DEVELOPMENT AND OPERATION OF EMERGING TECHNOLOGIES LABS AND MAKERSPACES IN THE MIDST OF THE COVID-19 CRISIS: A CASE STUDY

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Abstract

While the technological dimension of our digital world is advancing at a rapid pace, the Covid-19 crisis has revealed that the digital transformation and readiness of schools and adult education, is having difficulties in adapting and keeping up. However, at the same time, the crisis has exposed the importance and central role of digital technologies and above all, digital literacy as an underpinning pedagogical approach, within education systems, as well as in our professional and personal lives.

Emerging Technologies Labs and Makerspaces or hybrid versions of both are one possibility to get further training in the field of digital transformation and readiness. These labs can be bound to one location or even offer mobile functionalities and can be used by elementary schools to universities and adult education. The specific objective for appropriate use, depends on the equipment, but above all, on the underlying learning and pedagogical models.

In this paper, the authors discuss two important aspects: (i) What makes a successful Emerging Technologies Lab / a well-designed Makerspace? (ii) Which good practices and approaches are commendable and why? As such, this paper takes an explorative approach to identify the underpinning value of Emerging Technologies Lab and Makerspaces, vis-à-vis the digital transformation and readiness in the educational sector. This will be achieved through a mixed methods approach involving an online survey, followed by expert statements and an introduction of role models.

Keywords: Emerging technologies, emtech lab, makersspace, education.

1 INTRODUCTION

In this paper, the authors aim to show the considerations behind Space21Future [1], an Emerging Technologies Lab for school children and teachers, in the Viennese district of Floridsdorf. The Space21Future was planned and funded just before the Covid-19 situation, with its opening falling in the middle of the second lockdown in Austria. We like to show the underlying philosophy of the Lab, how the Lab runs if there was no Covid-19, and how the operations have been adapted to the Covid-19 situation. We will also introduce other initiatives that have served as inspiration for the creation of the lab.

The name Space21Future stands for "a learning space that enables children and young people to strengthen (digital) skills and develop their future perspectives" and should therefore be read as "Space to one future". In addition, the number 21 stands for the 21st district of Vienna, namely Floridsdorf, where the Lab is located. The initial equipment of Space21Future was financed by the district of Floridsdorf as part of a digitalization concept for the district. To demonstrate the importance of this topic, this project was also included in the program "21 Projects for the 21st District". Furthermore, this project was supported by the City of Vienna and its responsible municipal departments, as well as the Vienna Department of Education. Currently, the Lab is run by three teachers who are employed on a part-time basis to proactively manage the Lab. In the first year, the team consists of Michael Fleischhacker, initiator of the project and especially known for his initiative "Flipp den Fleischhacker", Alexander Pfeiffer is in the role of media scholar and Sandra Stella supports as an experienced media and games educator. Stephen Bezzina advises the team on adaptive learning.

Space21Future is located in the primary school (VS) Prießnitzgasse and is available to 21 elementary and 11 secondary schools in the district. The schools in Floridsdorf can book slots for different

"sessions". These sessions last one to four hours and are each attended by one class with two accompanying teachers. This would be the optimal case if Covid-19 did not exist and therefor the current lockdown situation and the covid-19 school traffic light color on orange or even red.

2 METHODS

This paper takes an explorative approach to identify the underpinning value of Emerging Technologies Labs, Fab Labs and Makerspaces, vis-à-vis the digital transformation and readiness in the educational sector. This will be achieved through a mixed methods approach involving an online survey, followed by expert statements. At the beginning there is a best practice analysis of similar projects and which aspects can be highlighted and identified as good practice.

3 LABS AND INITIATIVES THAT SERVE AS ROLE MODELS

The Space21Future of course has a number of sources of inspiration. We would now like to introduce these.

The Otelo network [2] has been showing for several years how to work with children and young people in the field of media education and the makerspace idea. It is especially exemplary how Otelo deals with the Covid-19 situation and even brings equipment directly to the students in the lockdown in cooperation with partners like "Conrad Electronic".

