planning, and community empowerment.
- *Mountain Cabin*: We operate a mountain cabin that hosts a variety of events, including science-focused summer camps, which immerse participants in the beauty of nature.
- *Partnerships*: The FabLab-Glow collaboration serves as the hub for a network of partnerships with organizations that foster informal learning and innovative teaching in the local area. For instance, Coderdojo Trento is a youth club that encourages computational thinking via coding; Level-up is an academic startup that creates kits for learning science and physics; Wondergene is an initiative focused on making genetic analysis, typically conducted in specialized laboratories, portable and accessible to non-experts, including schools. We also cooperate with Verona Fablab, which operates in a neighboring province, and we plan to expand our reach to other local areas.
- *Public events*: The FabLab organizes and participates in scientific fairs and public activities to engage with a broader audience and promote science and technology education. By showcasing the latest developments in the field and demonstrating the potential of constructionist learning, the FabLab aims to inspire community members to embrace innovative teaching methods and foster a culture of lifelong learning.

Open Questions

In building a thriving constructionist community, several open questions and challenges arise that need to be addressed in order to ensure the continued success of the UniTrento FabLab and similar initiatives. We will discuss some of these challenges here.

Q1: *Sustainability*. How can the UniTrento FabLab ensure long-term sustainability in its operations and community engagement? What measures can be taken to balance growth and resource management?

This is the fundamental question from which this article emerged. The first author's personal journey began with an encounter with constructionist literature more than a decade ago. Since then, he has spearheaded numerous initiatives within his department and university. After meeting with the second author, these experiences ultimately converged in the establishment of the FabLab as an educational hub, leading to the definition of the model described in this article. At the beginning, most of the activities rested on the shoulders of the two founders; fortunately, as the community

grows, an increasing number of people are becoming involved. Yet, the vision of the FabLab is still promoted and carried forward by the two of us, and the core group of people leading the Fablab has not expanded. The founders' syndrome is a common problem among many organizations (Schein, 2010). Given that the FabLab aspires to become a permanent center within the university, we must find new management models to ensure its sustainability over the years.

Q2: *Replicability*. How can the UniTrento FabLab's model be replicated in different settings? What are the key factors that contribute to its success, and how can they be adapted to other contexts?

We believe that addressing this question is fundamentally important for promoting the growth of the constructionist community. We are definitely not the first constructionist lab to be founded in a university, so we are likely grappling with the same issues that many other venues have encountered (Valentine, 2004). We believe that a literary debate on such issues is needed (Holbert, 2020), with this paper going in this direction.

Q3: *Integration with Formal Education*: How can the FabLab's constructionist approach be integrated into formal education systems at all levels (primary, secondary, tertiary) without compromising its core principles of free exploration, hands-on learning, and interdisciplinary collaboration? What might be the potential barriers and opportunities when aligning the constructionist approach with the existing pedagogical models in schools and universities?

Determining the ideal balance between the requirements of formal education – in particularly as declined in countries with more traditional educational systems (Kynigos, 2022) – and the freedom fostered by constructionism remains an unresolved issue, initially acknowledged by Papert himself (Papert, 1991). We believe that anyone captivated by the constructionist approach and striving to advocate for it within their community encounters this challenge. Along the way, the same mistakes may be repeated, such as the simplistic assumption that merely lecturing teachers about constructionism will pave the way for a bright constructionist future. Our current success stems from the understanding that the only feasible method for disseminating these ideas and cultivating a constructionist community is to embody the constructionist approach itself: creating an environment in which everyone involved—from students and teachers to volunteers and association staff—can appreciate the value of constructionism by experiencing it firsthand and rediscovering it anew.

A significant part of the constructionist approach is the embrace of "tinkering" – a playful and experimental exploration of materials, tools, and ideas. It is a method that welcomes trial and error, recognizing that mistakes are not failures but vital learning opportunities. This culture of accepting errors as part of the learning process is in stark contrast to many traditional educational systems, where errors are often penalized. Implementing a mindset that values mistakes as a source of insight and growth can be a transformative aspect of integrating constructionism into formal education. It encourages resilience, creativity, and the development of a deep, personal understanding of the subject matter.