Inspiring for Space21Future was also the techLAB of the Technical Museum Vienna [3] The techLAB showed that young people can get excited about new things even in short sessions and how individual attention is possible to further deepen interest.

The MITA Emerging Technologies Lab in Malta [4] although primarily for adults and students, serves as a model in terms of the session booking system and how a space can be quickly transformed "from one technical topic to another." In 2018/2019, Alexander Pfeiffer and Stephen Bezzina helped to build this Lab.

Particularly impressive and a template for Space21Future is the City of Cambridge (Boston, USA) STEAM initiative [5] This initiative operates creative and media spaces in the STEAM (Science, Technology, Arts, Engineering & Math) area of Cambridge. Here, they offer various initiatives such as the "Science Club for Girls", where the focus is on showing girls the opportunities in technical professions. A goal that is definitely also pursued by the Space21Future team.

Another successful example is the Future Learning Lab in Vienna [6]. Initiated by various political bodies and the University College of Teacher Education Vienna. The FLL operates teaching and learning spaces. With the goal to assist both sides, students and teachers.

4 OBJECTIVES

When it comes to what skills will be needed for the job market of the future, we would first like to refer you to the World Economic Forum's "The Future of Jobs Report 2020" [7]. The reports list the top skills for 2025. Among these are:

- Analytical thinking and innovation
- Active learning and learning strategies
- Complex problem-solving
- Critical thinking and analysis
- Creativity, originality and initiative
- Leadership and social influence
- Technology use, monitoring and control
- Technology design and programming
- Resilience, stress tolerance and flexibility
- Reasoning, problem-solving and ideation
- Emotional intelligence

- Troubleshooting and user experience
- Service orientation
- Systems analysis and evaluation

Many of these areas of expertise are to be covered by the planned and currently implemented activities of the Space21Future Lab. In the preparation and topics of the "offered lab sessions", the initiators of the Lab also refer to the classic 4C model [8], the challenges of participatory culture according to Henry Jenkins [9, 10] and the 5A model for media literacy by Paul Mihailidis.

According to Battelle for Kids (BFK), a not-for-profit organization with the mission of realizing the power and promise of 21st century learning for every student, the Learning & Innovation Skills – 4Cs are:

1 Critical Thinking
2 Communication
3 Collaboration
4 Creativity

For the development and visualization of the sessions in the context of the activities within the Space21Future, this enables a quick check of which competency fields are covered by which activity and with which intensity. In ongoing iterations, the accompanying teachers as well as the pupils are asked whether a competence gain or a self-reflection on these competences has taken place during a self-assessment.

In terms of participatory culture, Jenkins et. al. describe participation as prosumers in the books "Confronting the Challenges of Participatory Culture - Media Education for the 21st Century (Parts 1 & 2) back in 2006 as a culture in which private individuals (the public) do not act as consumers only, but also as contributors or producers. And this is one of the most important factors in the current media world, with platforms that particularly encourage this and are used massively by minors, such as Instagram, Tik Tok or Twitch.tv.

Jenkins et. al have identified a set of core social skills and cultural competencies that young people should acquire if they are to be full, active, creative, and ethical participants in this emerging participatory culture:

1 Play — the capacity to experiment with your surroundings as a form of problem-solving
2 Performance — the ability to adopt alternative identities for the purpose of improvisation and discovery
3 Simulation — the ability to interpret and construct dynamic models of real world processes
4 Appropriation — the ability to meaningfully sample and remix media content
5 Multitasking — the ability to scan one’s environment and shift focus as needed to salient details.
6 Distributed Cognition — the ability to interact meaningfully with tools that expand mental capacities
7 Collective Intelligence — the ability to pool knowledge and compare notes with others toward a common goal
8 Judgment — the ability to evaluate the reliability and credibility of different information sources
9 Transmedia Navigation — the ability to follow the flow of stories and information across multiple modalities
10 Networking — the ability to search for, synthesize, and disseminate information
11 Negotiation — the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms. [10, p56]

Jenkins et. al. also refer to Gee's idea of affinity spaces. As virtual or real places where the interest of young people to learn something is much higher than, for example, in the traditional school. The goal of the Space21Future is to become such a place in real as well as virtual world. These affinity spaces are described as follows.