Q4. *Collaboration and Networking*: How can the FabLab foster a culture of collaboration and networking among its community members, both within and beyond the university setting?

An indispensable component, often difficult to duplicate, involves nurturing a sense of unity and shared principles among community members, while valuing and honoring the variety of backgrounds, disciplines, and skills they provide (Schein, 2010). In our context, the community includes the FabLab staff, students engaged with the lab, former students who are now teachers, collaborators employed at Glow, and individuals involved in satellite associations.

To accomplish this, creating avenues for efficient communication and cooperation within the community is vital, promoting an environment of transparency, trust, and reciprocal respect (Katzenbach & Smith, 1993). We aim to organize regular community events and workshops to facilitate interaction, knowledge sharing, and skill development among members (Wenger, 1998); implement mentorship programs that pair experienced members with newcomers, fostering relationships and promoting the exchange of ideas (Kram, 1985); and recognize and celebrate the

accomplishments of community members, reinforcing their sense of belonging and motivation to contribute further (Amabile, 1997).

Q5. *Cooperation with external associations*. What are the most effective strategies to build and maintain partnerships with external organizations and institutions?

To ensure scalability, collaboration with external non-profit organizations is crucial. They can provide the workforce that a single lab could not furnish, and they are vital for sustaining the FabLab's growth and impact. We have adopted a dual model here, with Glow being directly founded by us. Meanwhile, other associations and companies form a constellation, each specializing in a different sector or regional area.

Adopting a boundary-spanning approach can help facilitate these collaborations, as it involves actively seeking opportunities to engage with diverse stakeholders and share resources, knowledge, and expertise (Aldrich & Herker, 1977; Tushman & Scanlan, 1981).

Additionally, the economic sustainability of these external associations is of significant importance. A clear understanding of the financial models, shared responsibilities, and revenue streams that support the collaboration is crucial for long-term success. By aligning the economic interests of the FabLab with those of the external associations, and ensuring transparency and fairness in financial agreements, the partnerships can be maintained on a stable and sustainable footing. This alignment contributes not only to the resilience and growth of the FabLab but also fosters a thriving ecosystem where each entity, including the university, benefits from mutual cooperation and shared goals.

Q6: *Measuring Impact*: What are the most effective methods to assess the impact of the FabLab's initiatives on students, educators, and the broader community? How can the FabLab continuously evaluate and improve its practices based on this assessment?

We have yet to find a definitive answer to this. To gather feedback on the experiences and perceived value of the FabLab's initiatives, we conduct regular surveys and interviews with students, educators, and community members. We monitor quantitative metrics such as attendance, participation rates, and the number of completed projects or collaborations. Additionally, we implement pre- and post-assessments to measure growth in skills, knowledge, and attitudes among participants.

Nevertheless, we remain unsatisfied. Given our relatively short history, longitudinal studies are still beyond our reach, and we may only perceive the indirect effects of our efforts, as evidenced by anecdotal stories of students that we have been able to follow from young age up to our classrooms, and reports from satisfied teachers. This lack of measurable impact may discourage many universities from pursuing such an approach.

Conclusions

Promoting a constructionist approach to teaching can be pursued in two ways: initiating major revolutions, such as the development of Logo in the 1980s and the development of Scratch more recently, which reach millions of students, teachers, and educators; or by helping one's local community realize and implement the promises of these major revolutions. This can be done more effectively when the relationship between the entity driving the change and the territory connected to it is particularly close, as in the situation described in this article. Despite the narrower scope, however, challenges are not lacking. The contribution of this article is to initiate a debate on the type of support that needs to be provided to these communities, in terms of sharing experiences and the difficulties encountered in the process of creation.

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