"Affinity spaces are distinct from formal educational systems in several ways. While formal education is often conservative, the informal learning within popular culture is often experimental. While formal education is static, the informal learning within popular culture is innovative. The structures that sustain informal learning are more provisional, those supporting formal education are more institutional. Informal learning communities can evolve to respond to short-term needs and temporary interests, whereas the institutions supporting public education have remained little changed despite decades of school reform." [10, p9]

Of utmost importance in regard to the Space21Future activities and for what the lab stands for is the 5A model for media literacy by Paul Mihailidis. His model consists of the following items:

1 Access - to media
2 Awareness - of authority, context and credibility
3 Assessment - of how media portray events and issues
4 Appreciation - for the diversity of information, dialog, collaboration, and voices online
5 Action - to become part of the dialog. [11, p11]

For the Space21Future team's consideration, the 5As provide the optimal complement to the 21st century competency models presented above.

5 SURVEY RESULTS

In order to obtain an opinion from colleagues in the educational sector in Austria on the topic of Emerging Technology Labs, FabLabs and Makerspaces for the development of minors, an online survey was conducted in the form of a conversation with a chat bot. A 5-point Likert scale, represented in the form of stars was used. 5 stars indicates the number 5 and thus a high level of agreement in each case.

Three experts from the media education sector were asked to comment the results of the survey. 64 people took part in the online survey, with 58 completing all questions. Most of the survey participants have been middle school teachers.

Table 1. Survey participants.

	Number of participants
Pre-school	3
Elementary School	2
Middle School	26
High School	7
College	9
University	9
Adult Education	6
Youth Worker / Out of school educatior	1
Not an Educator	2

The experts are persons experienced in the field of media education.

Table 2. Expert comments.

Expert ID	***Gender***	***Profession***
E1	female	Teacher (Media Education)
E2	male	Media Scholar
E3	male	Teacher (Media education)

The online survey was divided into the thematic sections:

- Opportunities for development of young people seen from different points of view.
- Further training for teachers
- Organization and funding of the lab
- Activities outside the lab supervised by the lab members.

The results of the first section confirm that Maker Spaces and Fab Labs can have a positive impact on the further development of children and young people (4.19). The response to the question of whether Maker Spaces and Fab Labs have an influence on the future career decisions of young people (4.34) and whether Maker Spaces and Fab Labs also manage to reach girls and educate them about technical and creative professions (4.37) achieved a remarkably high average value.

The question of whether Maker Spaces and Fab Labs can help to show children and young people from families without financial capacity new possibilities and to support them in reaching them also received broad agreement (4.16).

The final question of this section, whether Maker Spaces and Fab Labs can prepare young people for 21st century skills, was also rated positively (4.19).

Table 3. Opportunities for further professional development of young people seen from different points of view.

Question	Score (out of 5)
Importance of Maker Spaces/Fab Labs for the development of children and young people in general. (N=64)	4.19
Importance of Maker Spaces/Fab Labs regarding future career choices of children and young people. (N=64)	4.34
Importance of Maker Spaces/Fab Labs in regard to reaching out to girls and young ladies and the topic of technical s and creative professions. (N=64)	4.37
Importance of Maker Spaces/Fab Labs in regard to reaching out to children and young people from financially weaker families and provide regular support. (N=62)	4.16
Do Maker Spaces / Fab Labs have the potential to train and/or demonstrate skills needed in the 21st century? (N=62)	4.19

The experts' statements on this section confirm the positive assessment of the survey participants. However, it was pointed out that equipment alone does not mean media education in the Maker Spaces and Fab Labs. Clear didactic concepts are needed on how to support young people in and outside the labs. It was also pointed out that approaching young ladies as well as children from financially weak or disadvantaged households must be done with courage on the one hand, but with caution and planning ahead on the other, in order to actually use the positive possibilities of Maker Spaces and Fab Labs for these target groups.

The next section of the questionnaire dealt with the idea of using Maker Spaces and Fab Labs for the training and further education of pedagogical staff. This was positively assessed by the participants (3.97), but not as positively as we, the authors, expected.

Table 4. Further training for teachers.

Question	Score (out of 5)
The importance for Maker Spaces / Fab Labs to continuously train teaching staff (N=58)	3.97

The experts have explained this in such a way that teachers will certainly find good things to say about the Labs and their possibilities. But at the same time, there may be a fear of forced schooling and therefore only short, very superficial courses, so that everyone within the school system can attend. The experts were in agreement that the emphasis should be on voluntariness and differentiated units should be provided. Those units where it is explained what equipment is available, which features exist and what impact these developments have on the modern media world. And in addition, in-depth

sessions and project weeks with educators who want to go into depth and perhaps also like to be mentors in one of the labs by themselves in the future.

The next section was about organization and funding. Regarding the location, the survey participants find it quite important that the labs are accessible in full day trips (4.11) and thus excursions are easily possible. The second question dealt with funding. The question was whether the public sector should fund the Labs. Here, the average value is still positive (3.85), but based on the individual response analysis, one can also see some swings in the clearly negative direction.

Table 5. Organization and funding of the lab.

Question	Score (out of 5)
Importance of Maker Spaces / Fab Labs to be easily reachable by schools within educational field trips. (N=62)	4.11
Should Maker Spaces / Fab Labs be funded primarily with taxpayer money? (N=59)	3.85

When asked about these two points, the experts also agree that there should be a network of labs and they should be easily accessible. Outside of metropolitan areas, the experts suggested that labs can focus on specific topics and therefore on specific equipment. After a certain time, there could be a rochade. In this way, labs could also be established outside the metropolitan areas at relatively low cost.

In terms of public funding, some educators may have doubts about whether the right equipment is being purchased. In addition to difficult tenders and procurement procedures, the service life of the equipment is often limited, or some devices are quickly outdated. One possibility here could be rental contracts. Or partnerships with companies for dedicated research contracts, but always accompanied by a third, independent body. Where the public sector should step in, however, is in the area of personnel costs and the protection of the workforce.

The last section looked at activities of the Lab outside the premises with regard to the current Covid-19 situation. Here, the aspect of Lab2Go boxes and other challenges were addressed. Both points were clearly seen positively by the participants of the online survey [4.23 and 4.24].

Table 6. Activities outside the lab supervised by the lab members.

Question	Score (out of 5)
Support of “Lab2Go” Boxes, equipment which is temporarily used in a school including supervision by Space21Future team members. (N=62)	4.23
Online Challenges that can be introduced by teachers to their pupils. But participation is voluntary and no further equipment is needed (or provided as online resources to the pupils participating). The challenges are supervised by the Space21Future team members. (N=62)	4.24

The experts find the support of Maker Spaces and Fab Labs in the form of equipment rentals and non-contact support via video sessions absolutely positive. Particularly in the current situation, where children from mixed classes are often only in schools for supervision, but no new lessons should be taught. The ideas of voluntary challenges initiated by the labs, such as the Minecraft Challenge of the Space21Future, which is well distributed in the media, or the upcoming Run Challenge, are also perceived positively.

6 ON-SITE ACTIVITIES ENVISAGED BY THE SPACE21FUTURE TEAM

In the following, three selected examples will be given of how the interaction of technical equipment and didactic support is handled in the Space21Future. The list is sorted by technical tools:

Lego Education® Wedo and Lego Education® Spike:

Depending on the basic set used, work with Lego can take place with older elementary school children, but especially with children and young learners in middle school. Here the groups are divided in such a way that girls work together with boys in groups. Each group is assigned a set and different goals. For example, one of these goals might be, "Build a robot that can play rock-paper-scissors." At

the beginning of the session, roles are drawn. Roles are for instance "technician, quality manager, programmer or project manager". Roles can also be swapped (through negotiation in the group) before the start of the construction and programming. A project diary is to be kept during the construction. Goals and non-goals are defined by the group. The work steps, the successes but also the failures are documented. At the end, the project group gives a short presentation in which each group participant presents the project from his/her perspective.

Enough time should be allotted for this session. It is advisable to extend this to 3 hours or more. And also plan enough preparation and follow-up time. Because the small robots have to be disassembled and carefully sorted afterwards.

- *Bee-Bots:*

These look like toddler toys at first. With appropriate didactic support, however, they can also be used in middle school. Various "maps " can be created in advance, for example, as part of handicraft lessons and/or art education. This can also be combined wonderfully with German/English lessons and work instructions and stories can be created. Furthermore, this can be connected with geography and other lessons. In addition to this cross-curricular approach, the use of the Bee-Bots then provides an "Eureka moment" for the children and young learners. It quickly becomes evident that thinking ahead, as well as the ability to remember things and then carry them out, are skills that need to be trained on an ongoing basis. The Bee-Bots are an excellent tool for this purpose. In addition, the topic "bees" can also be used to discuss subjects related to biology and environmental issues with children and young learners. The buzzword here is for example "insect mortality." In previous sessions, this has initially come up by coincidence and then turned into very exciting discussions with the attendees. And, the accompanying teachers felt inspired.

- *Robo Wunderkind:*

The Lab is equipped with Robo Wunderkind sets for different ages. The companion app is intuitive and offers many different uses. Here we have the children and young learners work in two teams on different tasks in a one-hour session. Important afterwards is the reflection round and a discussion in which the children and young learners explain to the educators why coding and robots will become increasingly important in the future. At the end of the session, there is an initial introduction to the topic of artificial intelligence. During which the children and young people realize for example that the computer-controlled opponents and co-players in their computer games already represent a form of AI. A research activity is planned for the coming months, in which at least 5 schools will be equipped with Robo Wunderkind equipment, the equipment will be used over a longer period of time by the teachers on site, but accompanied by employees of the Space21Future and the company behind Robo Wunderkind, and evaluated on various aspects.

7 INITIATIVES DURING THE COVID 19 CRISIS

Due to the lockdowns imposed in Austria and the de facto ban on school excursions, the Space21Future has reacted and started off-lab activities.

The Lab2Go boxes are one activity. These are special boxes that contain a dedicated equipment set on a specific topic. The goal is that the boxes will move from school to school in the district and they will be used over a short period of time in different classes per location.

The first set is with OZO bots on the topic of geography. The students will learn the first steps of how to use programming commands and at the same time they have to know the provinces and the most relevant places in Austria, because they have to program the route of the OZO Bots and its special moves.

The second set is with Bee-Bots. The children and teenagers have to paint the map themselves in art class including the stores and landmarks in a city. And then they have to announce in the foreign language English which route the Bee-Bot will take. For example, the young learners have to speak out loud: “The Bee Bot wants to reach the pharmacy. To do so, it drives straight ahead for 200 meters and then turns left after 100 meters.” Assuming that one Bee-Bot square corresponds to 100 meters.

Other activities are the Challenges. Recently, the Minecraft Robot Challenge [12] was completed very successfully and can already be found on the website.

Currently, the Run Challenge is in preparation. Here we show how Microbits can be programmed with block-based language, so that they serve as a pedometer. The software "Move-Effect [13]" can then be used to enter the kilometers covered for the challenge. Children who have not yet received Microbits from the schools can also participate with their smartphones or counted kilometers via Google Maps or similar software. No one is excluded. The joy of exploration and movement should be conveyed, especially in difficult times like these.

8 CONCLUSIONS & OUTLOOK

We look forward to feedback on our activities and further research, such as the upcoming activity with Robo Wunderkind. We hope that the idea of Maker Spaces and Fab Labs for students and teachers will catch on and be massively expanded in Austria, Europe and the world in the coming years. Children are our future and we need to support them in the best possible way.

Finally, it should be explicitly mentioned that aspects such as (cyber)mobbing, sexism, hates speech and racism not only have no part to play in the Space21Future, we also actively discuss these topics. If, for example, such incidents occur during group work or interjections during presentations, we as the members of the Space21Future see it as our task to deal with these issues in the ongoing workshop. The aim of this Lab is to prepare young people for life, and communication with each other plays a central role in this process.

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